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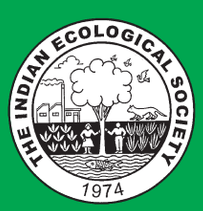

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Land Use Land Cover Change Detection Using Remote Sensing and Geographic Information System in Canal Command Area, Karnataka

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Abstract: Changes in land use land cover are a dynamic process taking place on the surface and it becomes a central component in current strategies in managing natural resources and monitoring environmental changes. LULC change detection is the process that helps in determining the changes related with land use and land cover with reference to geo-rectified remote sensing data. The objective of this paper is to analyze the land use land cover changes in the canal command area, Karnataka, India is using multi temporal remote sensing data (LANDSAT-8 of year 2015 and 2017) land use land cover changes has been performed. Eight LULC classes were established as crop land, fallow land, rockout crop, salt affected area, settlements, vegetation, water body and waterlogged. The LULC changes were unsupervised for classification during post-monsoon 2015 and 2016 waterlogged area was 2033.28 ha and 1703.07 ha, per cent respectively. The salt affected area was 1567.44 ha and 1232.91 ha, respectively. Waterlogged area shares 2026.89 ha and 1149.66 ha and salt affected area was 1336.86 ha and 1595.52 ha for pre-monsoon 2016 and 2017. Supervised classification during post-monsoon of 2015 and 2016, the waterlogged area was 1441.98 ha and 1489.77 ha, and salt affected area was 1797.03 ha and 1762.11 ha, respectively. Similarly for pre-monsoon 2016 and 2017, the waterlogged areaindicates that the anthropogenic activity like settlement, road and industrial area is largely broadened.

Keywords: Change detection, Geographic Information System, Land use land cover, Remote Sensing

Agriculture-ecosystem consists of inherently variable entities. This variability in the system is introduced due to variability of soil, climate, hydro-geological conditions and man-made practices followed for improvement of agriculture. The development of irrigation for improvement of agriculture had led to the development of water-logging and salinity problems in irrigation commands. Salinity problems also have developed in dry land conditions due to aridity of the climate. These problems of water-logging and salinity are found common world over. In India, an estimated 2.46 M ha of land is reported to have suffered from water-logging and the area containing salt-affected soils has been estimated 7.0 M ha Water-logging, closely associated with salinization/ alkalinization, continues to be a threat to sustained irrigated agriculture, affecting an estimated 6 M ha of fertile land in India. About 4.5 M ha of land have already become barren and more lands are being encroached upon by these problems every year Surajkumar and Shruti (2017). According to the FAO, land and plant nutrition management service, a significant proportion of cultivated land is salt-affected globally of the current 230 M ha of irrigated land, 45 M ha are salt-affected is 19.5 per cent and of the 1,500 M ha under dryland agriculture, 32 M ha are salt-affected. The state of Karnataka is no exception to these phenomena as the command areas of its many irrigation projects are suffering from water-logging and salinity problems. About 4 lakh ha has been affected by water-logging and salinity in the state. The Upper Krishna Project (UKP) is the most prestigious and an ongoing major irrigation project in the Karnataka state, that aims to irrigate the chronically drought hit areas of Kalaburagi, Yadgiri, Raichur, Koppal and Vijayapura districts of northern Karnataka. The predominant soils of the UKP command areas are black soils with fine texture and poor water transmission properties. Therefore, the problems of water-logging and salinity are unavoidable processes in vertisols (black cotton soils) and they are increasing at alarming rate because of their inherent poor drainage property coupled with potential evapo-transpiration rates that are much higher than the annual rainfall added to this, poor irrigation management further complicates this situation there by limiting crop production in irrigated areas. The water table was found to rise about 10 cm year^{-1} (CGWB 2013).

The natural drainage is insufficient to leach the salts that are brought in by irrigation water. Problems get aggravated due to seepage from canals and excessive irrigation, either in fields nearby or in higher-lying grounds. A report of monitoring surveys revealed that the number of villages affected by water-logging is increasing over the years since the commencement of irrigation. No systematic surveys were carried out so far regarding the areas affected by the twin problems affected water-logging and salinity. Due to limited

water availability at the tail end, farmers are forced to use poor quality water coming from nalas or underground and it has added a new dimension to the problem. The prioritization of degraded lands in terms of water-logging and salinity is essential in order to address this under UKP command area. This is essential to reclaim the affected areas which help in converting barren land to productive land and increasing the agricultural productivity. Also, most importantly improving the social status of the farmers of Hyderabad-Karnataka region is the need of the hour. For this, reliable and accurate mapping of these degraded lands affected by water-logging and salinity with their location and extent could be extremely useful in planning, investigations, design, construction, supervision, chalking out appropriate water management strategies and in overall policy making by the Government in this serious menace of land degradation. However, for effective policy making, spectral signatures, classification, delineation and characterization of waterlogged and salt affected areas in UKP command area are very much needed Venkataratnam and Ravisankar (2015). Presently, application of remote sensing technology has shown great promise of enhanced speed, accuracy and cost effectiveness in mapping and monitoring of degraded lands geographical information system tools could be effectively used to study the dynamic behavior of waterlogged and saline areas with remote sensing.

MATERIAL AND METHODS

Location of the study area: The study area is located between 16^0 29' N to $16^0$39' N latitude and $76^0$43' E to $76^0$54' E longitude. It is located 45 km away from the district headquarters and location map as showed below Figure 1. The gross command area of D-7 distributory is 15647.49 ha with a cultivable command area of 10322 ha and with a discharge capacity of 5.876 cumecs. The canal command covers parts of three topo-sheets of survey of India namely E43W10, E43W14 and E43W15 in the scale of 1:50000.

Instrumentation/tools used:

GPS: Global positioning system of Garmin make was used to record the position of sampling points and ground truthing.

Ground truth radiometer: Ground truth radiometer was used to estimate spectral reflectance curve of different land cover classes. Every substance emits, absorbs, transmits or reflects electromagnetic radiation in a manner, characteristic of the substance. This is the underlying principle involved in all remote sensing application. By measuring the quantity of radiation in each of the wavelengths, the characteristics of the substances can be defined. The reflectance patterns of different ground features in the waterlogged and salt affected areas were determined using Ground Truth Radiometer

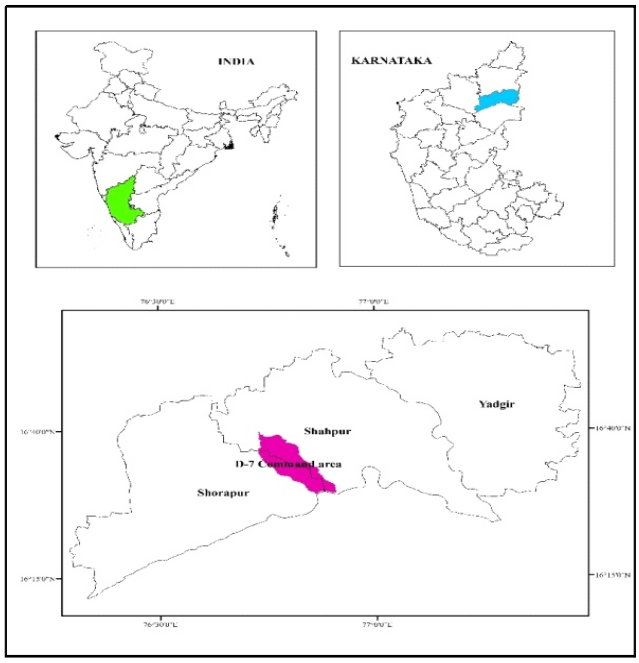

Fig. 1. Location map of study area

(GTR) having 4 bands in the range 0.4 to 0.9 µm. The reflected electromagnetic radiation from each objects or land cover in the waterlogged and salt affected area were observed and recorded, which were represented in terms of spectral reflectance of different land cover. Using GTR the spectral radiance of incoming radiations at desired spectral band was measured by placing band select knob at the specified spectral band position. GTR calibration plate is provided along with the unit. This plate was uniformly coated with barium sulphate ($BaSO_4$). Along with the unit, GTR calibration plate was taken to the field and placed on particular soil or vegetation under observation. The GTR unit was placed at 1 m above the GTR calibration plate and the reading was noted for each band and this reading was taken as 100 per cent reflected radiation. Subsequently the GTR readings were noted down for each band on different target areas like soil, vegetation *etc.* and calculation was made as the percentage with respect to the 100 per cent reading obtained from the GTR calibration plate (Sheng et al 2010). For better accuracy several readings were taken and calculated as average reading. While taking readings, sun should not be directly above the object as in mid noon. Care was taken to record the reading before noon or after noon and also readings were not taken when the sun is obstructed by clouds. Plate 1 depicts the view of observation taken using the GTR.

The per cent reflectance was calculated using following formula:

$$\text{Per cent reflectance} = \frac{\text{Reflectance of physical feature}}{\text{Reflectance of Barium Sulphate coated plate}} \times 100$$

Software used: a) Arc GIS verxxx b) ERDAS Imagine c) QGIS

Topographical maps: The Survey of India (SOI) topo-sheets E43W10, E43W14 and E43W15 on 1:50,000 scale covering D-7 distributory of SBC command were used as reference maps for geo-referencing of the remote sensing maps and demarcating the study area, drainage system, village boundaries, road network and to collect ground control points (GCP) in the study area.

Canal networks: The canal map was collected from Krishnapur office division of KBJNL which looks after the distributory. This map was used as a reference map for digitization of distributory and its laterals after scanning; Details of Shahapur branch canal is presented in Table 1 and details of laterals and villages under D-7 distributory is presented in Table 2 and Figure 2. View of Shahapur branch canal and view of D-7 distributory branched from SBC are depicted in Plate 2 and 3 respectively.

RESULTS AND DISCUSSION

Land use and land cover classification: The land use/land cover (LU/LC) classification was carried out using

Table 2. Details of laterals and villages under D-7 disributory

Village name	Lateral number
Hoskera	L1
Ganganal	L2, L3
Dhariyapur	L2, L4
MahalRoza	L4, L5, L24
Sagar	L4, L6, L7, L8
Sharadahalli	L8, L9, L10
Mandagalli	L12
Bijaspur	L13, L14, L15
Shakhapur	L11
Katamanahalli	L12
Parsapur	L16, L17
Beernur	L16
Hemanoor	L11, L17, L18, L19, L20, L22
Markal	L21, L22, L23
Shettikera	L3, L4, L24, L25
Badyapur	L24
Bahiramaraddi	L25
Rattal	L26
Devikera	L26, L27, L28
Arkerakhalsa	L11, L29, L30

Table 1. Details of Shahapur branch canal

Number	Particulars	Details	
1	Location		
	Latitude	16°39'46" N	
	Longitude	76°32' 10" E	
2	Off-take	At km76.11 of. Narayanapur Left Bank Canal	
3	No of distributaries	34	
4	Length (km)	76.00	
5	No of structures	CD works	50
		Bridges	33
		Cross regulators	2
		Head regulators	27
6	Length of distribution network (km)	1126.89	
7	Command area (Ha)	1,22,120	
8	Water utilization (TMC)	34.00	
9	District/Taluks benefitted	Yadgir/ Shahapur/Surpur	
10	Hydraulic particulars	At offtake	
	a. Bed width (m)	6.10	
	b. Full supply depth (m)	4.60	
	c. Free board (m)	0.9	
	d. Bed fall	1:6400	
	e. Canal inner slope	2:1 in banks	
	f. Side lining in cutting reaches	CC	
	g. Side lining in embankment reaches	CC	
	h. Outer slope of embankment reaches	1.5:1	
	i. Top width of bank on SR side (m)	6.1	
	j. Top width of bank on IP side (m)	3.05	

unsupervised and supervised classification. Interactive Self-Organizing Data Analysis (ISODATA) Technique for unsupervised classification was also followed.

Unsupervised classification: For LU/LC classification, the ERDAS Imagine classifier module has been used. In ERDAS, unsupervised classification, the user input the number of clusters desired and a confidence threshold (usually 0.95). The computer will then build clusters iteratively, with each new iteration, the clusters become more and more refined. The iteration stops when the confidences level is reached. After the clusters are built, the analyst must select the land cover classes and then assign each cluster to appropriate class. In this study, unsupervised classification with 30 clusters for images of November-2015, May-2016, November-2016 and May-2017 and 95 per cent confidences threshold has been performed. The result was image with groups of pixels each represented by a different colour. Now we have to highlight each cluster one at a time and then determine which of the class belongs to, by interpreting the original multispectral image. Then each cluster colour has to be changed to appropriate one. Finally the image was recorded into the number of class (Fig. 3). The abstract of the area occupied by different classes for the pre and post monsoon are presented in Table 3 to 4, respectively. The total numbers of classes were eight and among these classes

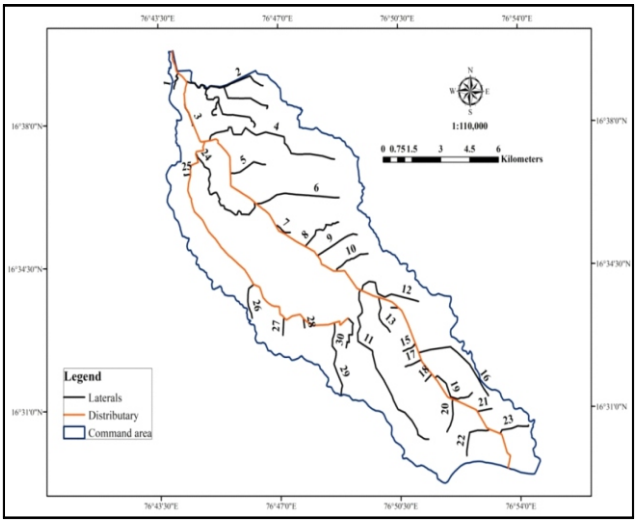

Fig. 2. Details of laterals under D-7 distributary

Table 3. Comparison of unsupervised classification for November-2015 and November-2016

Land cover	November 2015		November 2016		Change of percentage
	Area (ha)	Percentage of area (%)	Area (ha)	Percentage of area (%)	
Crop land	2551.77	16.31	3700.53	23.65	45.02
Fallow land	2531.25	16.18	1524.24	9.74	-39.78
Rockout crop	1897.74	12.13	2065.95	13.20	8.86
Salt affected area	1567.44	10.02	1232.91	7.88	-21.34
Settlements	2082.24	13.31	2196.18	14.04	5.47
Vegetation	2333.79	14.91	2511.54	16.05	7.62
Water body	649.98	4.15	713.07	4.56	9.71
Waterlogged	2033.28	12.99	1703.07	10.88	-16.24
Total	15647.49	100	15647.49	100	

Plate 2. View of Shahapur branch canal

Plate 3. View of D-7 distributary branchedfrom SBC

cropped area was highest having total area of 2552.77 ha and minimum area was water body 649.98 ha which accounts for 16.31 and 4.15 per cent of the cultivable command area respectively. The pattern of white and light blue patches indicating salt and water logged areas which were distributed in entire command with no definite pattern. However, in the North-East and South-West portion especially at the middle of the command it can be seen that, lot much pixels were occupied in these colours. In all it was observed that salt affected and waterlogged area was 1567.44 ha and 2033.28 ha which accounts for 10.02 and 12.99 per cent of the cultivable command area respectively.

The comparison of unsupervised classification for November 2015 and 2016 total number of classes were eight (Table 3). Among these classes cropped area was highest having total area of 2552.77 and 3700.53 ha and minimum area was water body 649.98 and 713.07 ha which accounts for 16.31, 23.65 and 4.15, 4.56 per cent of the cultivable command area, respectively during November 2015 and 2016. It was also observed that salt affected area was 1567.44 and 1232.91 ha and waterlogged area was 2033.28 and 1703.07 ha which accounts for 10.02, 7.88 and 12.99, 10.88 per cent of the cultivable command area during November 2015 and 2016, respectively. The total number of classes were eight and among these classes cropped area was highest having total area of 2369.07 (May 2016) and 3700.53 ha (May 2017) and minimum area was water body (1367.46 and 765.99 ha) which accounts for 15.14, 11.47 and 8.74, 4.90 per cent of the cultivable command area respectively during May 2016 and 2017 (Table 3). The salt affected area was 1558.53 and 1595.52 ha and waterlogged area was 2026.89 and 1149.66 ha which accounts for 9.96, 10.20 and 12.95, 7.35 per cent of the cultivable command area, respectively during May 2016 and 2017.

Supervised classification: From Figures 4 and 5 (November 2015) the total number of classes were eight and among these cropped area was highest having (6460.62 ha) and minimum area was water body (146.75 ha). During the same period the salt affected and waterlogged areas were 1797.03 ha and 1441.98 ha. During May 2016 (Fig. 6, 7) the eight different classes were present and among them fallow land area is highest at 4982.67 ha and minimum area was waterlogged 52.87 ha The salt affected and waterlogged area was 3486.96 ha and 52.87 ha, respectively. On an average, the salt affected area is more concentrated in the tail reach of the study area. Supervised classified image indicate that there is an increase in crop land area and slight decrease in water body, with an area of 8261.55 ha, and

Table 4. Comparison of unsupervised classification for May-2016 and May-2017

Land cover	May 2016		May 2017		Change percentage
	Area (ha)	Percentage of area (%)	Area (ha)	Percentage of area (%)	
Crop land	2369.07	15.14	1795.05	11.47	-24.23
Fallow land	2388.87	15.27	4706.19	30.08	97.00
Rockout crop	2325.69	14.86	3075.66	19.66	32.25
Salt affected area	1558.53	9.96	1595.52	10.20	2.37
Settlements	1336.86	8.54	1990.08	12.72	48.86
Vegetation	2274.12	14.53	569.34	3.64	-74.96
Water body	1367.46	8.74	765.99	4.90	-43.98
Waterlogged	2026.89	12.95	1149.66	7.35	-43.28
Total	15647.49	100	15647.49	100	

Table 5. Comparison of supervised classification (November-2015 and November-2016)

LU/LC	November 2015		November 2016		Change percentage
	Area (ha)	Percentage of area (%)	Area (ha)	Percentage of area (%)	
Crop land	6460.62	41.28	8261.55	52.79	27.88
Fallow land	2151.54	13.75	153.54	0.98	-92.86
Rockout crop	1834.11	11.72	2125.89	13.58	15.91
Salt affected area	1797.03	11.48	1762.11	11.26	-1.94
Settlements	498.81	3.187	510.66	3.26	2.38
Vegetation	1316.61	8.41	1212.48	7.74	-7.91
Water body	146.79	0.93	131.49	0.84	-10.42
Waterlogged	1441.98	9.21	1489.77	9.52	3.31
Total	15647.49	100	15647.49	100	

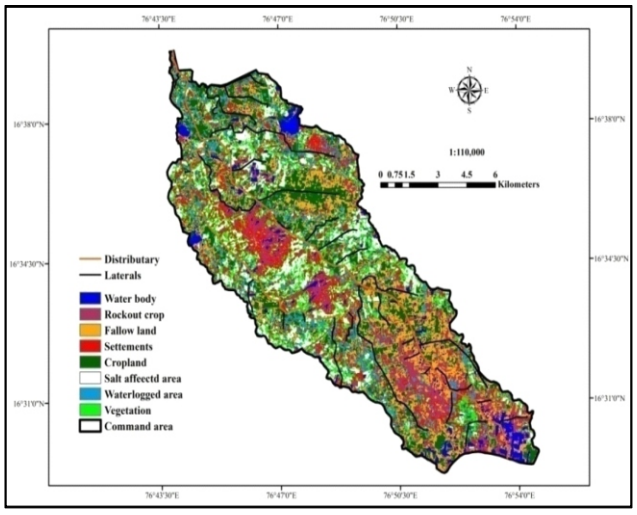

Fig. 3. Unsupervised classifications for November-2015 image

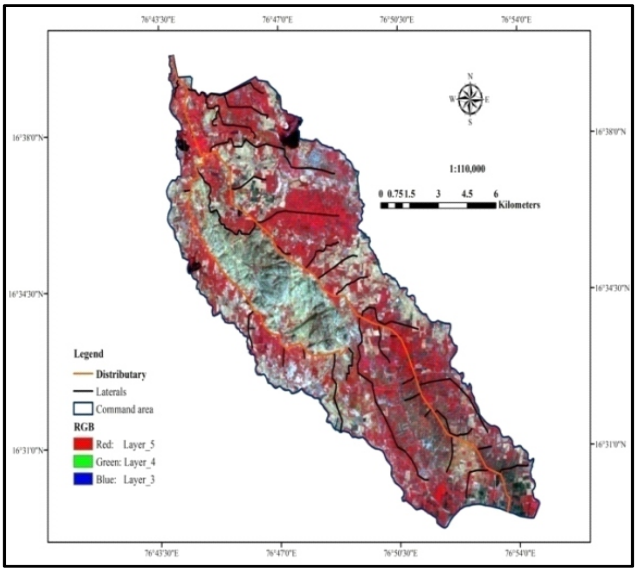

Fig. 4. False colour composite image of November 2015

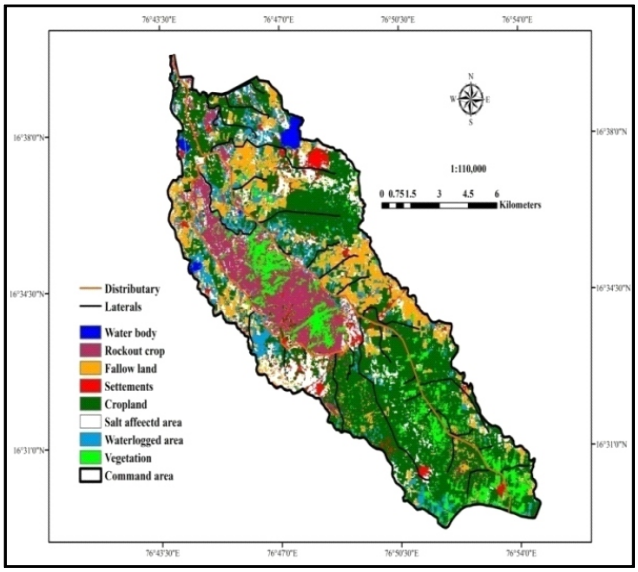

Fig. 5. Supervised classification image of November 2015

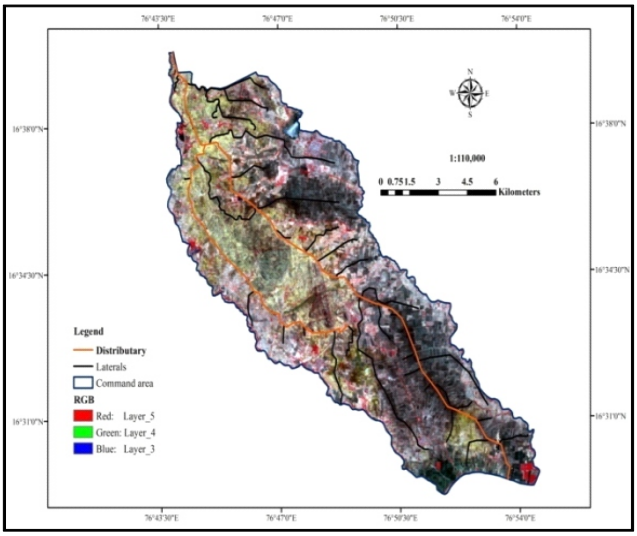

Fig. 6. False colour composite image of May 2016

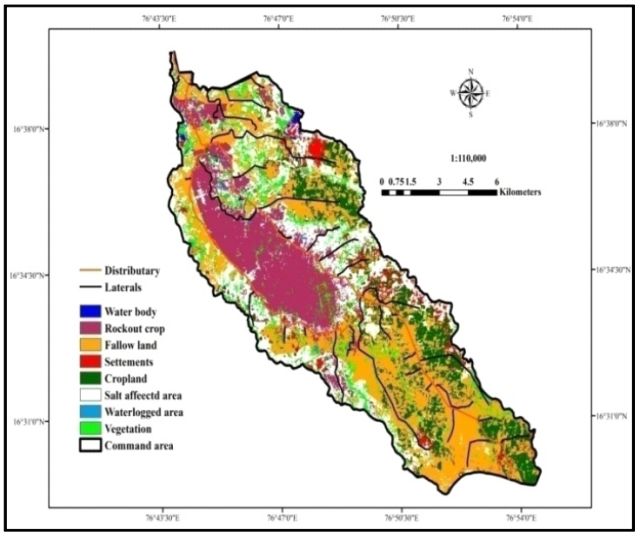

Fig. 7. Supervised classification image of May 2016

131.49 ha respectively (Fig. 8 and 9). From the classified image of May 2017, it was observed that there is an increase in fallow land and waterlogged as compared to May 2016, with an area of 5815.26 ha, and 53.46 ha (Fig. 10).

The comparison of supervised classification for November 2015 and November 2016 indicated that, the total number of classes were eight and among these classes cropped area was highest having total area of 6460.62 and 8261.55 ha and minimum area was water body 146.79 and 131.49 ha (Table 5). During the same period salt affected area was 1797.03 and 1762.11ha and waterlogged area was found 1441.98 and 1489.77 ha. Similarly, during May 2016 and total number of classes were eight and among these classes fallow land area was highest having total area of 4982.67 and 5815.26 ha (Table 6). The salt affected area was

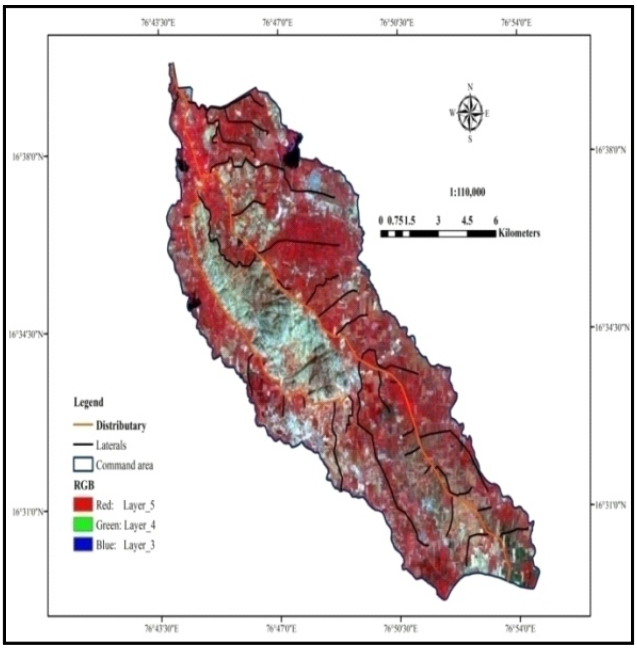

Fig. 8. False colour composite image of November 2016

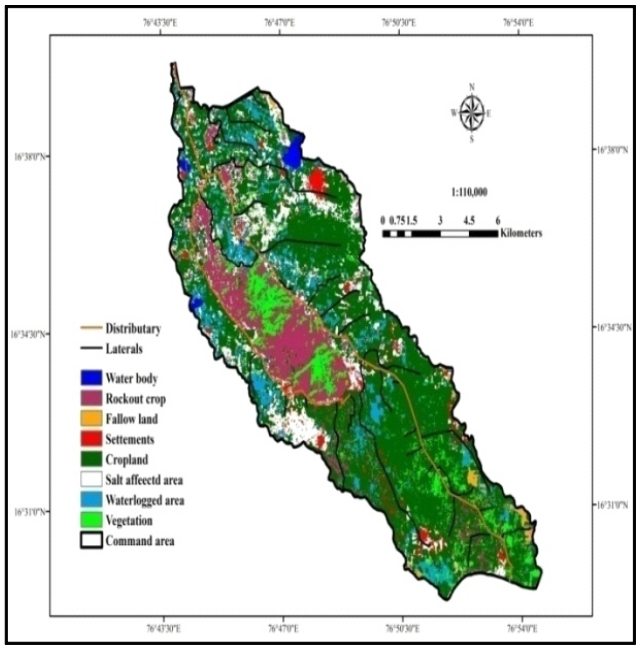

Fig. 9. Supervised classification image of November 2016

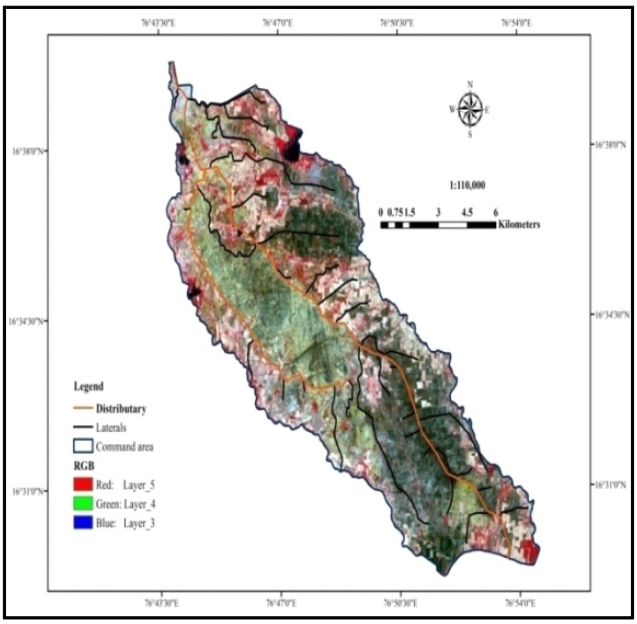

Fig. 10. False colour composite image of May 2017

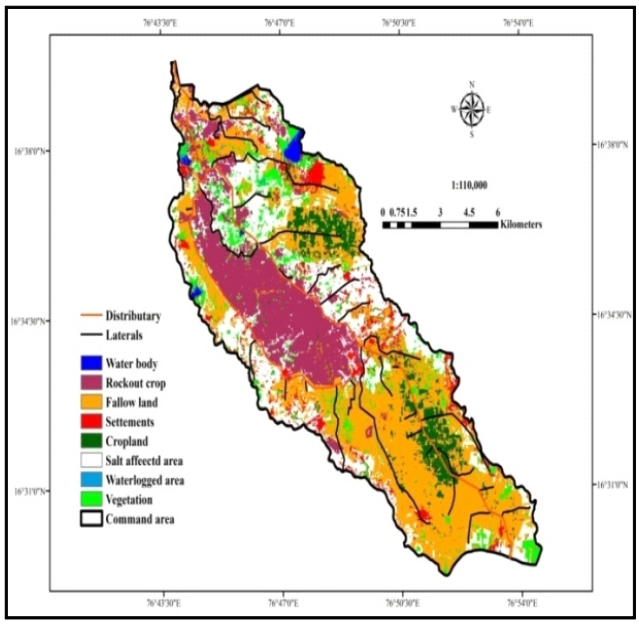

Fig. 11. Supervised classification image of May 2017

3486.96 and 3602.86 ha and waterlogged area was 52.87 and 53.46 ha.

CONCLUSION

Initially a false colour composite (FCC) of bands 5, 4 and 3 was prepared and visualized for each of the images. Then, each individual band was visualised one by one while using the temporal satellite data of the same area and the images were registered to the base map. The map imported from ArcGIS was considered as the base map. For carrying out registration, ground control points (GCPs) like crossing of rivers, canals, sharp turns in the rivers, bridges, road/canal intersection were located on the images. A polynomial transformation of first order was performed and resembling was done using the nearest neighborhood interpolation method. In this manner, images were registered with respect to base map. After completing registration, different images were displayed one over the other to compare

Table 6. Comparison of supervised classification (May-2016 and May-2017)

LU/LC	May 2016		May 2017		Change percentage
	Area (ha)	Percentage of area (%)	Area (ha)	Percentage of area (%)	
Crop land	1936.72	12.37	1206.82	7.71	-37.69
Fallow land	4982.67	31.84	5815.26	37.16	16.71
Rockout crop	3119.13	19.93	3108.00	19.86	-0.36
Salt affected area	3486.96	22.28	3602.86	23.02	3.32
Settlements	530	3.38	538.00	3.438	1.51
Vegetation	1444.14	9.22	1230.39	7.86	-14.80
Water body	95.00	0.60	92.70	0.59	-2.42
Waterlogged	52.87	0.33	53.46	0.34	1.12
Total	15647.49	100.00	15647.49	100.00	

superimposition. Land use land cover classification was carried out by unsupervised and supervised classification. The accuracy assessments of both techniques were made through a confusion or error matrix.

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Tree-Based Classification of Mangrove Forest using Hyperspectral Remote Sensing Data

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Abstract: The present study involves in decision-tree techniques, and support vector machine method for identifying the mangrove in the Muthupet forest using hyperspectral data. Delineation of mangrove is a complex procedure which is quite effective when optimized band rationing procedure is applied. A new mangrove vegetation index is developed and incorporated as one of the criteria for decision tree classifier. 163 bands of calibrated hyperion data has been selected for main data processing among which only 32 and 37 exhibited a strong reflectance across the very near infrared narrow bands of hyperion sensor, and insisted the presence of entire mangrove feature. The water band index (mangrove canopy), which delineate the dense mangrove. On the performance of machine classifier, it was observed that decision tree classifier with proposed new mangrove vegetation index resolved the limitation that exists in classifying the class, which has similar spectral signature information.

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Keywords: Atmospherically resistant vegetation indices, Decision tree, Hyperion, Normalized difference vegetation index

Mangroves are salt-tolerant plants and spread in the inter-tidal region in the tropical and subtropical zone, and distributed over the east and the west coasts of India. It is the evergreen trees that distributed in the lagoons, estuaries, deltaic region, and coastal zone (Heumann et al 2011, Prasad et al 2015). The Remotely sensed images are useful for earth related problems such as environmental monitoring and modeling, the most natural resources mapping are carried out using remote sensing techniques such as soil mapping, mineral mapping, land use, and land cover mapping. A variety of methods were agility and deployed to mapping mangrove forests from remotely sensed images, which are visual to semi-automated, unsupervised, object, pixel and sub-pixel method (Heumann 2011, Akira et al 2003, Lee et al 2009, Kanniah et al 2015). When compared to multispectral remote sensing, a hyperspectral remote sensing system is unique in the large quantity of high spectral resolution data as it contains the spectrum of objects on the earth provide electromagnetic radiation across more than hundreds of bands. The conventional method of remote sensing classification algorithms which found in-effective to enhance the mangrove distribution since the land cover classes such as agricultural, forest, and other land covers have similar spectral signature information. In recent trends of image classification techniques, the decision tree an algorithm had been used effectively for various classification problems (Kandrika and Roy 2008, Kodikara et al 2011), and it has a significant compensation for remote sensing classification problems since of their flexibility and computational efficiency. Beltran and Belmonte (2001) have evaluated decision-tree criteria for multispectral Landsat TM images and obtained 90 per cent classification accuracy. Kodikara et al (2011) have classified the Hyperspectral data onto the evaporite minerals in Lake Magadi. They mapped the lithological of Lake Magadi area using decision tree method based on the spectral indices from the collected sample. McCauley and Goetz (2004) have derived the images such as NDVI, band ratio (B5/B1) for decision tree classifier. Pandi et al (2018) have assessed the net canopy photosynthetic rate and species diversity in Pichavaram mangrove forest, Tamil Nadu, which covered with *Avicennia marina* followed by *Rhizophora apiculata, Excoecaria agallocha* and *Rhizophora mucronata*. They used important value index (IVI) and its net canopy photosynthetic rate is estimated based on Normalised Difference Vegetation Index (NDVI)-Leaf Area Index (LAI). Telave et al (2016) have reported that ecological composition and distribution using quadrat method at fifteen sites in Rajpuri creek. total number of eight species were reported of which *Avicennia marina; Sonneratia alba, Rhizophora mucronata and Aegiceras corniculatum* are the dominant species. An attempt is made in the present study to produce mangrove maps and using ENVI 4.7 for the hyperion images using decision tree classification and support vector machines for the portion of Thiruvarur district, muthupet mangrove region, Tamilnadu.

MATERIAL AND METHODS

Description study area: The Muthupet mangrove forest, Tiruvarur District, Tamilnadu, India which located between 1022'33" N and 7929'33" E (Fig. 1) and covering a zone of

around 13,500 ha of which well-developed mangroves involve just 4 per cent. The streams such as Paminiyar, Koraiyar, Kilaithankiyar, Marakkakoraiyar and various streams of the waterway Cauvery flow-through Muthupet. It covers the lagoon, mudflat, creek, and other land covers. The lowermost of the lagoon is deposited of silty clay. The saltiness is the dominant ecological factor, controlling the zonation of the Muthupetmangrove forest. Mangrove species, namely *Avicennia marina* is dominant around 90 percent occupancies among other species. The Muthupet mangrove forest was affected by cyclone Gaja on 16 November 2018 and devastating the mangrove and other vegetations.

Pre processing of hyperion data: Pre-processing steps of hyperion sensor can be mentioned as in various steps such as spatial subset, a subset of the spectral and bad band from hyperion data. The various pre-processing steps which includes bad band removal, vertical destriping followed by the atmospheric corrections.

Bad bands removal: The Hyperion level 1G data has 242 bands, in which only 198 are non-zero due to the low response of the detector (Tsai and Chen, 2008). Thus out of 242 bands, only 198 bands require calibration. The Hyperion data is therefore processed with the calibrated 198 non-zero bands (bands 1 to7 and 225 to 242 intentionally removed for mangrove species matching (Apan et al 2004, Padma and Sanjeevi 2014). Despite hyperion has198 non-zero bands, 162 number of bands are selected for main data processing due to poor response from the detector of sensor and atmospheric effects (Table 1). The band selection can be carried out using the fundamental tool in ENVI 4.7 –Resize the data.

Vertical destriping: The bad columns found in band number 8 and 9 can be removed by taking the average of the adjacent pixels,either with a 4-pixel average (the average of the four nearest neighbors) or with an 8-pixel average (the average of the eight nearest neighbors).This can be performed using the pixel editor tool of the image window in ENVI module (Fig. 2).

DN to radiometric calibration: Since the Fast line of sight atmospheric analysis of hypercube (FLAASH) module can accept the radiance image data, the conversion to the DN values of radiance values is mandatory. Two scaling factors are required for the VNIR and SWIR bands (Ganesh et al 2012, Meera Mohan and Geetha 2015). The radiance image can be obtained from the radiometric calibration tools of ENVI 4.7

Atmospheric correction: The electromagnetic signals measured by the spaceborne or airborne hyperspectral sensors are a combination of the signals from earth's surface, atmospheric constituents, and sensor errors(Alex, 2012; Tong et al 2014). Therefore, for quantitative analysis of the earth's reflectance, the error due to the atmospheric effects have to be removed from the acquired image (Fig. 3).

Computation of vegetation indices: Three vegetation indices and new mangrove index were used for delineating the mangrove forest using Hyperspectral data of remote sensing. The vegetation indices and band ratio, which was applied on Hyperion reflectance images as follows.

- Normalized difference vegetation index (NDVI)-Gago et al (2015)
- Atmospherically resistant vegetation index (ARVI)-Kaufman and Tanre (1996)
- Water band index (canopy)-Penuelas et al (1995).
- New-Mangrove vegetation Band Index - Present study

Normalized difference vegetation indices (NDVI): The normalized difference vegetation index (NDVI) incorporated as one of the essential criteria for representing vegetation. NDVI which was computed from Reflectance at a wavelength of 760 nm and reflectance at the wavelength of 708 nm respectively (Eq. 1).

$$NDVI = \frac{(R760 - R708)}{(R760 + R708)} \qquad (1)$$

Table 1. Accuracy assessment for decision tree classification and support vector machine

Classes	Decision tree algorithm					Support vector machine				
	Dense mangrove	(%)	Sparse mangrove	(%)	Total	Dense mangrove	(%)	Sparse mangrove	(%)	Total
Un classified	0	0	0	0	0	0	0	0	0	0
Dense mangrove	8132	95.01	210	11.60	8342	8667	96.01	350	10.23	9017
Sparse mangrove	342	4.03	1600	88.39	1942	360	3.98	3071	89.76	3431
Total	8474	100	1810	100	10284	9027	100	3421	100	12448
Classes	Producer accuracy (%)		User accuracy (%)			Producer accuracy (%)		User accuracy (%)		
Dense mangrove	95.9		97.4			96.01		96.11		
Sparse mangrove	88.3		82.3			89.7		89.50		

Atmospherically resistant vegetation indices (ARVI): The ARVI is modification of NDVI, which is resistant to atmospheric scattering. It is most suitable for tropical regions. ARVI was computed using the vegetation Index Calculator under the vegetation analysis tool in ENVI using Eq. 2 (Kaufman and Tanre 1996).

Where RB = R – γ (B-R), and γ are based on the aerosol type (γ = 1, when the aerosol model is not present), γ is (gamma value) a weighting function.

$$ARVI = \frac{(R705 - R580)}{(R705 + R708)} \quad (2)$$

Water band index: Water band index is used to assess the canopy status of mangrove; higher values of water band index are indicated good health condition, since water content of mangrove canopies increases, the strength of the absorption around 970 nm increases relative to that of 900 nm. The minimum and maximum values of water band index values are 0 and 3. The hyperion reflectance at 900 nm and 970mm are used in this study to get the water band index image (Eq. 3).

$$Water\ band\ index = \frac{R900}{R970} \quad (3)$$

New-mangrove vegetation band index: This present study aimed to delineate the mangrove forest by pure ratios, the band numbers 37 and Band 32 is used for the study, and it is optimized band ratio to delineate the entire mangrove from the study area, reflectance at the wavelength of 721.90 nm, and reflectance of 671.02 nm are selected for computation of mangrove (Eq. 4).

$$Magrove\ band\ index = \frac{R721.90}{R671.02} \quad (4)$$

Decision tree algorithm*:* The Decision tree algorithm is proposed to overcome the constraint of commonly used classification techniques such as Maximum likelihood, parallel piped classifier, and support vector machines. It is a multistage decision approach by classifying an unknown sample of a class using more than one decision functions of a consecutive manner. The tree provides a root node and a group of internal nodes (splits) and a set of terminal nodes (leaves). The root node and internal nodes are non-terminal nodes, which linked to decision stages, whereas the terminal nodes indicate the final classification (Fig. 5). The input parameters are fed into a decision tree approach and made desired rules to delineate the mangrove forest

Support vector machine: The support vector machine (SVM provides better classification results from complex data. The optimal hyper-plane separates the classes and maximizes the margin of the classes. The SVM classification has been executed by ENVI package with Radial basis function (RBF) kernel type performed well in most cases. The default parameters such as gamma, penalty parameter have been assigned as 0.091, and 100 respectively. The penalty parameter is mainly involved in non-separable classes (Eq. 5)

$$K(xi,xj) = \exp(-g||xi - xj||2), g > 0 \quad (5)$$

Where g is the user-defined gamma.

Accuracy assessment: The accuracy assessment of decision tree, and support vector machine was determined by object level using a confusion matrix. Moreover, the producer's and user's accuracy was computed for sparse and dense mangrove.

RESULTS AND DISCUSSION

The 163 bands of hyperion sensor can be used for data main processing since it contains inherit information across the electromagnetic spectrum. VNIR Band 37 and 32 provided the more information since it is sensitive to the vegetations studies. Those bands 37 and 32 have not been affected by severe noise and detectors errors. Vertical destriped images which retrieved the information causes improved the image classification accuracy substantially. The FLAASH based atmospheric corrected image (Fig. 3) which exhibit strong absolute reflectance as it removes the water absorption bands and other atmospheric effect effectively across electromagnetic spectrum. It is also observed that FLAASH module was a best alternative tool among atmospheric correction tools that has been used for hyper-spectral remote sensing approach, and it is being removed the scattering effects while radiation interacts in upper atmosphere with molecules, dust particles. The typical spectral signature for mangrove can be obtained. The typical reflectance data has been grounded for various vegetation indices generation. NDVI image was generated which delineated the entire vegetation features. The wavelength 760 nm and 708 nm were measured small difference from the reflectance over vegetation features. Water band index for canopy over mangrove can be quantified through wavelength such as 900nm and 970nm respectively. The maximum value of the water band index is 3. Higher value of water band index indicates that dense mangrove where as small value of water band index indicates that sparse mangrove. ARVI is another vegetation index which is generated from the combination of the reflectance in the blue and red band respectively, and the maximum value of ARVI was 0.6. The optimised bands such as band 37 (721.9 nm) and band 32 (671.0 nm) were used for mangrove vegetation index. The ratio of band 37 and band 32, strongly delineated the entire mangrove rather than any other band ratio. Five major LULC classes dense mangrove, sparse mangrove,

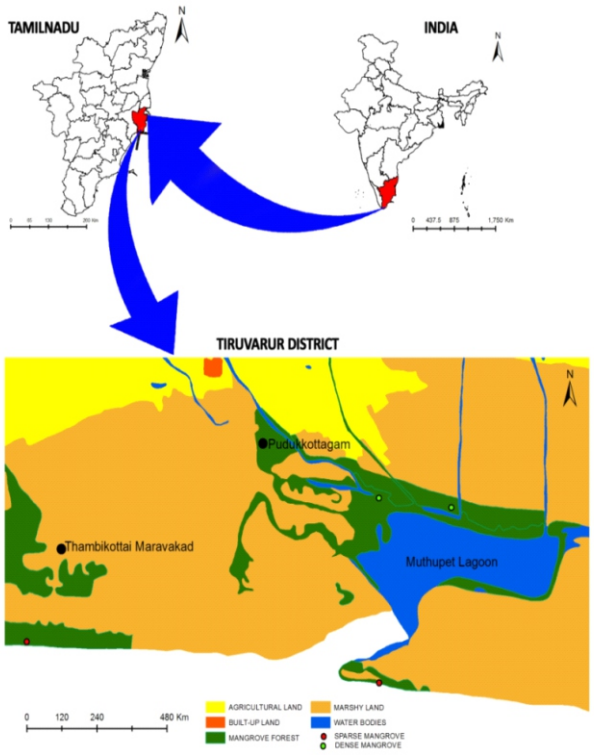

Fig. 1. Geographic location of the study area along with the sampling points in Muthupet Lagoon, Tiruvarur District, Tamilnadu, India

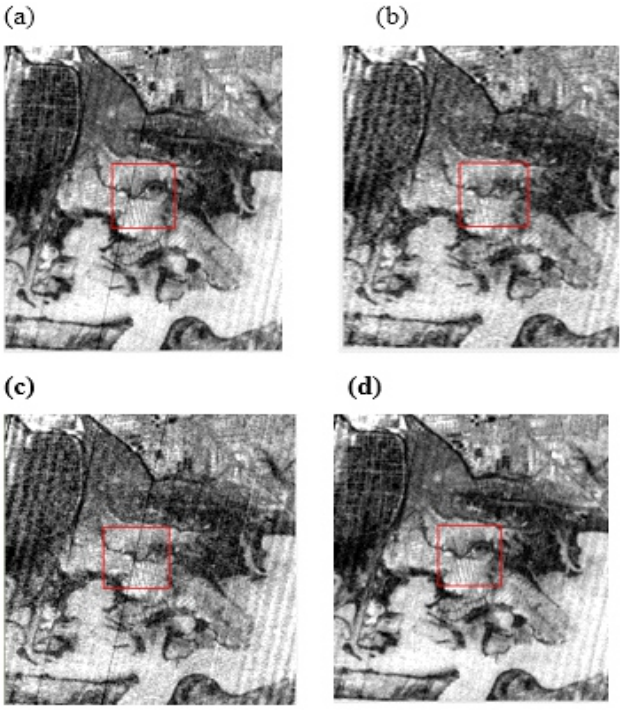

Fig. 2. Greyscale imagery (a) Bad column present at band 8 (b) After removing bad column of band 8 (c) Bad column present at band 9 (d) After removing bad column of band 9

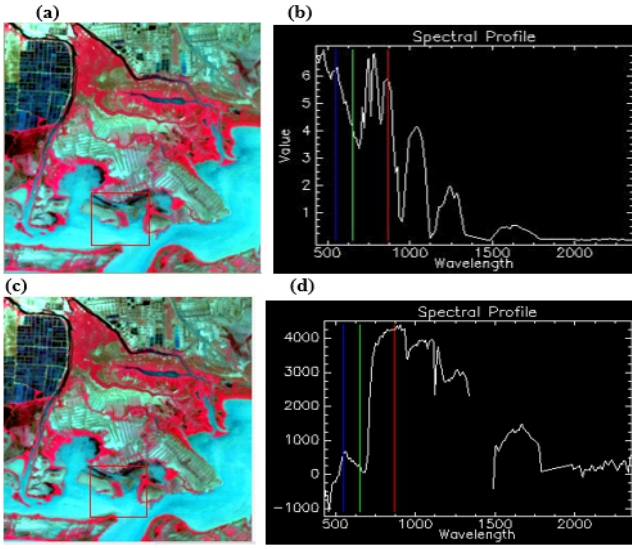

Fig. 3a,b. Before atmospheric correction (Radiance image and Spectral profile) (c,d) After atmospheric correction (Reflectance image and Spectral profile

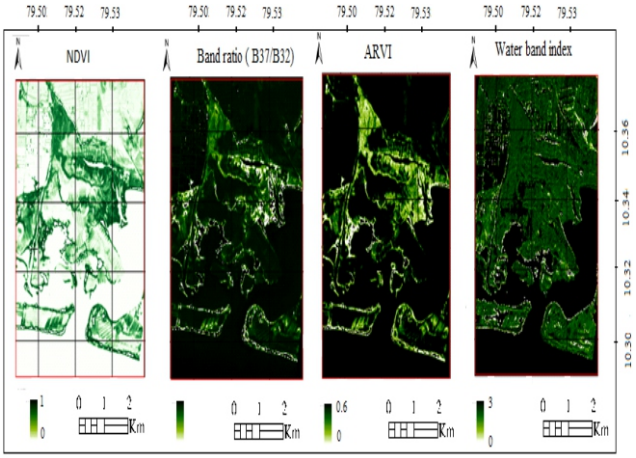

Fig. 4. Image of the vegetation indices NDVI (Normalised vegetation Index) Band ratio (B37/B32) ARVI (Atmospherically resistant vegetation index) Water band Index (Canopy)

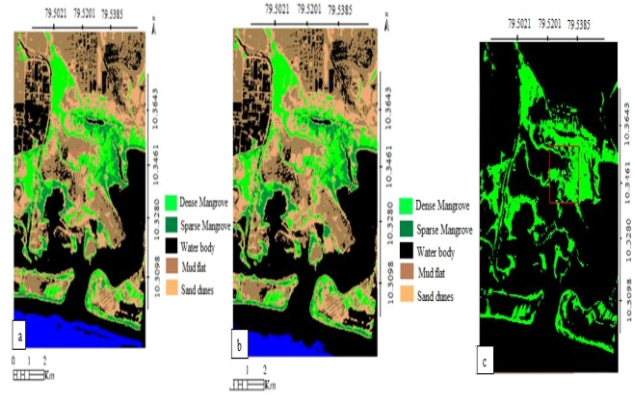

Fig. 6a. SVM Classification (b) Decision tree classification (c) Mangrove vegetation index

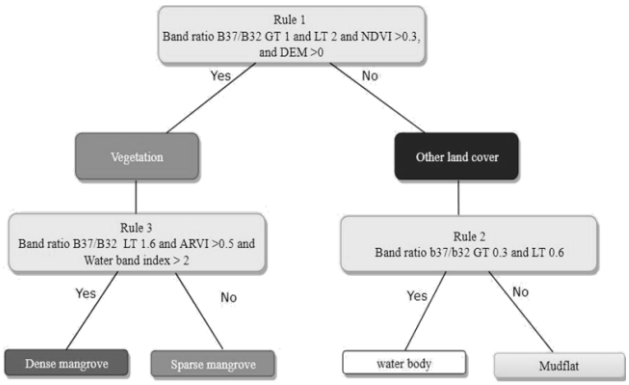

Fig. 5. Flow chart for decision tree algorithm

water body, mudflat and sand dunes were identified. The decision tree is performed for the entire vegetation indices created from the hyperion data, the classification performed based on four rules were implemented and it is adequate to delineate the sparse and dense mangrove, and other land cover. Rules 1: New-mangrove vegetation index greater than 1 and less than 2 and NDVI 0.3 and DEM greater than zero, then the area has vegetation, otherwise other land cover classes. Rules 2: New-mangrove vegetation index higher than 0.3 and less than 0.6 then the area has non-mangrove (Other land covers).Rules 3: New-mangrove vegetation index less than 1.6 and ARVI greater than 0.5, and water band index higher than 2, and then the area has dense mangrove. Finally decision tree classified map have been developed for the hyperion data (Fig. 6b) which depicts that the green colour shows the mangrove forest. After decision tree classification the classified image is analysed by comparing the features with ground data manually, which depicts DT classified results provided better classification accuracy. The accuracy assessment for the classified image (Table 1) shows the producer and user accuracy of decision classifier for dense and sparse mangrove are 96 percent, 97.4 percent, 88.3, and 82.3 per cent respectively. Similarly producer accuracy and user accuracy for support vector machine was obtained for dense and sparse mangrove are 96.01 per cent, 96.11 per cent, 89.7 per cent and 89.50 per cent respectively. In summary, our work demonstrates the advancement of Decision tree classification for the mangrove mapping from hyper-spectral satellite images. It indicates that unique DT approach by partitioning datasets as a function of various vegetation indices with different boundary condition, Finally, DT methods are simple, fast and insensitive to the noise in the input dataset. Therefore, Decision tree systems are predominantly useful in mapping of mangrove variations.

CONCLUSIONS

In this research work, the decision tree algorithm with supporting of normalised vegetation index, atmospherically resistant index, water band index, and new mangrove vegetation index resolved the limitation that exists in classifying the class which has similar spectral signature information. Delineation of dense and sparse mangrove is a complex procedure with quite effective when optimized band rationing and water band index applied. Among 163 calibrated Hyperion bands, only bands 32 and 37 provided the strong absolute reflectance, insisting the presence of entire mangrove feature. The new mangrove vegetation index discriminating the mangrove class from over other land covers, providing higher classification with more than 90 percent accuracy.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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Land Degradation Index using Salinity Index by GIS-MCDM Method in Al-Hashimiya Irrigation Project in Babil Province, Iraq

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Abstract: Al-Hashimiyah irrigation project was chosen within the Iraqi sedimentary plain in Babil province, south of Baghdad city with an estimated area of 42284 ha , because of its geomorphological and physiographical diversity, as well as the lands are affected by various manifestations of degradation. Soil data of salinity was used. TOPSIS method was tested, to make a decision and multi-standard integration with geographic information systems (GIS-MCDM) was used in the calculation of the land degradation index using the salinity index. The results showed that the guide to land degradation according to TOPSIS method was efficient and appropriate and ranged between 0-1, The calculations indicated a significant correlation with the salinity index. The GIS-MCDM method has demonstrated the effectiveness, flexibility and efficiency in the calculations of land degradation index using salinity factor.

Keywords: GIS-MCDM, Al-Hashimiya, Land degradation, Salinity factor

The phenomenon of desertification in the Iraqi environment was not recent, as historical codes indicate the aggravation in large parts of the Iraqi sedimentary plain, resulting mainly from the salinity of the soil, which led to the affected lands become desolate and unproductive agricultural. At present, decades of weak governance, constraints and political problems have made large swathes of the sedimentary plain vulnerable, at a time when Iraq needs more than 3 billion US dollars annually to secure basic food raw materials during the next decade in the event of continued activity of land degradation, Studies indicate that 60% of the Iraqi sedimentary plain suffers from serious problems of salt accumulation and creeping sand dunes, especially in the western and eastern parts thereof, which has a direct negative effect on agricultural productivity (Muhaimeed 2016). To study the state of land degradation in accordance with a comprehensive scientific vision, it is necessary to follow methods based on scientific basis for the optimal use of natural resources of land and water (Al Shafie 2010). The process of collecting information and data on these resources is one of the methods used in a number of international studies and systems aimed at strengthening the planning and agricultural development decisions of any country. This process requires the integration of information and data from several sources and using efficient and effective means and tools in building a solid database structure, be ready and available, including GIS and remote sensing as well as the integration of multiple-criteria decision-making (MCDM) and GIS, collectively referred to as GIS-MCDM, GIS is a powerful, useful and unique tool for storing, processing, analyzing and visualizing spatial data for decision making. MCDM provides a rich set of procedures and algorithms to evaluate and prioritize decision alternatives (Afshari and Yusuff 2012), as well as the synergistic relationship between GIS and MCDM in theoretical and applied research (Malczewski 2006). Spher and Zucca (2012) showed in a study conducted in Brazil and Mozambique, the MCDM methods are a set of a comprehensive set of physical, chemical, biological and human factors indicators must be available when assessing the state of land degradation. The MCDM includes a set of secondary methods to compare and select an alternative from a range of available alternatives; Technique for order preference by similarity to ideal solution (TOPSIS) is one of these methods, a multi-standard method of identification "The TOPSIS is a cost-effective and flexible tool that provides a tool for identifying, defining, and weighing the indicators used. It can be a valuable way to address the complexities of land management and control, and its main advantages are that it is easy to use and takes into account all types The standards and its arithmetic operations are sequential, Therefore, this study was designed to study the state of land degradation by using the salinity index according to the GIS-MCDM method of calculating the land degradation index.

MATERIAL AND METHODS

Study area: The project of Al-Hashimiyah irrigation in the province of Babil was chosen as a study area due to its geomorphological and physiographical characteristics, as

well as its agricultural exploitation and the existence of a previous report of semi-detailed soil surveys of the study area (Ministry of water resources et al 2012). The project is located within coordinates (470371 3590807 and 496111 3574379) and a total area of 42284 ha as showed in the project's site map (Fig. 1 and Table 1).

Spatial data input: Data and information available in paper maps were introduced in the ArcGIS9.x program using the scanner and File.tif in the form of images. The maps included the soil units and the sites of the soil biomes. The UTM WGS84 Datum was assigned within the N38 range, Map of 10 ground control points (GCPs) for accuracy.

Quantitative data input: The data and table data containing the spatial data characteristics of the physical and chemical analysis of the study teddy bears were entered manually using the MS Excel program and converted to a database so that they could be linked later to the soil units and units plan with the characteristics and soil characteristics required in the production of final maps, the soil salinity data were used in these calculations.

Maps numbering: At this stage, mapping and positioning of soil pedons and transforming them into digital maps (file. shp) were carried out with two types of features available in these programs: Point features, which represent the map of soil pedon and polygon features, which represents the map of soils units.

Process of linking geo-tabular data: At this stage, the attribute tables, representing the map of the distribution of soil units and Pedon sites with spatial data, are carried out to obtain integrated geo-maps for soil surveys ready to conduct spatial processes for the production of the Land degradation Index.

Land degradation index calculation: TOPSIS approach was proposed by Hwang and Yoon (1981), and is one of the MCDM, a technique of Order Preference by Similarity to Ideal Solution), which is abbreviated TOPSIS and collectively referred to as GIS-MCDM when integrated with GIS. This method involves calculating the land degradation index by using the salinity index, which was divided into several varieties under different tradeoffs to measure the positive or negative state of each indicator. The soil degradation index was classified into six classes on each soil unit in the study area. According to method of Withers and Vipond (1974) and Bennett (2008) as shown in Table 2. After obtaining grade values for the salinity index for each soil unit, the following steps are taken in calculating the land degradation index in the study area.

Construction of the index rank matrix for soil units: The salinity index rank (one indicator in this case) was used to construct the matrix required to calculate the final LDI guide.

$$D= \begin{matrix} A1 \\ A2 \\ . \\ . \\ An \end{matrix} \begin{bmatrix} f11 & f12 & ... & f1n \\ f21 & f22 & ... & f2n \\ . & . & ... & . \\ . & . & ... & . \\ fm1 & fm2 & ... & fmn \end{bmatrix} \quad ....(1)$$

As: D: final degradation index, A: Soil units, n represents the number of soil units. fn: salinity index, fm: number of items index. fmn: class index of the soil unit.

Calculate the natural resolution matrix (r).

$$rij = \frac{fij}{\sqrt{\sum_{j=1}^{n} f_{ij}^2}} .....(2)$$

As: f: Indicator i for each soil unit (one indicator in this case), n: Number of soil units.

Determining and calculating positive optimal state (D-i ^ +) and negative (D-i ^ -):

$$D_i^+ = \sqrt{\sum_{i=1}^{n} (V_{ij} - v_j^+)^2} .....(3)$$

$$D_i^- = \sqrt{\sum_{i=1}^{n} (V_{ij} - v_j^-)^2} .....(4)$$

Final land degradation index: LDI values calculated according to equation (5) are limited to (0-1). The minimum values represent the land that is not affected by low degrees of degradation, and the lands affected by higher degrees of degradation are represented by the higher values of this guide. The degree of land degradation is directly proportional to the value of this guide.

$$LDI = \frac{D_i^-}{D_i^+ + D_i^-} .....(5)$$

D_i^+ positive state indicating land degradation per soil

D_i^- negative state indicating land degradation per unit of soil

V_{ij} weight of the matrix (for soil unit)

V_j^+ highest weight of the matrix (for soil unit)

V_j^- least weight of the matrix (for soil unit)

Classification of land degradation: LDI scores are classified into four proposed by Al Shafie (2018) (Table 3).

RESULTS AND DISCUSSION

The land degradation index according to the TOPSIS method ranged between 0 and 1 in the soil units, refers to the class Non or slightly degraded and occupied an area of 4582.25ha (10.83%) (Table 3 and Fig. 2). The value of deterioration index (0.25), refers to the class moderately degraded occupied an area of 9016.2 ha (21.32%) and the value of deterioration (0.5) which refer to the class degraded occupied an area of 23633.7 ha (55.89%) and the value of

Table 1. Chemical and physicals properties of the study area

ID	Soil_Unit	Sand	Silt	Clay	Soil_tex	Water table	pH_	ECe	Lime	Gypsum	ESP
1	TSdnp62	6	56	38	SicL	50 cm	7.90	40.92	24.93	1.82	37.22
2	Vtfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
3	Vtfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
4	TTda63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
5	TTma62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
6	TTda63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
7	TSmp61	31	26	43	Sic	400 cm	8.22	33.20	19.68	4.44	15.35
8	TSdnp62	6	56	38	SicL	50 cm	7.90	40.92	24.93	1.82	37.22
9	TTda62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
10	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
11	TTda63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
12	TTmn63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
13	TTda62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
14	TSmn61	31	26	43	Sic	400 cm	8.22	33.20	19.68	4.44	15.35
15	TSdnp62	6	56	38	SicL	50 cm	7.90	40.92	24.93	1.82	37.22
16	TTda62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
17	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
18	TSdnp63	7	66	27	SicL	350 cm	7.25	33.35	29.35	2.35	61.45
19	VTfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
20	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
21	TSdnp62	6	56	38	SicL	50 cm	7.90	40.92	24.93	1.82	37.22
22	TTdn63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
23	TSdn63	7	66	27	SicL	350 cm	7.25	33.35	29.35	2.35	61.45
24	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
25	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
26	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
27	VTfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
28	TTdn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
29	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
30	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
31	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
32	VTfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
33	TTda62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
34	VTfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
35	TSdnp62	6	56	38	SicL	50 cm	7.90	40.92	24.93	1.82	37.22
36	TTda63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
37	TSdnp62	6	56	38	SicL	50 cm	7.90	40.92	24.93	1.82	37.22
38	TSdn63	7	66	27	SicL	350 cm	7.25	33.35	29.35	2.35	61.45
39	TSdnp62	6	56	38	SicL	50 cm	7.90	40.92	24.93	1.82	37.22
40	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
41	TTda62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
42	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
43	TTda62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55

Cont...

ID	Soil_Unit	Sand	Silt	Clay	Soil_tex	Water table	pH_	ECe	Lime	Gypsum	ESP
44	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
45	VTmap61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
46	TTda63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
47	Ttda63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
48	TSdnp62	6	56	38	SicL	50 cm	7.90	40.92	24.93	1.82	37.22
49	VTmap61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
50	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
51	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
52	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
53	VTmap61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
54	TTda63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
55	VTfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
56	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
57	VTfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
58	TSmnp61	31	26	43	Sic	400 cm	8.22	33.20	19.68	4.44	15.35
59	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
60	TTda63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
61	TSdnp62	6	56	38	SicL	50 cm	7.90	40.92	24.93	1.82	37.22
62	VTfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
63	VTmap61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
64	VTfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
65	TTda62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
66	TSdn63	7	66	27	SicL	350 cm	7.25	33.35	29.35	2.35	61.45
67	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
68	VTfa61	17	50	33	SicL	347 cm	7.70	2.19	30.67	2.00	9.11
69	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
70	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
71	TTda63	12	72	16	SiL	130 cm	8.05	8.80	22.66	0.59	27.56
72	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
73	TTda62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
74	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55
75	TTmn62	5	64	31	SicL	160 cm	7.64	11.51	24.66	1.09	12.55

Table 2. Classes, description and degree of differentiation of soil salinity

Class	Description (dS m^{-1})	Grade of preference*
1	0-2	1
2	2-4	2
3	4-8	3
4	8-16	4
5	16-32	5
6	> 32	6

*Al Shafie (2018)

Table 3. Types, descriptions and range of land degradation by TOPSIS method (Al Shafie 2018)

Class	Descriptions	Range
1	Non or slightly degraded	< 0.25
2	Moderately degraded	0.25 – 0.5
3	Degraded	0.5 – 0.75
4	Highly degraded	> 0.75

deterioration (1) highly degraded) area of 5051.8 ha and 11.95 per cent of the total area of the study area. The results showed that 67.84 per cent of the study area was affected by deterioration and high deterioration due to high levels of salinity. This is due to the nature of agricultural practices that lack proper management and heavy Soil texture. The use of the TOPSIS method in producing soil index maps provides flexibility in the selection of indicators of degradation land degradation according to the environmental conditions and specificity of each study area, with the possibility of giving weight to any indicator according to its impact, importance or role in the land degradation processes.

CONCLUSIONS

The area of the study suffers from degradation due to high salinity. Three types of land degradation, characterized by low-degradation, degraded and highly degradation

Table 4. Soil map units and salinity values and a guide and types of land degradation

id	SMU	ECe (dS m^{-1})	LDI	Land degradation class
38	TSdn63	33.35	1	Highly degraded(> 0.75)
39	TSdnp62	40.92	1	Highly degraded(> 0.75)
40	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
41	TTda62	11.51	0.5	Moderately degraded(0.25-0.5)
42	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
43	TTda62	11.51	0.5	Moderately degraded(0.25-0.5)
44	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
45	VTmap61	2.19	0	Non or slightly degraded (< 0.25)
46	TTda63	8.80	0.25	Moderately degraded(0.25-0.5)
47	Ttda63	8.80	0.25	Moderately degraded(0.25-0.5)
48	TSdnp62	40.92	1	Highly degraded(> 0.75)
49	VTmap61	2.19	0	Non or slightly degraded (< 0.25)
50	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
51	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
52	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
53	VTmap61	2.19	0	Non or slightly degraded (< 0.25)
54	TTda63	8.8	0.25	Moderately degraded(0.25-0.5)
55	VTfa61	2.19	0	Non or slightly degraded (< 0.25)
56	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
57	VTfa61	2.19	0	Non or slightly degraded (< 0.25)
58	TSmnp61	33.2	1	Highly degraded(> 0.75)
59	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
60	TTda63	8.8	0.25	Moderately degraded(0.25-0.5)
61	TSdnp62	40.92	1	Highly degraded(> 0.75)
62	VTfa61	2.19	0	Non or slightly degraded (< 0.25)
63	VTmap61	2.19	0	Non or slightly degraded (< 0.25)
64	VTfa61	2.19	0	Non or slightly degraded (< 0.25)
65	TTda62	11.51	0.5	Moderately degraded(0.25-0.5)
66	TSdn63	33.35	1	Highly degraded(> 0.75)
67	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
68	VTfa61	2.19	0	Non or slightly degraded (< 0.25)
69	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
70	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
71	TTda63	8.8	0.25	Moderately degraded(0.25-0.5)
72	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
73	TTda62	11.51	0.5	Moderately degraded(0.25-0.5)
74	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)
75	TTmn62	11.51	0.5	Moderately degraded(0.25-0.5)

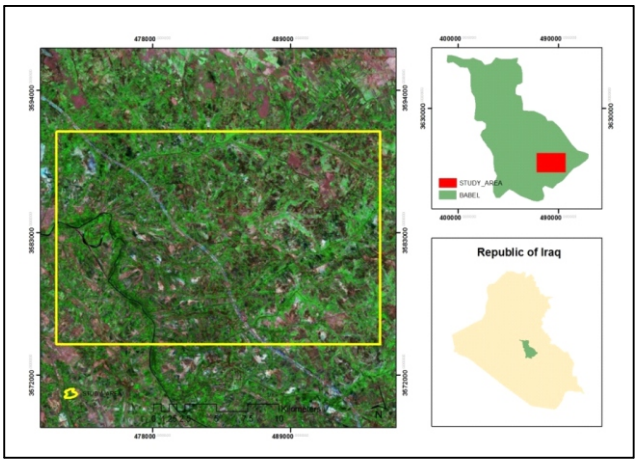

Fig. 1. Site map of the study area

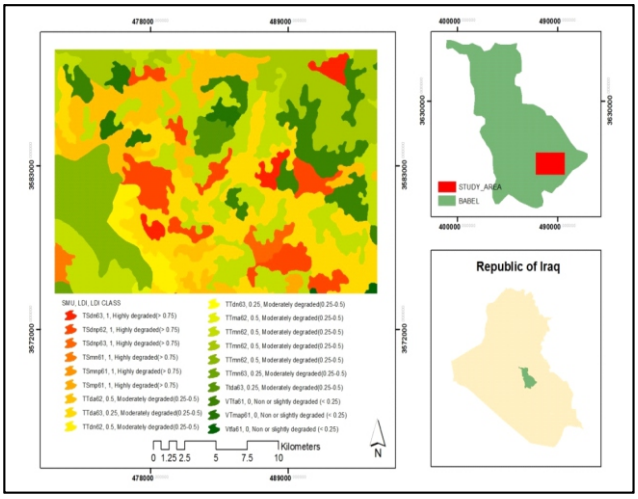

Fig. 2. Salinity units and values and classes of land degradation index in the study area

species, were identified. The salinity index was used as a single input because it is the determinant factor for agricultural production in the study area. The GIS-MCDM method was tested in this study to obtain flexibility and efficiency in the calculations related to the land degradation index as well as its ability to absorb other indicators, whether descriptive or quantitative, and controls their weight according to their importance according to the environmental conditions that characterized the study area.

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Application of Artificial Intelligence to Estimate the Reference Evapotranspiration at North Bihar, India

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Abstract: This paper estimates the reference evapotranspiration on daily basis and to develop the models using various training functions of Artificial Neural Network (ANN). The potential of ANN is investigated in modeling of daily reference evapotranspiration obtained using standard Penman-Monteith equation. The study compares results obtained using mean absolute error, root mean square error, coefficient of determination and Mean absolute percentage error statics used as criteria for evaluation of model performance. The major objective of this study was to estimate daily reference evapotranspiration using an artificial neural network technique with LM, GDM and OSS learning algorithms and compares if a trained neural network with limited input variables can estimate reference evapotranspiration (ET_o) efficiently. The comparison results indicate that the LM training function is faster and has a better accuracy than GDM and OSS. The value of coefficient of determination for LM, GDM and OSS function is 0.960, 0.959 and 0.949 respectively. LM produced high value of determination coefficient and lower value of root mean square error rather than other two training functions. So it is considered as best model for reference evapotranspiration estimation in Pusa.

Keywords: ANN, Levenberg- Marquardt, Reference evapotranspiration, Penman-Monteith equation

Evaporation from the dams, rivers and lakes are among the most important losses in many hydrological project design and water resources planning studies. The prediction of evapotranspiration quantity is of essential significance in the administration of water resources, water system, irrigation, horticulture, soil protections and water balance and hard to adequately simulate its variation because of the complex communication amongst land, atmosphere and relies on numerous climatic components. It is a key factor for irrigation framework design and administration, crop production, natural evaluation water assets management and planning. Exact evaporation estimations are fundamental for the adjusting of irrigation water use in dry and semiarid areas, more conditioned by water deficiencies, where capable irrigation engineering and management is required. Estimation of evaporation for remote country zones where no evaporation data are accessible is of extraordinary attention regarding the hydrologists and meteorologists (Kisi 2006). Artificial neural system assumes a critical part to overcome complexity and nonlinearity in process and have been discovered extremely reasonable to handle the issues that are numerically hard to describe. It is a biologically stimulated computational model that comprises of processing components (neurons) and association between them (weights). Dumka et al (2018) estimated climate based daily reference evapotranspiration using various training function of ANN and concluded that both GDM and OSS training functions are almost equally fitted.

MATERIAL AND METHODS

Location of the study area: Pusa is located in Samastipur district of Bihar, India and is a part of great Ganga basin. Geographically it is located at 25°98' N latitude and 85° 67' E longitudes with elevation of 52 m from the mean sea level. Pusa falls in a monsoon tropical zone, and is considered as semi arid and sub tropical atmosphere. The mean annual temperature is about 25.5°C; the mean annual rainfall is 1097 mm. January is the coldest month having mean daily temperature in the range of 7-10°C and maximum daily mean temperature is in the range of 20-25°C. December is considered as the driest month having an average precipitation of 2 mm summer season begins from March and goes up to June and is described by continuous increment in temperature, periodic thunder, hail storm at a place and high rainfall. Summer season is followed by storm season which remains till September. The daily metrological data of maximum and minimum temperature, wind velocity, relative humidity and sunshine hours of 5 years for the year 2011 to 2015 were collected from the local metrological observatory at Pusa, Bihar.

Development of models for study area: For study region, the data set was taken as standard meteorological data of maximum and minimum temperature, mean relative humidity, sunshine hours and wind speed as input and utilizing these sources of inputs evapotranspiration was estimated by CROPWAT 8.0. These inputs and output were then modeled, utilizing Matlab-2015. Total number of data for

every year's time frame turns out to be 365. At that point the entire quantity of data of 5 year was 1826. Out of which, 70% data were utilized for training and 30 per cent are utilized for testing.

FAO-56 Penman-Monteith method: The FAO Penman-Monteith method requires radiation, air temperature, air humidity and wind speed data. The humidity values were found out using psychometric chart using the wet bulb and dry bulb temperature data. The FAO Penman-Monteith equation is follow as:

$$ET_o = \frac{0.408\,\Delta\,(R_n - G) + \gamma\left(\frac{900}{T+273}\right)U_2(e_s - e_a)}{\Delta + \gamma\,(1 + 0.3U_2)} \quad (1)$$

Where, ET_0= Reference evapotranspiration (mm day^{-1}), R_n=net radiation at the crop surface (MJm^{-2} day^{-1}), G= soil heat flux density (MJm^{-2} day^{-1}), T= mean daily air temperature at 2 m height (°C), U_2= wind speed at 2 m height (ms^{-1}), e_s= saturation vapour pressure (kPa); e_a= actual vapour pressure (kPa), e_s-e_a= saturation vapour pressure deficit (kPa), Δ = slope of vapour pressure curve kPa ($^oC^{-1}$), γ= psychometric constant (kPa $^oC^{-1}$). In which all the parameters were calculated from the proposed formulae using spreadsheet.

Artificial neural network (ANN): ANN employs a set of neurons connected by links and generally consists in layers. The relations of the connections are scaled by adjustable parameters called weights. In the feed forward calculation, the nodes in the input layer get the input signals which are passed to the hidden layer and after that to the output layer. The signals are multiplied by the present values of weights, and afterward the weighted inputs are added to output then net input to every neuron of the next layer. The net input of a neuron is gone through an activation or exchange function to create the output of the neuron. In this study different training functions are used e.g. TRAINLM, TRAINGDM and TRAINOSS. An ANN with 50 neurons in single hidden layer generated with a feed-forward algorithm and training functions were implemented using neural network toolbox of Matlab.

Performance indices: The performance during training and testing was evaluated using performance indices. These indices are defined as follow:

Mean absolute error (MAE): MAE measures the average magnitude of the errors in the set of predictions, without considering their direction. It is computed using the equation:

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|Y_i - X_i\right| \quad (2)$$

Root mean square error (RMSE): The root mean square error is used to measure the prediction accuracy of the developed model. It compares difference between predicted and observed values and gets the information on short term performance. The root mean square error (RMSE) is computed by following relationship:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(X_i + Y_i)^2} \quad (3)$$

Coefficient of determination (R^2): Its value represents the percentage of variation that can be explained by the regression equation. A value of 1 means every point on the regression line fits the data. It is calculated by following formula:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(X_i - Y_i)^2}{\sum_{i=1}^{n}(X_i - Y)^2} \quad (4)$$

Mean absolute percentage error (MAPE): The mean absolute percentage error (MAPE), also known as mean absolute percentage deviation (MAPD), is a measure of prediction accuracy of a forecasting method in statics. MAPE function best when there are no extremes to the data (including zeros). The difference between observed and predicted values is divided by the actual value again.

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{X_i - Y_i}{X_i}\right| * 100 \quad (5)$$

RESULTS AND DISCUSSION

The values of statistical parameters of the reference evapotranspiration calculated from CROPWAT 8.0 (Table 1). There is uniformity in the data over 5 years. The range of reference evapotranspiration data over 5 years (2011-15) is between 0.79 to 6.10 mm day^{-1}. The lowest value of reference evapotranspiration i.e. 0.79 mm day^{-1} was in 2013, and the maximum value of ET_o was found to be 6.10 mm/day in 2015. The variation in evapotranspiration data of 5 years is shown in Figure 1.

The feed forward network is used with Levenberg-Marquardt, Gradient Decent Momentum, One Step Secant algorithms and Logsig transfer function was used. The single hidden layer was used for calculation of ET_o. Data set is separated as training set and test data. Training set MAE, RMSE, R^2, MAPE of ANN with observed daily ET is obtained. The best fit models for testing periods with different training algorithm are shown in Table 2. For LM training algorithm which is best among other two has MAE, RMSE, R^2 and MAPE value is 0.182, 0.221, 0.960 and 8.986

Table 1. Statistical parameters of reference evapotranspiration

Year	2011	2012	2013	2014	2015
Min ET_o (mm day^{-1})	0.81	0.84	0.79	0.88	0.87
Max ET_o (mm day^{-1})	5.99	5.94	5.88	5.87	6.10
Mean ET_o (mm day^{-1})	2.97	3.09	3.05	3.02	3.01

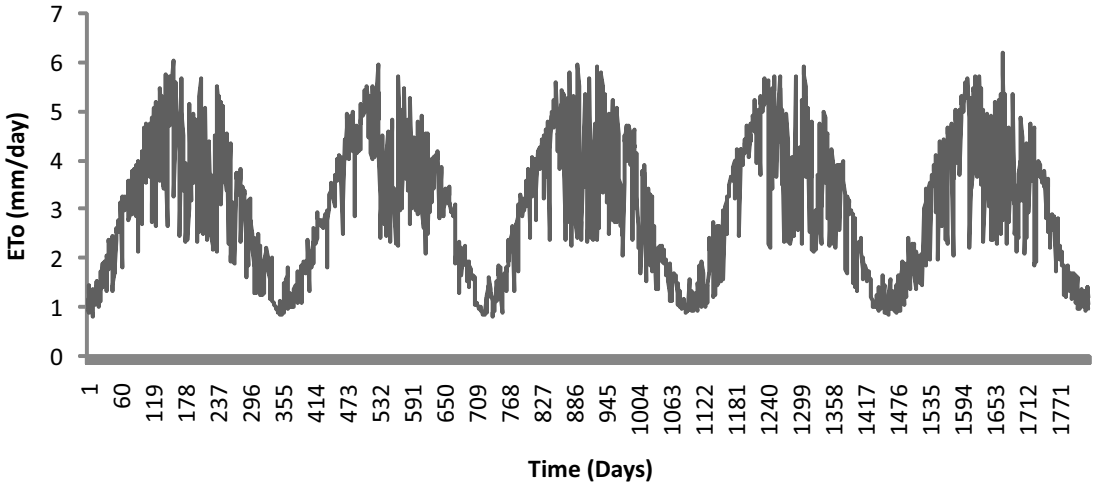

Fig. 1. Variation of reference evapotranspiration over 5 years (2011-15)

Table 2. Statistical parameters of reference evapotranspiration

Training function	MAE	RMSE	R^2	MAPE
LM	0.182	0.221	0.960	8.986
GDM	0.240	0.331	0.959	9.749
OSS	0.200	0.269	0.949	8.104

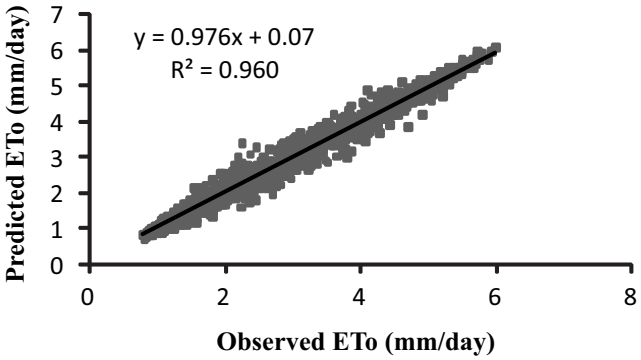

Fig. 2a. Scatter charts of daily ET_o (c) during testing period for LM training algorithm

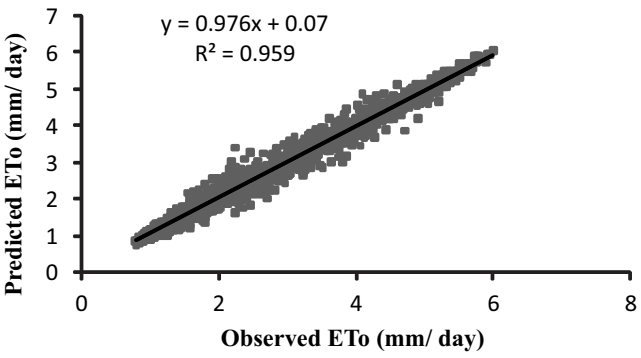

Fig. 2b. Scatter charts of daily ET_o during testing period for GDM training algorithm

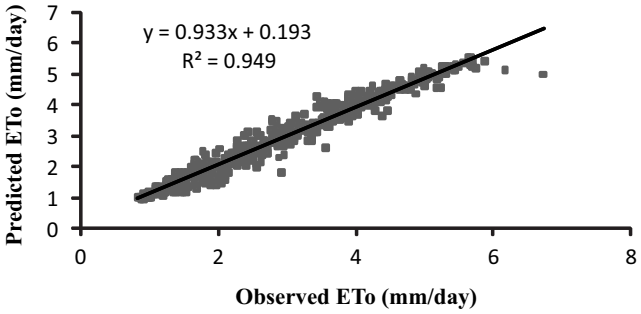

Fig. 2c. Scatter charts of daily ET_o during testing period for OSS training algorithm

respectively.ANN daily ET_o scatter charts are given below by Fig 2a, 2b and 2c respectively. From table 2, the results obtained for selecting best parameter are presented. Following this, the advantages of the developed models for ET_o estimation is discussed.

CONCLUSION

The estimation of reference evapotranspiration was successfully calculated by Penman-Monteith methods. The accuracy of ANN method is seen for calculation of reference evapotranspiration using climatic variables present for study area. The reference evapotranspiration during 5 years (2011-15) varied from 0.79 mm day^{-1} to 6.10 mm day^{-1}. Based on the performance indices Levenberg-Marquardt training function was the best model with coefficient of determination 0.960. The ANN with Levenberg-Marquardt was better as compared to Gradient Descent Momentum and Open Step Secant training functions because of lowers value of RMSE. This study proposed that ANN model with different training functions should be applied to different regions which have different climatic conditions to verify ANN model ability for prediction daily ET_o.

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Meteorological Drought Assessment Based on Standardized Precipitation Index

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Abstract: This study was conducted using the rainfall data for 44 years (1971-2014) of Parbhani district of Marathwada region for assessment meteorological drought and wet conditions based on Standardized Precipitation Index (SPI) for different time scales. The SPI was computed using gamma distribution at 1-, 3-, 6-, 9-, 12- and 24-month time scales. The results of analysis demonstrated that out of total period of 528 months 32 extreme drought, 69 severe drought, 82 extreme wet and 160 severe wet events occurred in the study region. The information generated from this analysis could be appropriately used for crop planning along with proper rainwater harvesting and storage structures in rain-fed and drought affected areas.

Keywords: Meteorological drought, Gamma distribution, SPI, Maharashtra state

The drought may be divided into four different categories, viz., metrological (lack of precipitation), agricultural (lack of root zone soil moisture), hydrological (drying of surface water storage) and socio-economical (lack of water supply for socio-economic purpose). A combination of drought or sequence of droughts and human activities may lead to desertification of vulnerable semiarid and dry sub-humid areas, whereby soil structure and soil fertility gets degraded and bio- productive resource decrease or disappear in the area**.** The important parameter quantifying a drought are duration, severity, location in absolute time i.e. initiation and termination time points, areal coverage and magnitude or intensity. The study on short-term duration of drought is important for agricultural interests, whereas medium and long-term duration of drought is important for water supply management interests (Mishra and Desai 2005). A region can experience wet and dry spells simultaneously on various timescales due to the dynamic nature of draught. Various drought indices such as percent normal precipitation (PNP), standardized precipitation index (SPI), effective drought index (EDI), China Z-Index (CZI) and stream flow drought index (SDI) have been developed to quantify a drought, each with its own strengths and weakness. SPI depends based only on precipitation and for this reason, the SPI has become very popular due to its low data requirements. The SPI gives a macroscopic insight of the impact of the deficit of precipitation, which is very difficult to be estimated otherwise. The present study was conducted for assessing the metrological draught condition and its severity in the Parbhani district of Maharashtra, India based on SPI values at various time scales.

MATERIAL AND METHODS

Study area and data collection: The study was conducted on Prabhani district located in Maharashtra State, India. The Prabhani district total area is about 6250.58 km^2. It lies between 18°45'and 20°10' North latitudes and 76°13' and 17°39' East Longitudes and located at 357m above mean sea level at Marathwada region in Maharashtra state of India. The climate of study area is characterized as semi-arid and tropical. The mean yearly precipitation is 955mm.The daily meteorological data for forty four years (1971-2014) was arranged into monthly set for analysis of meteorological drought and wet conditions.

Standardized Precipitation Index (SPI): McKee et al (1993) introduced the concept of standardized precipitation index (SPI). It is computed by fitting an appropriate probability density function to the rainfall summed over the time scale of interest. The computation of the SPI using a Gamma probability density function to a given time series of rainfall involves fitting a probability density functions as:

$$g(x) = \frac{1}{\beta^{\alpha} r(\alpha)} x^{\alpha-1} e^{-x/\beta} \qquad (1)$$

where, α is shape parameter, α > 0; β is scale parameter, β > 0; x is the amount of precipitation; and Γ(α) is the gamma function of α, expressed as $\int_0^{\infty} y^{\alpha-1} dy$

Using the approximation of Thom (1958), the parameters α and β can be estimated as:

$$\alpha = \frac{1}{4A}\left(1 + \sqrt{1 + \frac{4A}{3}}\right) \qquad (2)$$

$$\beta = \frac{\bar{x}}{\alpha} \quad (3)$$

$$where,\ A - In(x) = \frac{\sum \ln(x)}{n}\ for\ n\ observation \quad (4)$$

Integrating the probability density function (Eq. 1)with respect to x yields the cumulative probability, G(x) as:

$$G(x) = \int_0^x g(x)dx = \frac{1}{\beta^{\alpha} r(\alpha)} \int_0^x x^{\alpha-1} e^{-x/\beta} dx \quad (5)$$

Substituting t = x/β, the Eq. (5) is reduced to:

$$G(x) = \frac{1}{r(\alpha)} \int_0^x t^{\alpha-1} e^{-t} dt \quad (6)$$

It is possible to have several zero values of rainfall in a sample set. Gamma distribution is undefined for x = 0, therefore in order to account for zero value probability, the cumulative probability function for gamma distribution (Eq. 6) is modified as:

$$H(x) = q + (1 - q)\, G(x) \quad (7)$$

where, q is the probability of zero rainfall. Finally, the cumulative probability distribution is transformed into the standard normal distribution to yield the SPI as:

For $0 < H(x) \leq 0.5$

$$Z = SPI = -\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right) \quad (8)$$

where,

$$t = \sqrt{In \frac{1}{(H(x))^2}} \quad (9)$$

For $0.5 < H(x) \leq 1.0$

$$Z = SPI = +\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right) \quad (10)$$

where,

$$t = \sqrt{In \frac{1}{(H\text{-}(x))^2}} \quad (11)$$

and the coefficient are given as;

$c_0 = 2.515517$ $c_1 = 0.802853$ $c_2 = 0.010328$

$d_1 = 1.432788$ $d_2 = 0.189269$ $d_3 = 0.001308$

Based on the calculated values of SPI, the drought and wet conditions existing at a place could be identified and categorized (Table 1). The drought and wet patterns were also classified based on SPI values by setting a threshold or truncation level. The SPI ≤ -1.0 represents drought pattern, while SPI ≥ 1.0 represents wet pattern in the study region. Severity (S) of drought is calculated as the cumulative sum of consecutive negative SPI values and the duration (D) of drought is defined as the corresponding number of consecutive months with continuous negative values. The intensity (I) of drought is calculated by dividing severity to its duration (Dayal et al 2018, Malik and Kumar 2019). severity (S) of wet is calculated as the cumulative sum of consecutive positive SPI values and the duration (D) of drought is defined as the corresponding number of consecutive months with continuous positive values. The intensity (I) of drought is calculated by dividing severity to its duration.

Table 1. Classification of drought and wet categories

SPI value	Category	Symbol
SPI ≥ 2.0	Extreme Wet	W3
1.5 ≤ SPI < 2.0	Severe wet	W2
1.0 ≤ SPI < 1.5	Wet	W1
-1.0 < SPI < 1.0	Normal	N
-1.5 < SPI ≤ -1.0	Drought	D1
-2.0 < SPI ≤ -1.5	Severe drought	D2
SPI ≤ -2.0	Extreme drought	D3

RESULTS AND DISCUSSION

Assessment of meteorological drought based on SPI values: The drought for Parbhani station was assessed using SPI at1-, 3-, 6-, 9-, 12- and 24-month time scale. Out of 528 months, the extreme drought occurred during 32 months (6.06 %) and severe drought occurred during 69 months (13.06%) only (Table 2) and extreme wet occurred during 82 months (15.53%) and severe wet occurred during 160 months (30.30%) only (Table 3). This reveals that the chance of serious drought events is not very high however, there are nearly 46 per cent chances of serious wet conditions. As observed from the, For SPI-1, the maximum occurrence of normal drought was 77.27 per cent in March and May and minimum occurrence of normal drought in August and October (56.88%) (Table 4). The maximum occurrence of normal drought was 86.36 per cent in March and minimum occurrence of normal drought in July (61.36%) for SPI-3 (Table 5). The SPI-6, revealed that the maximum occurrence of normal drought was 75 per cent in October and minimum occurrence of normal drought in May (56.88%) (Table 6). For SPI- 9 the maximum occurrence of normal drought was found as 75 per cent in October month and minimum occurrence of normal drought in August and September month 61.36 per cent (Table 7). The maximum occurrence of normal drought was 70.45 per cent in January, February and October months and minimum occurrence of normal drought in August month 61.36 per cent was observed in case of SPI-12 (Table 8). The maximum occurrence of normal drought was 70.45 per cent in July month and minimum occurrence (47.72%) of normal drought in December month (Table 9).

Characterizing drought and wet events: The total number

of drought months 30 (SPI-1), 58 (SPI-3), 79 (SPI-6), 70 (SPI-9), 65 (SPI-12) and 89 (SPI-24) (Table 10). The number of drought incidences are 26 (SPI-1), 42 (SPI-3), 61 (SPI-6), 57 (SPI-9), 50 (SPI-12) and 83 (SPI-24). The average duration of drought is 1.15, 1.38, 1.30, 1.23, 1.30 and 1.07 months respectively for SPI at 1-, 3-, 6-, 9-, 12 and 24-month time scale. It indicates that the short-term drought occurs in the region. The longest duration of drought severity continuously increased from 3 months (SPI-1) to 34 months (SPI-24); however, its average intensity varied from -2.46 to -1.18, which fall under extreme and severe drought category (Table 10).

The total number of wet months are 132 (SPI-1), 94 (SPI-3), 97 (SPI-6), 94 (SPI-9), 97 (SPI-12) and 89 (SPI-24)

Table 2. Extreme and severe drought months based on different time scales

Drought category	SPI scale (month, year)	SPI values range
Extreme drought	SPI-1: (Jun, 1996), (Jul, 1971; 1987), (Aug, 2004), (Sep, 1987; 1991; 2000)	-3.14 to -2.02
	SPI-3: (Jun, 1996), (Jul, 1971), (Oct, 1991), (Nov, 1991; 2000), (Dec, 1991)	-2.75 to -2.00
	SPI-6: (Jan, 1992), (Feb, 1996; 2001), (Mar, 1972), (May, 1972; 1973; 1983), (Jun, 1996), (Jul, 1972)	-2.98 to -2.01
	SPI-9: (Apr, 1992), (May, 1977; 1992; 2001)	-3.19 to -2.04
	SPI-12: (Aug, 2004)	-2.01 to -2.01
	SPI-24: (Jan, 1973), (Mar, 1973), (Apr, 1973), (May, 1973), (Jul, 1987), (Dec, 1972)	-2.13 to -2.01
Severe drought	SPI-1: (Jun, 2011), (Jul, 1992), (Aug, 1991), (Sep, 2003)	-1.88 to -1.61
	SPI-3: (Jul, 1987; 2009), (Aug, 1997; 2004), (Oct, 2004), (Nov, 1976), (Dec, 1976)	-1.98 to -1.59
	SPI-6: (Feb, 1997; 1990; 2004), (Mar,1990; 1992; 2012), (Apr, 1972; 1987; 1992; 2012), (May, 1992; 2012), (Jul, 1987; 1996; 2009), (Aug, 1997), (Oct, 2014), (Nov, 2004; 2014)	-1.99 to-1.55
	SPI-9: (Jan, 1973), (Feb, 2005), (Mar, 1973), (Jun, 1973; 1983; 2009; 2012), (Jul, 1996), (Aug, 1997), (Sep, 1971), (Oct, 1972), (Dec, 2014)	-1.88 to -1.51
	SPI-12: (Jan, 1973), (Feb, 1973), (Mar, 1973), (Apr, 1973), (May, 1973), (Jun, 1973), (Jul, 1973; 1987; 1992; 1996; 2009), (Aug, 1977; 2012), (Oct, 1972), (Nov, 1972), (Dec, 1972)	-1.98 to -1.56
	SPI-24: (Feb, 1973), (Jun, 1973), (Jul, 1973; 2009), (Aug, 2004), (Sep, 2004; 2009), (Oct, 1987; 2004; 2009), (Nov, 2009)	-2.00 to -1.51

Table 3. Extreme and severe wet months based on different time scales

Drought category	SPI scale (month, year)	SPI values range
Extreme wet	SPI-1: (Jan, 1981; 1995; 1997; 2002), (Feb, 1984; 1986; 2002), (Mar, 1989; 1995; 2005; 2014), (Apr, 1995; 2003), (May, 1990), (Jun, 1993), (Jul, 2005), (Oct, 1990), (Dec, 1997)	2.01 to 2.65
	SPI-3: (Feb, 1981; 1987; 1998), (Mar, 1981; 1995; 2014), (Apr, 1995; 2014), (May, 1990), (Jun, 1990), (Jul, 2005), (Aug, 1989), (Dec, 1997)	2.01 to 2.94
	SPI-6: (Mar, 1998), (Apr, 1998), (Jul, 2005), (Aug, 1989), (Sep, 1988), (Oct, 1990)	2.00 to 2.35
	SPI-9: (Jan, 1991), (Jun, 2002; 2005), (Aug, 1989), (Oct, 1990), (Nov, 1990), (Dec, 1990)	2.07 to 2.31
	SPI-12: (Jan, 1991), (Feb, 1991), (Mar, 1991), (Apr, 1991), (Jul, 1991), (Sep, 1998), (Oct, 1990), (Nov, 1990), (Dec, 1990)	2.03 to 2.29
	SPI-24: (Jan, 1990; 1991), (Feb, 1990; 1991), (Mar, 1990; 1991), (Apr, 19901; 1991), (May, 1990; 1991), (Jun, 1990; 1991), (Jul, 1990; 1991), (Aug, 1989; 1990), (Sep, 1989; 1990), (Oct, 1989; 1990), (Nov, 1989; 1990), (Dec, 1989; 1990)	2.01 to 2.41
Severe wet	SPI-1: (Jan, 1978; 1979; 1985; 1986, 1987; 2005), (Feb, 1997; 1982; 2000; 2013; 2014); (Mar, 1981; 2006), (Apr, 1976; 1978; 2005; 2011), (May, 1974; 1975; 2000), (Jun, 1980; 1990; 1992), (Aug, 1973; 1983; 1990; 2000), (Sep, 1975; 1983), (Oct, 1998; 2001), (Nov, 1977; 2001; 2010), (Dec, 1981; 1983; 2013)	2.01 to 2.65
	SPI-3: (Jan, 1978; 2002), (Feb, 1984; 1994; 2002), (Mar, 2005), (Apr, 1989; 2005), (May, 1975; 1995; 2004; 2005; 2014), (Jun, 1980; 1993), (Jul, 1989; 1993), (Aug, 1990; 2005), (Sep, 1975; 2005), (Oct, 1975; 1983; 1990; 1998), (Nov, 1975; 1983; 1996; 1998), (Dec, 1990; 1998; 2001)	1.50 to 2.00
	SPI-6: (Jan, 1984; 1991; 1999; 2002), (Feb, 1984; 1997; 1999; 2002), (Mar, 1991; 2002), (Apr, 1978; 1995; 2005; 2014), (May, 1981; 1990; 2014), (Jun, 1980; 1993; 2002), (Aug, 1990), (Sep, 1975; 1990), (Oct, 1975; 1983; 1988; 1998), (Nov, 1975; 1983; 1988; 1990; 1998), (Dec, 1975; 1983; 1988; 1998; 2005)	1.51 to 1.98
	SPI-9: (Jan, 1976; 1984;1989; 1999), (Feb, 1979; 1984; 1989; 1991; 1999), (Mar, 1976; 1984; 1989; 1999; 2006), (Apr, 1984; 1991; 1999), (May, 1984; 1998; 2002), (Jun, 1990; 1991; 1991; 1993; 1998), (Jul, 1989), (Aug, 1990; 2005), (Sep, 1995; 1988; 1989), (Oct, 1975; 1983; 1988; 1998), (Nov, 1975; 1983; 1988; 1998), (Dec, 1975; 1983; 1988; 1998)	1.52 to 2.00
	SPI-12: (Jan, 1976; 1984; 1989; 1999), (Feb, 1976; 1984; 1989; 1999), (Mar, 1976; 1984; 1989; 1999), (Apr, 1976; 1984; 1989; 1999), (May, 1976; 1984; 1989; 1991; 1999), (Jun, 1984; 1989; 1990; 1991), (Jul, 1989), (Aug, 1998), (Sep, 1975; 1990; 1998), (Oct, 1975; 1983; 1988; 1998; 2005), (Nov, 1975; 1983; 1988; 1998), (Dec, 1975; 1983; 1988; 1998)	1.51 to 1.97
	SPI-24: (Aug, 1999), (Sep, 1990; 1999), (Oct, 1999)	1.60 to 1.94

Table 4. Occurrence of drought and wet conditions at 1-month time scale (SPI-1)

Month	Wet events			Normal	Drought events			Max. occurrence event (%)
	W3	W2	W1	N	D1	D2	D3	
January	4	5	6	29	0	0	0	65.90
February	3	6	6	29	0	0	0	65.90
March	4	2	4	34	0	0	0	77.27
April	2	4	8	30	0	0	0	68.18
May	1	4	5	34	0	0	0	77.27
June	1	3	3	31	4	1	1	70.45
July	1	0	8	31	1	1	2	70.45
August	0	4	6	25	7	1	1	56.88
September	0	3	4	32	1	1	3	72.72
October	1	2	10	25	6	0	0	56.88
November	1	3	7	33	0	0	0	75.00
December	3	4	4	33	0	0	0	75.00

Table 5. Occurrence of drought and wet conditions at 3-month time scale (SPI-3)

Month	Wet events			Normal	Drought events			Max. occurrence event (%)
	W3	W2	W1	N	D1	D2	D3	
January	1	2	8	33	0	0	0	75.00
February	3	3	3	35	0	0	0	79.54
March	3	1	2	38	0	0	0	86.36
April	2	2	3	31	6	0	0	70.45
May	1	4	4	31	4	0	0	70.45
June	1	2	4	32	4	0	1	72.72
July	1	2	6	27	5	2	1	61.36
August	1	3	5	28	5	2	0	63.63
September	0	4	3	29	8	0	0	65.90
October	0	4	4	30	4	1	1	68.18
November	0	4	4	28	4	2	2	63.63
December	1	3	2	32	4	1	1	72.72

Table 6 Occurrence of drought and wet conditions at 6-month time scale (SPI-6)

Month	Wet events			Normal	Drought events			Max. occurrence event (%)
	W3	W2	W1	N	D1	D2	D3	
January	0	4	4	30	4	0	1	68.18
February	0	5	4	28	1	3	2	63.63
March	1	2	4	28	5	3	0	63.63
April	1	4	3	30	2	3	0	68.18
May	0	4	3	25	6	2	3	56.81
June	1	2	5	28	6	0	1	63.63
July	1	1	7	28	3	3	1	63.63
August	1	2	6	26	8	1	0	59.09
September	1	3	4	28	8	0	0	63.63
October	1	4	2	33	3	1	0	75.00
November	0	5	3	31	3	2	0	70.45
December	0	5	3	32	4	0	0	72.72

Table 7. Occurrence of drought and wet conditions at 9-month time scale (SPI-9)

Month	Wet events			Normal	Drought events			Max. occurrence event (%)
	W3	W2	W1	N	D1	D2	D3	
January	1	4	3	30	4	1	0	68.18
February	0	5	3	32	2	1	0	72.72
March	0	5	4	29	4	1	0	72.72
April	0	4	4	31	3	0	1	70.45
May	0	3	6	29	2	0	3	68.18
June	1	4	0	30	4	4	0	68.18
July	1	1	6	28	5	2	0	63.63
August	1	2	5	27	7	1	0	61.36
September	0	4	4	27	8	1	0	61.36
October	1	4	2	33	3	1	0	75.00
November	1	4	3	30	6	0	0	68.18
December	1	4	3	30	5	1	0	68.18

Table 8. Occurrence of drought and wet conditions at 12-month time scale (SPI-12)

Month	Wet events			Normal	Drought events			Max. occurrence event (%)
	W3	W2	W1	N	D1	D2	D3	
January	1	4	3	31	3	1	0	70.45
February	1	4	3	31	4	1	0	70.45
March	1	4	4	28	5	1	0	63.63
April	1	4	4	29	4	1	0	65.90
May	0	5	4	29	4	1	0	65.90
June	0	4	4	30	4	1	0	68.18
July	1	1	4	30	2	5	0	68.18
August	1	1	6	27	5	2	1	61.36
September	1	3	4	28	7	0	0	63.63
October	1	5	2	31	3	1	0	70.45
November	1	4	3	30	4	1	0	68.18
December	1	4	3	32	3	1	0	72.72

Table 9. Occurrence of drought and wet conditions at 24-month time scale (SPI-24)

Month	Wet events			Normal	Drought events			Max. occurrence event (%)
	W3	W2	W1	N	D1	D2	D3	
January	2	0	6	26	7	0	1	59.09
February	2	0	6	26	7	1	0	59.09
March	2	0	6	26	7	0	1	59.09
April	2	0	5	27	7	0	1	61.36
May	2	0	5	28	6	0	1	63.63
June	2	0	5	27	7	1	0	61.36
July	2	1	3	31	2	2	1	70.45
August	2	1	5	27	6	1	0	61.36
September	1	2	4	28	5	2	0	63.63
October	2	1	4	27	4	4	0	61.36
November	2	0	6	27	5	2	0	61.36
December	2	0	6	21	7	0	1	47.72

Table 10. SPI-based drought pattern of rainfall series

SPI category	No. of drought months	No. of drought Incidences	Average duration months	Longest drought pattern			
				Longest duration (month)	Period of longest drought	Drought severity	Average intensity
SPI-1	30	26	1.15	3	August to October 1991	-4.98	-1.66
SPI-3	58	42	1.38	3	July to September 1971	-4.72	-1.57
					May to July 1973	-3.54	-1.18
					October to December 1991	-7.38	-2.46
					August to October 2004	-4.62	-1.54
					June to August 2009	-3.84	-1.28
					July to September 2014	-3.80	-1.27
SPI-6	79	61	1.30	7	August1972 to February 1973	-9.07	-1.30
SPI-9	70	57	1.23	13	July 1972 to July 1973	-18.43	-1.42
SPI-12	65	50	1.30	12	August 1972 to July 1973	-18.86	-1.57
SPI-24	89	83	1.07	34	September 1985 to June 1988	-47.52	-1.40

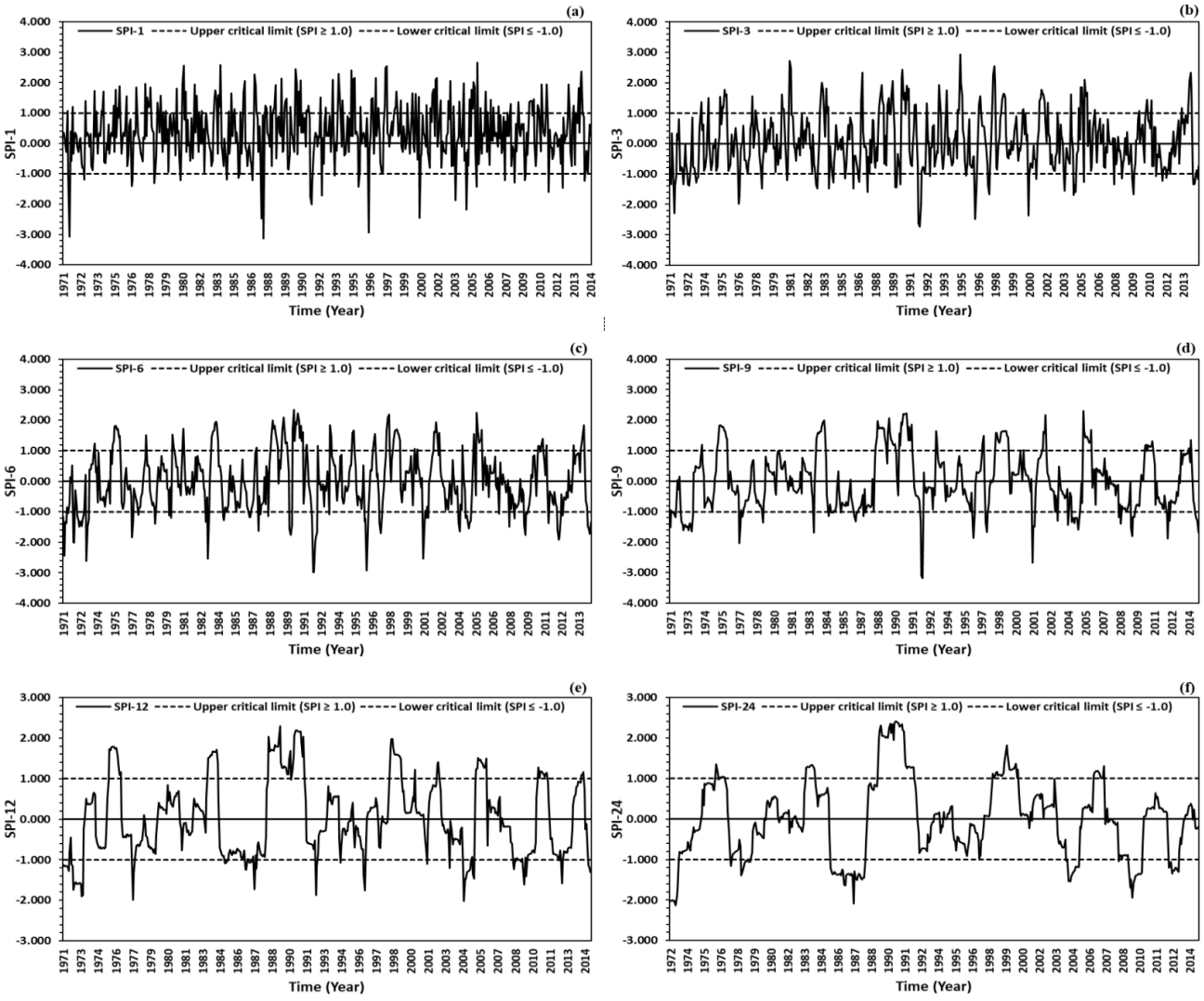

Fig. 1(a to f). Drought and wet events duration, severity and intensity on SPI-1 to SPI-24 time series

Table 11. SPI-based wet pattern of rainfall series

SPI category	No. of wet months	No. of wet Incidences	Average duration months	Longest wet pattern			
				Longest duration (month)	Period of longest wet	Wet severity	Average intensity
SPI-1	132	108	1.2	4	January to April, 1978 January to April,2005	5.78 6.76	1.44 1.69
SPI-3	94	71	1.32	6	October, 2001 to March, 2002	9.28	1.55
SPI-6	97	78	1.24	11	May,1990 to March, 1991	19.56	1.78
SPI-9	94	82	1.15	14	June, 1990 to July, 1991	24.57	1.75
SPI-12	97	73	1.33	22	September, 1988 to June, 1990	35.14	1.60
SPI-24	89	82	1.09	36	June, 1989 to May,1992	68.65	1.90

(Table 11). The maximum number of wet incidences was 108 (SPI-1), 71 (SPI-3), 78 (SPI-6), 82 (SPI-9), 73 (SPI-12) and 82 (SPI-24). The average duration of drought is 1.20, 1.32, 1.24, 1.15, 1.33 and 1.09 months for SPI-1 to SPI-24. It indicates that the wet incidents occur for short duration. The longest duration of wet severity continuously increased from 4 months (SPI-1) to 36 months (SPI-24), and average intensity varied from 1.44 to 1.90, which fall under severe wet category (Table 11). Figure 1(a to f) demonstrate the duration, severity and intensity of drought and wet events for 1, 3, 6, 9, 12 and 24 month time series during 1971 to 2014, respectively.

CONCLUSIONS

The amount of precipitation and the distribution at Marathwada region of Maharashtra state in India, being unpredictable and uneven, are responsible for frequent drought spells in the past years. The Parbhani district has also indicated signs of climate change on its water resources and agriculture. This study was conducted using the rainfall data at Parbhani district with specific objectives to assess meteorological drought based on Standardized Precipitation Index (SPI) for different time scales. The values of the SPI revealed that during the total period of 528 months (1971-2014) under study,32extreme drought, 69severe drought, 82 extreme wet and 160 severe wet events occurred. The longest duration of drought severity continuously increased from 3 months based on SPI-1 to 34 months with SPI-24; however, its average intensity varied from -2.46 to-1.18, which fall under extreme and severe drought category. The longest wet severity continuously increased from 4 months with SPI-1 to 36 months with SPI-24 and average intensity varied from 1.44 to 1.90, which fall under severe wet category.

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Evaluation of Land Degradation Assessment Studies: Attributes Applicable to Various Geographical Regions

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Abstract: The mapping land degradation and monitoring requires many input pertains to physical, meteorological, biological, socioeconomic and cultural factors. A methodology has been proposed through which land degradation assessments can be ranked based on the numbers of indicators. Twenty seven land degradation assessment studies conducted from various geographical regions were evaluated by using a new evaluation index, which ranged 0.1 to 9.4. Internal matrix of this index and representative studies were assessed through frequency distribution, Agglomerative Hierarchical Clustering (AHC) and by Principal Component Analysis (PCA). This study provides a compressive list of minimum quantitative and qualitative parameters applicable to various ecosystems for land degradation assessments. Versatility index was also formulated by using an evaluation index, total quantified parameters and number of attributes requires management practices. This effort provided a judging criterion to evaluate future endeavors along with management approaches.

Keywords: Land degradation, Evaluation index, Ecosystem services, Multivariate analysis, Versatility index

Land degradation is the long-term loss of ecosystem function and services, brought by disturbances which exceed to the resiliency of the system (UNEP 2007). Nature of land degradation is highly variable and its intensity associated with interaction of biotic and abiotic indicators (Shahab et al 2018). Across the globe, severity and intensity of land degradation have been assessed by several researchers for different land uses like forest, natural pastures and wastelands (Mathur and Sundaramoorthy 2018). Additionally, some assessment methodologies have also been developed like the status of vegetation condition (Kumar 1992), Habitat Complexity Score (Catling and Burt 1995), Pasture Condition Score (Cosgrove et al 2001), Descriptor sheet for USA rangelands (Pyke et al 2002), Habitat Hectares - Victoria (Parkes et al 2003), Biodiversity Benefits Index (Oliver and Parkes 2003). Rapid Appraisal of Riparian Condition (Jansen et al 2004), Bio Metric (Gibbons et al 2005), Bio Condition assessment toolkit (Eyre et al 2006) and LADA (Slavko et al 2014). Such tools are relayed on many inter-related quantitative and qualitative indicators (Hosseini et al 2018). Such indicators based assessments having their own merits and demerits (Christian et al 2018 and Gaur and Squires 2018). For an example, Interpreting Indicators of Rangeland Health (IIRH) is the most commonly used rangeland health assessment protocol for the United State rangelands (Pellant et al 2005, Toevs et al 2011). It uses 17 indicators to rate the three attributes of rangeland health pertains to soil and site stability, hydrologic function, and biotic integrity. However, it doesn't address the possible management guidelines and their interpretations. Pasture Conditions Score (PCS) developed by the United State Department of Agriculture (USDA) utilized ten indicators related to vegetation and soil conditions and compared to IIRH its rating criteria and interpretation provides caustic factors and potential management (Sanderson et al 2009). A major weakness of the PCS is that it lacks site-specific reference conditions with which management option can be recommended. Further, its rating categories for some indicators (like ground cover) needs simplification (Sanderson 2014).

Despite of exhaustive scientific efforts and valuable information's pertaining to land degradation, indeed, no clear consensus exists as for assessing such assessments and for their ranking. Thus, the present study was conducted with the objectives to evaluate the degradation assessment studies conducted from diverse geographical regions and develop an index to assess the versatility of the assessment studies.

MATERIAL AND METHODS

Twenty-seven different representative studies were evaluated on the basis of indicators studied in them. These studies were appraised with an evaluation index, which was

$$Evaluation\ \ index = \left[\left(\frac{V_{PS}}{Min\ VP_{15}}\right)+\left(\frac{S_{PS}}{Min\ SP_{10}}\right)+\left(\frac{H_{PS}}{Min\ HP_{9}}\right)+\left(\frac{L_{PS}}{Min\ LP_{4}}\right)+\left(\frac{S-E_{PS}}{Min\ S-EP_{11}}\right)+\left(\frac{C_{PS}}{Min\ CP_{7}}\right)\right]\times Total\ Studied\ Parameters$$

Above equation was prepared with the help of literature

survey wherein primary parameters and their sub-parameters were listed. Thus, in this equation V_{PS}, S_{PS}, H_{PS}, L_{PS}, $S\text{-}E_{PS}$, C_{PS} are indicates vegetation, soil, hydrological, livestock, socio-economic, and climatic parameters studied, respectively. Minimum numbers (sub-parameters that provides the status of primary parameters with reference to land degrardation, Caspari et al 2015) of these attributes are (1) Vegetation**:** bare surface area (%) (length and width), litter quantity and status, cover (canopy and grass), biomass, richness, alpha diversity, beta diversity, Relative Importance Value (relative density, relative frequency, relative abundance), height, DBH, spatial pattern (clumped, random or uniform), invasive species dominance, reproductive capability of perennial plants, ratio of palatable/unpalatable species and evenness (2) Soil: texture, organic carbon, nitrogen, phosphorus, bulk density, soil pH, electric conductivity, SAR, soil stability test, erosion type (sheeting, pedestal, terracette, rill scalding) (3) Hydrological: channel depth, gully, rill (Width and depth), slope, and patterns of water flow, water table, and drainage, runoff and infiltration rate (4) Livestock: grazing intensity, livestock trampling impact, live stock types, carrying capacity (5) Socio-Economics: removal of plant parts, grazing exclusion (non-grazing), literacy rate, population density, employment opportunities, expansion of agricultural activities, knowledge about land use protection, age distribution, accessibility to market, family size and land Size and (6) Climate: rainfall, temperature, wind speed, relative humidity, aridity index, drought frequency. Frequency distribution analysis was performed to assess the internal matrix of evaluation Index and the results were interpreted with Skewness, Kurtosis and chi-square tests. Agglomerative Hierarchal Cluster (AHC) analysis was attempted to subdivide or partition a set of heterogeneous objects into relatively homogeneous groups and this was carried out through un-weighted pair-group with Pearson correlation similarity coefficient and this multivariate approach was utilized to figure out the internal matrix primary and sub parameters of representative studies. Exploratory Factor Analysis (Principal Component Analysis) was carried out as a data reduction techniques and this ordination technique was utilized to find out the behavior of primary parameters in representative studies. PCA was performed with the Pearson correlation coefficient and the significance of correlations among variables was assessed through Bartlett's test of sphericity (Mathur 2014). These multivariate analyses were carried out by using PAST (Hammar et al 2001) and XLSTAT (2017) softwares.

RESULTS AND DISCUSSION

The elected studies (Table 1) revealed frequent utilization of six primary parameters related to vegetation, soil, livestock, socio-economic, hydrology and climate in different combinations. Among the 27 studies, only one primary parameter (vegetation) was utilized in four different assessments. Combination of two (vegetation/soil/climate) and four (vegetation/soil/hydrological/climate and vegetation/livestock/socio-economic/climate) parameters were utilized in each six different studies (Table 1). Similarly, eight and three studies utilized three and five different combinations of primary parameters, respectively. Use frequencies of different primary parameters were headed by vegetation (26) followed by soil (19), climate (12), livestock (8) and hydrology and socio-economic (7). In addition to these primary parameters, remote sensing and GIS tools were also utilized in some studies. Maximum vegetation (8) and hydrological (4) parameters were utilized in a study conducted by Khoshkhahad et al (2012) for evaluation of appropriate rangeland health at Fars province, Iran. While, maximum (15) soil parameters were utilized to quantify effects of grazing on vegetation and soil properties of desert communities (Li et al 2008). Similarly, Tesfahunegn et al (2016) had utilized maximum (twelve) socio-economic parameters for assessing soil quality (degradation severity) by using farmer's knowledge of weed species, crop type and soil management practices in Mai-Negus catchment, Northern Ethiopia. Maximum value (9.4) of evaluation index was observed in a study conducted by Tahmoures et al (2013) followed by studies of Masoudi and Amiri (2015) and Tesfahunegn et al (2016) with 6.54 and 6.40 values, respectively (Table 1). Minimum value (0.33) was for the study of Liu et al (2004) where they utilized only two vegetation parameters, however, their major focused was about to develop an automatic method for efficient and timely mapping of severity of grassland degradation in Western China by using various remote sensing approaches. Thus, although their study utilized minimum parameter, but on the other hand maximum remote sensing techniques like difference vegetation index (DVI), ratio VI (RVI), NDVI, soil adjusted VI (SAVI), modified SAVI (MSAVI), infrared percentage VI (IPVI), and modified simple ratio (MSR) were utilized as an assessment tool. Thus, value of this index determined by parameter studied and minimum number of parameters of each attributed in fraction manner and total number of attributes studied in a multiplicative manner. Thus, a higher score indicates that researchers approached many different parameters that ultimately suggested multi-factor evaluation of degradation status. Internal matrixes of evaluation index and among 27 representative studies were evaluated by frequency distribution, and multivariate techniques (cluster analysis and PCA).

Frequency Distribution: Results of frequency distribution

(FD) interpreted through skewness, kurtosis, and chi-square tests (Table 2. In FD Skewness is a measure of symmetry and a dataset is symmetric if it looks the same to the left and right of the center point. The skewness of a normal distribution is zero and a symmetric data should have skewness near zero. A symmetrical distribution with a long tail to the right (higher value) has a positive skew and an asymmetrical distribution with a long tail to the left (lower values) has a negative skew. If the skewness is less than -1 or greater than +1, the distribution is highly skewed while, if the value ranges between -1 an $-^{1}/_{2}$ or between $+^{1}/_{2}$ and +1, the distribution will be declared as moderately skewed and if skewness is between $-^{1}/_{2}$ and $+^{1}/_{2,}$ the distribution is approximately symmetric. Kurtosis quantifies whether the shape of the data distribution matches the Gaussian distribution, in general, a Gaussian distribution has a kurtosis of zero and a flatter distribution has a negative kurtosis. The reference standard is a normal distribution, which has a kurtosis of three. A normal distribution has kurtosis exactly 3 is called mesokurtic, <3 called platykurtic (its central peak is lower and broader) and >3 called leptokurtic (central peak is higher and sharper). The skweness (0.61) and Kurtosis (-0.60) suggested a skewed and flatter distribution (Table 2 and Fig. 1) further, as the computed value of Chi-square test is lower than significance alpha level (0.05) indicated that the sample does not follow a normal distribution. FD classified the evaluation index into ten classes: class 1 represent the lower (0.0) to upper bound (0.956) with nine studies, class 2 (0.956-1.912) with two studies, class 3 (1.912-2.868) with four studies, class 4 (2.868-3.824) with two studies, class 5 (3.824-4.781) with three studies, class 6 (4.781- 5.737) with two studies, class 7 (5.737-6.693) with four studies while, class 8 and 9 (6.693-7.649; 7.649-8.605) not represent by any study while class 10 8.608-9.56 with one study. Thus, this

Table 1. Primary parameters and evaluation index of some representative studies

Sr. No.	Researcher	Vegetation	Soil	Hydrological	Livestock	Socio-economics	Climatic	Attributes studied	Evaluation index
1	Li et al. (2009)	0.333	0.000	0.000	0.000	0.000	0.000	1.000	0.333
2	Mahadavi et al (2013)	0.467	0.700	0.222	0.000	0.000	0.143	4.000	6.127
3	de Soyza et al (2000)	0.133	0.100	0.000	0.500	0.000	0.000	3.000	2.200
4	Qiu et al (2013)	0.133	0.300	0.000	0.000	0.091	0.000	3.000	1.573
5	Masoudi and Amiri (2015)	0.200	0.000	0.000	0.500	0.364	0.571	4.000	6.540
6	Casson et al (2009)	0.067	0.100	0.111	0.250	0.091	0.000	5.000	3.093
7	Eyre et al (2015)	0.333	0.100	0.000	0.000	0.000	0.000	2.000	0.867
8	Zhang et al (2005)	0.400	0.000	0.000	0.000	0.000	0.000	1.000	0.400
9	Masoudi (2014)	0.133	0.100	0.000	0.250	0.182	0.286	5.000	4.754
10	Masoudi and Amiri (2013)	0.133	0.000	0.000	0.000	0.000	0.143	2.000	0.552
11	McGranahan et al (2013)	0.333	0.100	0.000	0.250	0.000	0.000	3.000	2.050
12	Liu et al (2004)	0.133	0.000	0.000	0.000	0.000	0.000	1.000	0.133
13	Wen et al (2010)	0.200	0.000	0.000	0.000	0.000	0.000	1.000	0.200
14	Masoudi et al (2006)	0.000	0.300	0.333	0.000	0.000	0.286	3.000	2.757
15	Basso et al (2012)	0.333	0.500	0.222	0.000	0.000	0.286	4.000	5.365
16	Mandal et al (2010)	0.133	0.900	0.111	0.000	0.000	0.000	3.000	3.433
17	Tong et al (2004)	0.200	0.100	0.000	0.000	0.000	0.000	2.000	0.600
18	Tesfahunegn et al (2016)	0.067	0.300	0.000	0.000	1.091	0.143	4.000	6.402
19	Ruherford and Powrie (2010)	0.333	0.600	0.000	0.000	0.000	0.000	2.000	1.867
20	Khoshkhahad et al (2012)	0.533	0.200	0.444	0.000	0.000	0.143	4.000	5.283
21	Moradi et al (2012)	0.200	0.000	0.000	0.000	0.000	0.143	2.000	0.686
22	Lopez et al (2013)	0.267	0.100	0.000	0.000	0.000	0.000	2.000	0.733
23	He et al (2015)	0.067	0.000	0.000	0.250	0.091	0.286	4.000	2.773
24	He et al (2005)	0.467	0.700	0.000	0.000	0.000	0.143	3.000	3.929
25	Li et al (2008)	0.267	1.500	0.000	0.250	0.000	0.000	3.000	6.050
26	Pei et al (2008)	0.333	1.000	0.000	0.250	0.000	0.000	3.000	4.750
27	Tahmoures et al (2013)	0.267	0.500	0.333	0.000	0.364	0.429	5.000	9.461

non-parametric test clearly indicated that use parameters for land degradation were not uniformly utilized at global level.

Cluster analysis: AHC was conducted for assessing the possible internal linkage among the 27 studies (Table 3 and Fig. 2). Based on the similarities, AHC classified these studies into five clusters and out of them, cluster one and two included 11 and 10 studies, respectively, while remaining clusters included two, three and one studies, respectively. Numbers of these studies in Table 3 are corresponded to the serial number of Table 1. Studies of cluster one are predominantly utilized two to eight different vegetation parameters. Among them we observed four different patterns for their use i.e. direct status of land degradation (Liu et al 2004, Tong et al 2004, Wen et al 2010), indirect status of land degradation by using pattern dynamics with different succession stages (Zhang et al 2005, Lopez et al 2013, Masoudi and Amiri 2013, McGranahan et al 2013), comparative studies of degradation with protective and un-protective systems (Li et al 2009, Lopez et al 2013) and the fourth one pertains to developing and validate quick system, and manual for diversity and degradation, respectively (Liu et al 2004, Eyre et al 2015).Studies of cluster two mainly utilize soil variables along-with vegetation or soil with hydrological variables. For this group major objectives were: how the soil properties affected by wind erosion (He et al 2005, Ruherford and Powrie 2010), impact of grazing on soil and vegetation dynamics (Pei et al 2008, Li et al 2008, Qiu et al 2013), how the management practices related to soil functions and soil quality indices (Mandal et al 2010) and modeling for salinization and soil degradation (Masoudi et al 2006, Tahmoures et al 2013).Studies of cluster three grouped together due to combined use of vegetation, livestock and soil parameters and conducted by de Soyza et al (2000) and Casson et al (2009). Cluster four encompasses the studies that utilized socio-economic, vegetation and livestock parameters (Masoudi 2014, He et al 2015, Masoudi and Amiri 2015). However, study of Tesfahunegn et al (2016) conducted at Mai-Negus catchment, Northern Ethiopia region were singly grouped in cluster five. This study was dissimilar to other groups due to use of socio-economic (12 parameters), soil, vegetation and climate parameters aimed to assess the soil quality (degradation severity) by using farmer's knowledge of weed species, crop type and soil management practices. Thus, AHC analysis further confirms the dominant inclusion of vegetation parameter in various degradation assessment studies.

Table 2. Frequency distribution of evaluation index values

Frequency distribution parameters	Values
Skewness (Pearson)	0.615
Kurtosis (Pearson)	-0. 602
Chi-square test (p value 0.05)	0.002

Principal component analysis : The cumulative percentage of first four axes of PCA together accounted more than 80 per cent variability (Table 4) and this proved the usefulness of this tool in this study (Mathur and Sundaramoorthy, 2016). Eigenvalues and factor score of

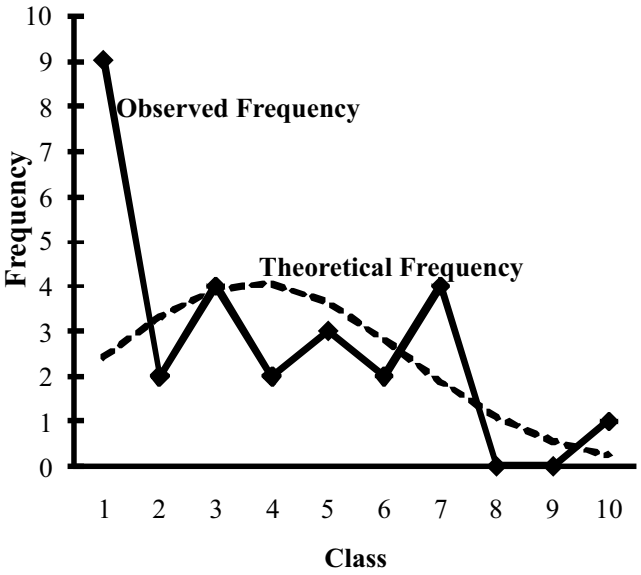

Fig. 1. Observed and theoretical frequency distribution of evaluation index score

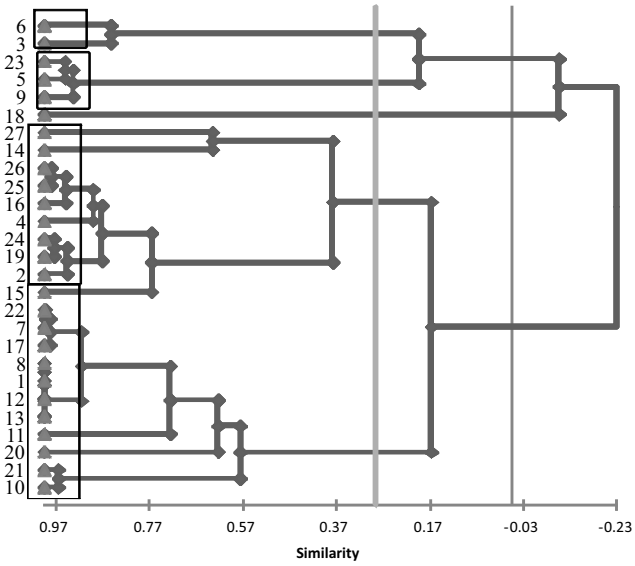

Fig. 2. Dendrogram of Agglomerative Hierarchical Cluster (AHC) analysis (*Numbers are correspondent to S. No. of Table 1)

each parameter are presented in Table 4 and Figure 3. The interpretation of the PCA bi-plot was made under the following criteria: when two variables are far from the center, then, if they are close to each other, they are significantly positively correlated (r close to 1); if they are orthogonal, they are not correlated (r close to 0); and when they are on the opposite side of the center, they are significantly negatively correlated (r close to -1). Squared cosines were used to link the variable with the corresponding axis, and the greater the squared cosine, the greater the link. PCA biplot suggested the close proximity of vegetation and soil parameters with each other and are located on the same axis along with hydrological parameters, while socio-economic and climate parameters were located on the opposite axes. Livestock located on the separate and opposite to hydrological parameter that shows non-togetherness of these two.

For Bartlett's test of sphericity, there are two levels to interpret this test (a) *H0*: There is no correlation significantly different from 0 between the variables, and (b) *Ha*: at least one of the correlations between the variables is significantly different from 0. In this study, as the computed p-value (0.12) is greater than the significance level alpha (0.05), one cannot reject the null hypothesis H0 and suggesting that primary variables were not related with each except a significant positive relationships between hydrological and climatic parameters (R^2 = 0.38 P<0.01) Thus, this bi-plot provides the future line of actions pertain to utilization of unique set of parameters for degradation status examples are climatic-socioeconomics-livestock, hydrological-livestock-socio-economics. Frequency distribution utilized for identification of the internal matrix of evaluation index indicated high variability's in use of studied parameters and researcher specific preferences. Here a question arises that each degraded land/habitat having specific degradation factors subsequently requires specific management strategies. However, we are still not aware about the bi-directional relationships among parameters and with-in the sustainable development framework, assessment studies should not end up with the identification of factors only. They should be weighted and evaluated by an arbiter tool. Thus, we require a global criterion for holistic assessment of degradation studies and this need itself speaks about the importance of our study. Cao (2008) and Cao et al (2010)

Table 4. Variables of principal component analysis and factor scores of various parameters

PCA parameters	F1	F2	F3	F4
Eigenvalue	1.77	1.47	1.01	0.85
Variability (%)	29.49	24.58	16.91	14.10
Cumulative (%)	29.49	54.06	70.97	85.07
Vegetation	-0.72	0.26	0.15	-0.17
Soil	-0.42	0.23	0.70	0.48
Hydrological	-0.21	0.86	-0.12	-0.16
Livestock	0.53	-0.22	0.69	-0.39
Socio-economic	0.66	0.28	-0.06	0.59
Climatic	0.56	0.69	0.10	-0.25

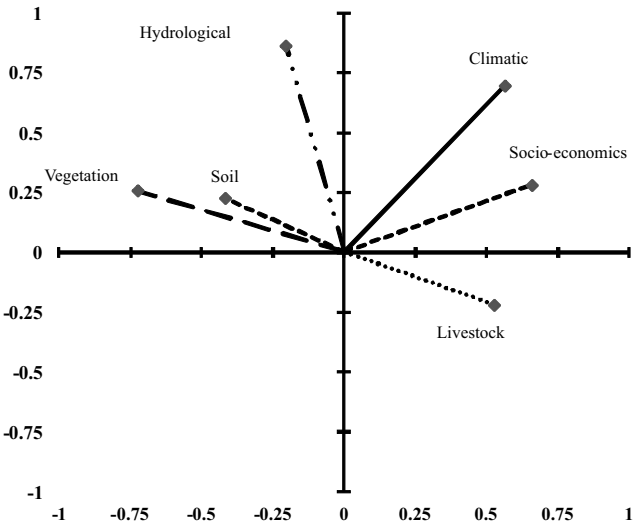

Fig. 3. Bi-plot of principal component analysis

Table 3. Variables of Agglomerative Hierarchical Cluster (AHC) analysis

Cluster parameters	Classes				
	1	2	3	4	5
Objects	11	10	2	3	1
Sum of weights	11	10	2	3	1
Within class variance	0.04	0.22	0.04	0.07	0.00
Minimum distance to centroid	0.07	0.22	0.14	0.14	0.00
Average distance to centroid	0.17	0.40	0.14	0.21	0.00
Maximum distance to centroid	0.51	0.84	0.14	0.30	0.00
Study number	1,7,8,10,-13,17,20-22	2,4,14-16,19,25-27	3,6	5,9,23	18

*Numbers are correspondent to S. No. of Table 1

have advocated that addressing of only one parameter could not solve land degradation problem. Integration of meteorological and anthropogenic factors for such studies have been emphasized by Cao et al (2014) and Feng et al (2015). Corral-Quintanna et al (2016) have provided some possible interrelationships among the qualitative parameters associated with degradation status. The results of cluster analysis can also be utilized for the non-addressed objectives and thus, create an opportunity. Further, such information's auxiliary funnel with our PCA results that provided some possible combinations of parameters.

With our evaluation index, and through the results of FD, AHC and PCA analysis, a versatility index was prepared with the incorporation of two major attributes (1) how many parameters can be quantified and how many qualitative in nature and (2) how many attributes required management practices. From analyzing the various assessment manuals and guidelines it was estimated that out of fifty six minimum parameters (describe above), forty eight can be assessed quantitatively while eight can be qualitative in nature. Qualitative parameters may be pertaining to vegetation **(**litter quantity and status, reproductive capability of perennial plants), livestock (grazing intensity, livestock trampling impact, livestock types, carrying capacity) and socio-economic (removal of plant parts, grazing exclusion). Then the number of attributes required management practices can be numerically corroborated with structure, function, provisional and cultural services provided by a piece of land and which are directly or indirectly affected with degradation. Thus, versatility index can be mathematically expressed as:

Versatility Index
=(Evaluation Index + Total Parameters Quantified +
Number of Attributes Required Management Practices)

CONCLUSION

Identification of attribute pertains to land health and their subsequent quantifications are very crucial steps for combating land degradation. Thus, holistic integration of actions and measures undertaken at federal, regional, and inter-ecosystem level studies should be priorities. And this can be better understood and implemented with identification of limited threshold of parameters to be evaluated. The present study was the first compressive effort to evaluate various land degradation assessment studies across the globe. This study provides a list of minimum quantitative and qualitative parameters applicable to various ecosystems for land degradation assessment studies. Versatility index emphasized quantitative analysis of various parameters so that assessment studies should be more meaningful. Further, it also weighted the management practices that should be focused on reallocation of structure, function, provisional and cultural attributes of the system.

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Dendrochronological Potential of *Tectona grandis, Pinus kesiya* and *Quercus serrata* from Mizoram, Northeast India for Growth

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Abstract: The dendrochronological study of teak (*Tectona grandis*), Khasi pine (*Pinus kesiya*) and oak (*Quercus serrata*) was carried out in two forest divisions of Mizoram, Northeast India. Three tree-ring chronologies were developed of which, *T. grandis* is 31 year (1987- 2017 C.E.), *P. kesiya* is 40 year (1978-2017 C.E.) and *Q. serrata* is 47 year (1971-2017) long. The tree-ring chronology statistics showed significant dendrochronological potential of these trees from the region. However, the taxa *Q. serrata* had some limitations in the present record and needs further investigation. Further collection of samples from these forests is required to strengthen the chronology statistics and to extend the chronology time span. Common event year with lower growth has been observed in both *T. grandis* and *P. kesiya.* The negative event year identified in the individual trees of *T. grandis* and *P. kesiya* are mostly related to drought records of the Mizoram. The tree-ring based past drought database can provide a scientific basis for the management of drought mitigation strategies towards hydrology and agriculture in this region.

Keywords: Drought, Event year, Khasi pine, Oak, Teak, Tree-rings

Dendrochronological studies have been found to be useful for developing better management plans for forest growth and production under changing climate scenario and promote sustainable use of forest ecosystem services (Sharma et al 2017, Upadhyay and Tripathi 2019). A large number of dendrochronological studies related to climatic, geological and environmental aspects have been carried out in various geographical regions of India. These studies are mainly concentrated in the Western and Eastern Himalayan region and primarily based on conifer tree species (Bhattacharyya and Shah 2009, Shah et al 2014, Pandey et al 2016). In addition, tree-ring analysis has also been carried out on few broad-leaved taxa from the Western Himalaya (Bhattacharyya et al 2006) and Eastern Himalaya (Shah and Mehrotra 2017). Tree-ring based studies from tropical regions particularly from Peninsular India are limited and mostly carried on single taxa i.e., Teak (Shah et al 2007, Bhattacharyya et al 2007, Borgaonkar et al 2010). In the North-eastern region of India, dendrochronological studies on various aspects are mostly carried out in higher latitude region regions such as Arunachal Pradesh (Bhattacharyya et al 2008, Shah and Bhattacharyya 2009, 2012), Meghalaya (Chaudhary and Bhattacharyya 2002, Shah and Bhattacharyya 2012) and Manipur (Singh et al 2016). There is no report on dendrochronological studies from the lower latitudinal region of Northeast Indian states i.e., Mizoram. However, in adjoining regions of Mizoram, dendrochronological studies were carried out from Bangladesh (Chowdhury et al 2008, 2016, Rahman et al 2017a, b) and Myanmar (D'Arrigo et al 2011, Hlaing et al 2014). The present study is a maiden attempt to understand the dendrochronological potential of three tree taxa i.e., teak (*Tectona grandis*), Khasi pine (*Pinus kesiya*) and Oak (*Quercus serrata*) from Mizoram, lowermost state of Northeast India. The main objectives of the present study were examine annual nature of growth rings of *T. grandis, P. kesiya* and *Q. serrata* using technique of cross dating and to determine annual growth synchronicity within the tree and between trees of each taxa and as well as among these three taxa.

MATERIAL AND METHODS

Study site, sample collection and processing: The present study was carried out in Mizoram, northeast India. Mizoram borders Myanmar and Bangladesh and has second highest forest cover in the country after Lakshdeep (ISFR 2017). The region has rugged hilly terrain with north-south axis separated by river valleys. The elevation of these hills ranges from 500-2000 m and Phawngpui is the highest peak located at 2100 m asl. The tree cores sampling sites are located in two forest divisions of Mizoram i.e., Aizawl forest division in Aizawl district and Champhai forest division in Champhai district. As per Köppen climate classification, the climate of Aizawl is a humid subtropical climate (Cwa) whereas Champhai district has Subtropical highland climate

(Cwb). The tree cores were collected from conifer taxa (*P. kesiya*) and two broad-leaved taxa (*T. grandis* and *Q. serrata*). The sampling of *T. grandis* was done at Tuirial riverine forest reserve at Aizawl forest division (Fig. 1). The locality falls under humid sub-tropical forest where top story is mainly formed by trees like *Artocarpus chaplasha, Chukrassia tabularis, Michelia champaca, Bombax ceiba, Terminalia myriocarpa, Mesua ferrea, Toona ciliata, Gmelina arborea, Albizzia chinensis, Schima wallichii*, etc. The sampling of *P. kesiya* and *Q. serrate*, was carried out in Ngur and Vengthar villages respectively of the Champhai forest division. These sites are located along India-Myanmar border separated by Hahrva River. This is a subtropical to temperate type forest where *P. kesiya* and *Q. serrate,* grow along with other dominant tree taxa such as *Q. griffithii* and *Schima wallichi*. The tree cores were collected using Haglof increment corer. The cores were collected from breast height (1.3 m), generally with two cores per tree. However, in some case only one core was possible due to slope and rot (Table 1). All tree cores were processed using standard dendrochronological techniques (Speer 2010). The tree cores were air dried to avoid shrinkage and finally mounted in the wooden grooved mount using water-based glue. All samples were polished using different grade of sand papers to make the growth ring boundary clearly visible under the microscope.

Data acquisition and tree-ring chronology development: The growth rings of all the samples were observed and counted under the stereo-zoom microscope. Each ring was counted starting from pith to bark. The skeleton plot technique of cross dating (Stokes and Smiley 1968) has been used to assign an exact calendar date to each ring. The width of each dated ring was measured to the nearest 0.001 mm precision using the Velmax tree-ring measuring system (Velmex Inc 2009) attached to a PC with MeasureJ2X software package (Voor Tech Consulting 2008). The measured ring-widths of all dated tree cores from individual sites; the series have been checked for possible error in dating and measurement using the computer program "COFECHA" (Holmes 1983, Grissino-Mayer 2001). The poorly dated series are either removed or re-dated by checking samples for possible error occurred.

Each ring width series was standardized to remove the age-related growth trends and stand dynamics while preserving variations that are likely related to climate (Cook 1985, Cook and Kairiukstis 1990). The standardization was carried out in computer program ARSTAN (https://www.ldeo.columbia.edu/tree-ring-laboratory/resources/software). In the procedure of standardization, each series' raw measurement was first power transformed and then 1st Friedman super smoother and alpha curve (Friedman 1984) was used. The autoregressive modelling was applied to remove the first order auto-correlation existed. After detrending, individual time series were averaged using a bi-weight robust mean function (Cook 1985, Cook and Kairiukstis 1990) to produce the tree-ring indices. Generally,

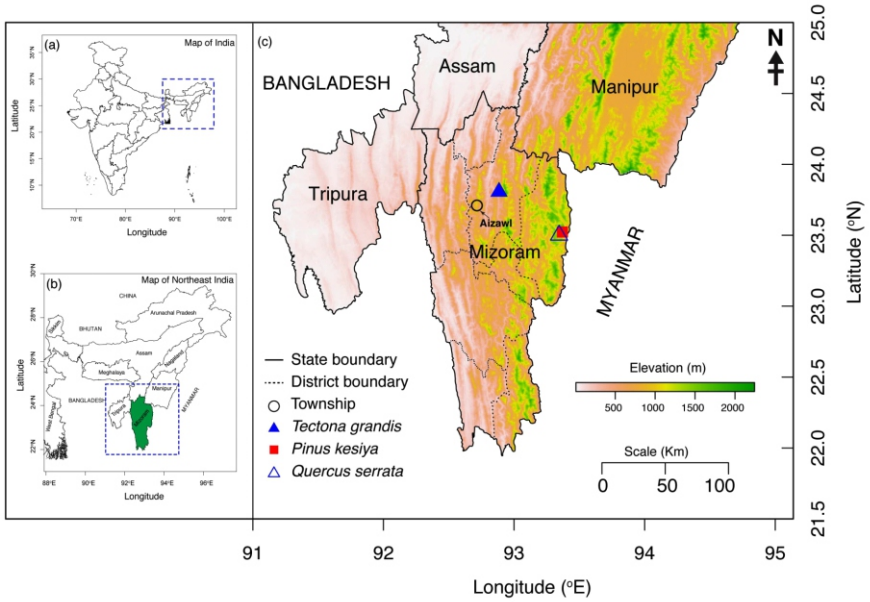

Fig. 1. Sampling sites of *Tectona grandis*, *Pinus kesiya* and *Quercus serrata* at Mizoram, Northeast India. The elevation gradient is based on the digital terrain elevation dataset SRTM30 (http://srtm.csi.cgiar.org)

the sample size declines in the early portion of a tree-ring chronology; we used the subsample signal strength (SSS) criteria (Wigley et al 1984) with a threshold value of 0.85 to determine the most reliable time span of the chronology. The tree-ring chronology statistics of all three species were calculated (Table 2). The degree of association between the site/taxa chronologies was calculated using Pearson correlation analysis for the common period.

Event year analysis: The tree growth is controlled by various climatic factors, was estimated with correlation or response function analyses method (Fritts 1976) to estimate average relationships between tree growth and climate parameters in temporal time span (Guiot 1991). However, trees also experience less frequent and time-dependent growth limiting factors during extreme events (Lebourgeois et al 2010) and these extreme events were recorded in tree-rings as an extraordinary tree-growth response and can be represented through years with a remarkable growth increase or reduction. The extreme events can be detected using additional analysis termed as 'event year' or 'pointer year' (Schweingruber et al 1990). In the present study, positive and negative event years were identified at the individual tree level using tree-width data of *T. grandis, P. kesiya* and *Q. serrata*. The identified events years are analyzed as representation of extreme events especially in terms of climatic events. The event year was calculated using method described by Maaten-Theunissen et al 2015.

Table 1. Tree core sampling sites of Mizoram, Northeast India

	Tectona grandis	*Pinus kesiya*	*Quercus serrata*
SN	Tuirial riverine forest	Ngur village	Vengthar village
Lat (°N)	2348′ 25.78	2332′ 19.33	2329′ 17.41
Lon (°E)	9253′ 06.47	9322′ 24.67	9220′ 15.48
Elev (m)	410	1566	1414
SL	Moderate	Moderate	Moderate
AS	E-NE	NE-NW	S-SW
NT/NC	21/42	20/40	16/31

SN = site name; SC=site code; Lat (°N) = latitude in degree north; Lon (°E) = longitude in degree north; Elev (m) = sampling site elevation in meter; SL = slope of the site; AS = aspect of the sampling site; NT/NC = number of trees/number of cores

Table 2. Statistical details of tree-ring chronologies developed from Mizoram, Northeast India

	Tectona grandis	*Pinus kesiya*	*Quercus serrata*
SIC	0.415	0.409	0.373
MSL	20	28	30
TS (YRS)	1987-2017 (31)	1978-2017 (40)	1971-2017 (47)
NT/NC	21 (38)	19 (36)	9 (14)
MS	0.264	0.195	0.222
SD	0.188	0.174	0.208
AC-1	-0.361	0.079	0.063
SSS	15 tree	11 tree	7 tree

See Table 1 for details

RESULTS AND DISCUSSION

The annual rings of *T. grandis* are distinctly ring porous (Fig. 2). The earlywood vessels are large and few in numbers and latewood vessels are small and copious. The rings in sapwood part were yellowish in color and were difficult to delineate as compare to the heartwood. False rings were also observed in few samples, which were identified through its anatomical differences, and also in some cases using cross-dating technique. In *P. kesiya*, clear zonation between earlywood and latewood was observed but there was a gradual change in wood colour from whitish to dark brown. Presence of large number of false rings in both earlywood and latewood might be due to changes in moisture conditions. There was no clear distinction between sapwood and heartwood. The wood of *Q. serrata* was straight grained and medium textured. Sapwood was pale brownish-white, whereas, heartwood light greyish-brown in colour. The wood was distinctly ring-porous with small to large exclusively solitary pores, thick walled, simple perforation plate and tyloses. There was no clear distinction in colour of earlywood to latewood. Using COFECHA program, tree-ring series having high correlation with the master series of each species/site were included in the final datasets and mean series inter-correlation was recorded. The series, which were poorly correlated with the master and having low correlation, were removed. Thus, among the total number of tree cores collected (Table 1) successfully cross-dated 38 cores from 21 trees of *T. grandis*, 36 cores from 19 trees of *P. kesiya* and 14 cores from 9 trees of *Q. serrata* (Table 2). The series mean inter-correlation d for *T. grandis, P. kesiya* and *Q. serrata* was 0.415, 0.409 and 0.373, respectively. This showed that the samples for all three taxa have degree of commonality in the individual series contributing to the site chronology. However, the lower series mean inter-correlation of *Q. serrata* indicates the need for further attention towards cross dating. This might be due to the irregular nature of the growth rings and difficulties in delineating the ring boundaries due to uni-seriate to multi-seriate rays. Moreover, the moderate values of series mean inter-correlation were in *T. grandis* and *P. kesiya* may be due to the moist climatic condition prevailing in the state of Mizoram, Northeast India.

Based on the successfully cross-dated ring width data, three tree-ring chronologies were prepared. The tree-ring chronology of broad-leaved taxa i.e., *T. grandis* from Aizawl forest division is 31 of years and extends from 1987 to 2017

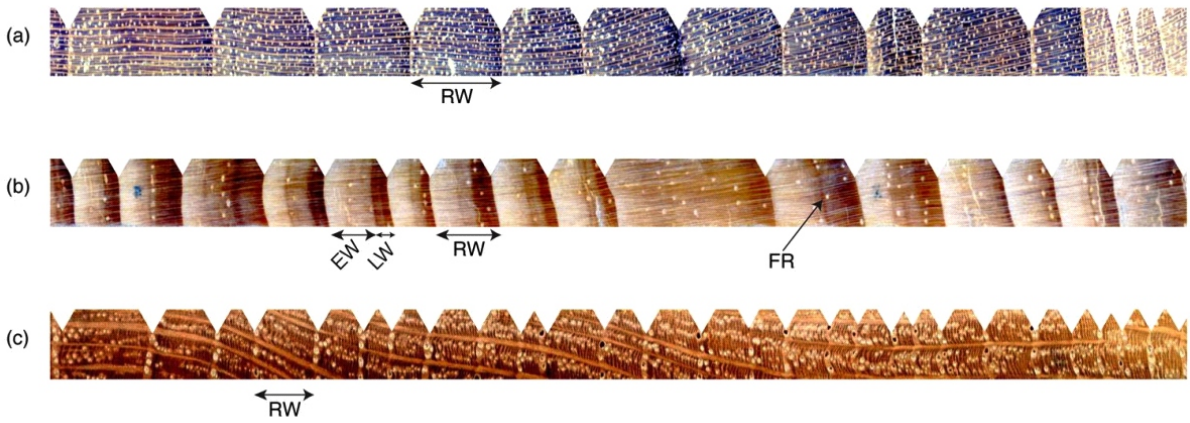

Fig. 2. Growth ring features of (a) *Tectona grandis*, (b) *Pinus kesiya* and (c) *Quercus serrate* The abbreviations are: RW = ring width; EW = early wood; LW = latewood; FR = False ring or false band

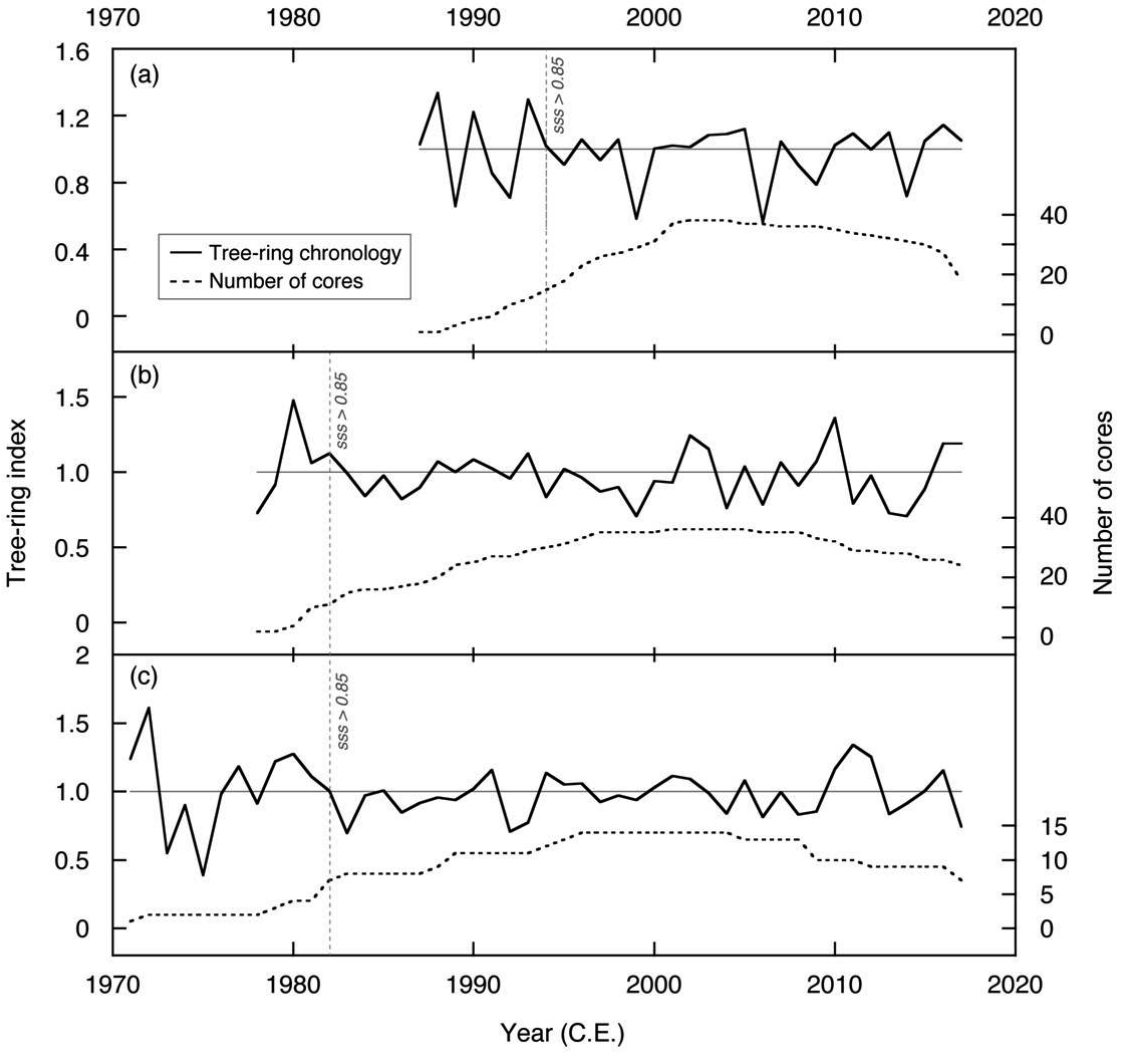

Fig. 3. Standard tree-ring chronologies of (a) *Tectona grandis*, (b) *Pinus kesiya* and (c) *Quercus serrata* developed from Mizoram, Northeast India

C.E. The tree-ring chronologies developed from Champhai forest division are of both conifer and broad-leaved taxa. The chronology length of conifer taxa, *P. kesiya* is 40 years (1978-2017 C.E.) and broad-leaved taxa, *Q. serrata* is 47 years (1971-2017). The correlation between these three chronologies witnessed that *T. grandis* and *P. kesiya*, shows significant positive correlation with 0.349) for the common period of 1987-2017 C.E. The correlation of *Q. serrata* with both *T. grandis* and *P. kesiya* are positive but not significant. A tree-ring chronology of the species with a low autocorrelation, a high mean sensitivity and a high standard deviation has good potential for dendroclimatological studies. The mean sensitivity, which is a measure for the relative difference in width between consecutive rings was for *T. grandis, P. kesiya* and *Q. serrata* is 0.264, 0.195 and 0.222, respectively. The standard deviation observed in chronologies of *T. grandis, P. kesiya* and *Q. serrata* was 0.188, 0.174 and 0.208, respectively. The high value of mean sensitivity and moderate to high values of standard deviation observed in chronologies of all the three taxa indicates the presence of considerable high-frequency variance and potential for dendrochonological studies. The presence of auto-correlation in tree-ring chronology is an additional statistical parameter to determine the degree to which a given year's growth is correlated with the preceding year's growth. Its high values indicate that a significant portion of the observed ring-width is a function of the preceding year's growth rather than exogenous factors. The value of first order auto-correlation in chronologies of *T. grandis, P. kesiya* and *Q. serrata* was –0.361, 0.079 and 0.063 respectively. The absence of significant first order auto-correlation in all three chronologies showed that the current year climatic factor is more responsible for the growth of all three species in this region. Based on the subsample signal strength (SSS) criteria observed in the tree-ring chronology of *T. grandis, P. kesiya* and *Q. serrata*, to achieve a threshold value of 0.85 and thus to extend the reliable time span of the chronology, more samples are required for all the three studied taxa.

Based on the event year analysis, negative event years in both *T. grandis* from Aizawl forest division and *P. kesiya* from Champhai forest division was observed. Most of the negative year recorded as a drought year in Mizoram. The negative event year in *T. grandis, was* 1999, 2006, 2008 and 2009 (Fig. 4) and in *P. kesiya was* 1994, 1999 and 2006 (Fig. 5). The southwest monsoon dominated state Mizoram witnessed widespread intense dry spell, which started during June 2005 and extended up to mid 2006 (Saha et al 2016). The drought year event of 2006 was observed in tree-ring width records of both *T. grandis* and *P. kesiya* as lower growth. In addition, the all India drought of 2009, accounted a wide spread dry spell at various meteorological records of Mizoram such as Aizawl, Sialsuk, Hnahthial, Kolasib, Bilkhawthlir Saiha, Lawngtlai and Serchhip. The capital town Aizawl of Mizoram was exposed to the longest dry spell event from July 2008 to April 2010, which lasted for 22 months (Saha et al 2016), which is clearly visible in the records of *T. grandis* ring width from Aizawl forest division. In *Q. serrata,* the event year was not recorded in large scale. However, in some individual trees, negative event year was observed during 1999 and 2006 (Fig. 6). The event year and mostly the negative event year provide a scientific basis for the management of drought mitigation strategies at this region. Based on the past records of drought using tree-rings shall be useful for the decision makers to account drought event in resource planning such as selection and implementation of suitable crop production and other water management policies related to agricultural and horticultural crops in Mizoram.

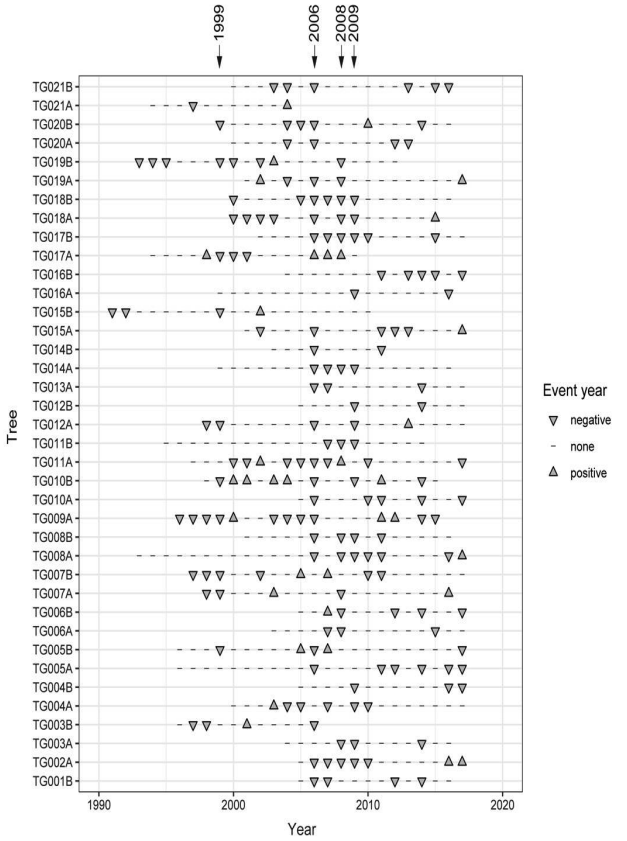

Fig. 4. Dot plot showing event years for individual trees of *Tectona grandis* (TG) at Tuirial riverine forest. The filled triangle point down and triangle point-up represent negative and positive event years respectively. The non-event years are indicated with minus signs

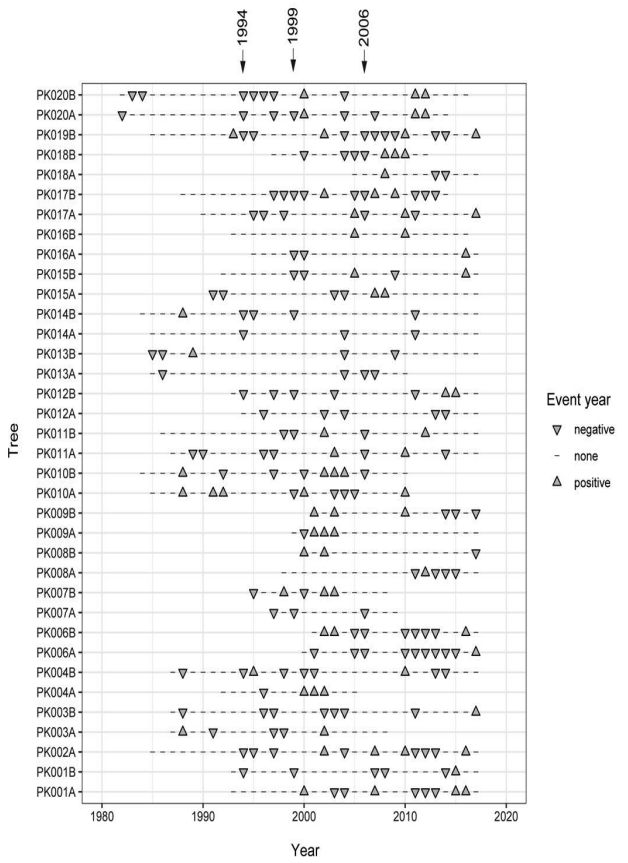

Fig. 5. Dot plot showing event years for individual trees of *Pinus kesiya* (PK) at Ngur village. See Fig 4 for details

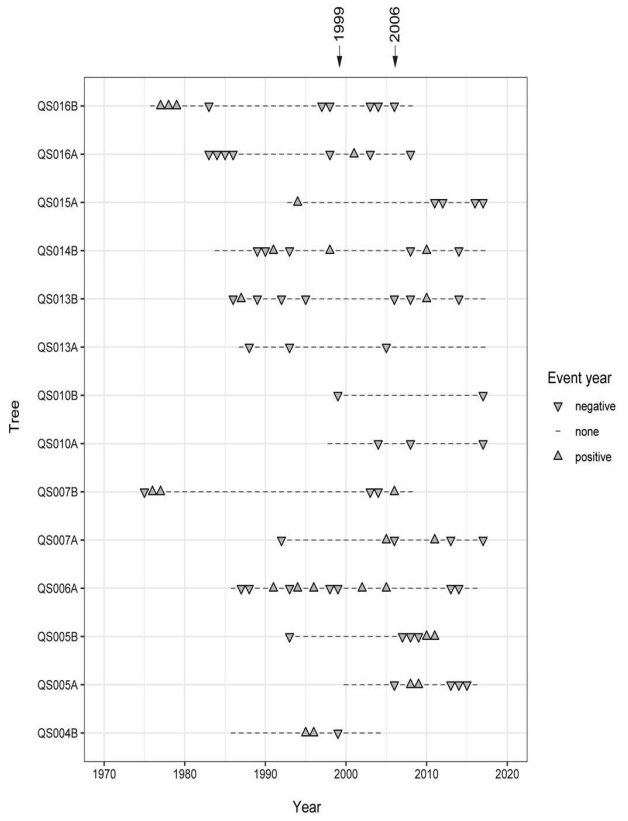

Fig. 6. Dot plot showing event years for individual trees of *Quercus serrata* (QS) at Vengthar village. See Fig 4 for details

CONCLUSIONS

Tree cores of *Tectona grandis*, *Pinus kesiya* and *Quercus serrata* were successfully cross dated from the state of Mizoram, a new geographical location in Northeast India, suggested that *T. grandis* and *P. kesiya* have higher dendrochronological potential as compared to *Q. serrata* in this region. The statistics of the tree-ring chronologies reflect a common signal in the series because of the common forcing factor over a site. It is suggested that the trees at a site are responding in a similar manner to environmental forces and are likely to have a climate signal. The event year recorded in ring widths are found to be associated with drought years of the region and such findings can help in developing longer tree-ring based drought database that will facilitate water management planning which will also be helpful in agricultural sector of Mizoram. Further studies are recommended on various aspect of tree-ring analysis in this southwest monsoon-dominated region of Northeast India to mitigate ongoing climate change crisis in the state.

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Systematic Position of *Tamarix* in the Region of Tlemcen (Western Algeria)

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Abstract: Plant groups in the region of Tlemcen are the subject of a large number of scientific studies, due to their important specific richness. The alluvial forest of this region form plant stands dominated by *Tamarix*. The objective of this study is to show the species that is actually present, between *Tamarix africana* and *T. gallica*, on the banks of Tafna wadi. Three stations were selected for sampling. The only species present and dominant was *Tamarix africana,* and *T. gallica* was not observed on the banks of Tafna wadi.

Keywords: Algeria, Systematic position, *Tamarix africana, Tamarix gallica,* Tafna wadi, Tlemcen

The Mediterranean basin is quite diverse in plant species and is of great interest to any scientific study, given its great wealth of flora linked to the heterogeneity of historical, paleogeography, geological and ecological factors. Riparian forests are veritable alluvial forests, which naturally border streams along river systems (Decamps 2003). They represent vegetation structures at least partly azonal (Quézel and Médail 2003). The vegetation of alluvial forests on the edge of the Mediterranean wadi is characterized by strong climatic and soil constraints, salinity, wind, drought and shallow or mobile soils. In the region of Tlemcen, alluvial forest form quite diverse plant stands; mainly dominated by the genus *Tamarix* (Quézel and Santa 1962-1963). This genus is mainly present by two species, *Tamarix africana* and *T. gallica*. *Tamarix* are common in salt edge, the study of this genus is extremely difficult. Tamaricaceae have a great interest as conservative plants of arid and semi-arid soils against various physical erosion. The objective of the study is to determine which of these two species (*Tamarix africana* and *T. gallica*) is present on the banks of Tafna wadi.

MATERIAL AND METHODS

Three study sites were selected at the Tafna wadi from western Algeria, specifically in north-western Algeria. They are located between 1°19' and 1°28' of western longitude and 34°37' and 35°17' north latitude **(**Fig. 1**)**, geographically limited in the north by the Mediterranean Sea, in the south by the town of Sebdou, in the west via the Algerian-Moroccan border, to the east by the wilaya of AînTémouchent and to the south east by the wilaya of Sidi Belabbés. The choice is based on the presence of the genus *Tamarix*. The sampling was carried out of several such individuals, with the aim of identifying the species present in the field.

Study site 1**:** Located upstream of Beni-Bahdal Dam, on the road to Wilaya number 46, with an altitude of 675 m, latitude 34°41' north and longitude of 1°27' west. The recovery rate is 15-20 per cent a slope of 25-30 per cent.

Study site 2: Located 10 km from Maghnia, on the nation road 35, a few kilometers from the town of Hammam Boughrara. It settles at latitude of 34°53' north, a longitude of 1°38' west, an altitude of 296 m and a recovery of 30 per cent and a slope of 10 per cent.

Study site 3: Located at northern latitude of 35°17', a west longitude of 1°28' and an altitude of 10 m. The recovery rate is 25 per cent and the slope is 5 per cent.

To know the climate of the study sites the ombrothermic diagrams of Bagnouls and Gaussen on the one hand, and the rainwater quotient of Emberger (Q_2), which is specific to the Mediterranean climate, on the other hand were shared. After several field trips and observations, the samples were identified using the following flora, the new flora of Algeria (Quézel and Santa 1963), -Flora and vegetation of the Sahara (Ozenda 1991) and Dobignard and Chatelain's synonymic flora index.

RESULTS AND DISCUSSION

Dry period is observed for all the sites, extending from April to October (Fig. 2), and the Emberger climagram (Fig. 3**)** proved that since all three are in the semi-arid bioclimatic stage, temperate winter for the first site, cool winter for the second, and warm winter for the third site.

Botanical characters of the genus *Tamarix*: The genus *Tamarix* belongs to the Tamaricaceae family. *Tamarix* is usually trees or shrubs, acicular or ring-shaped squami form-reduced twigs, and dense cluster inflorescences usually gathered at the top of the stems. White or pink flowers, tetramers or pentamers; 5 to 10 stamens inserted on a

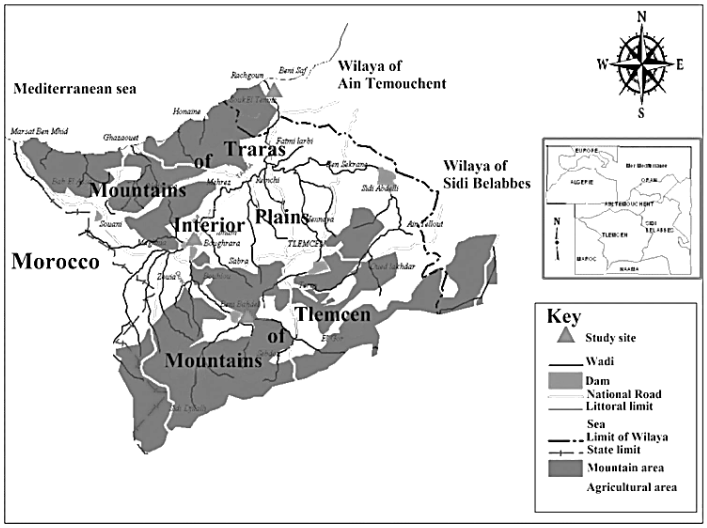

Fig. 1. Map of study station location

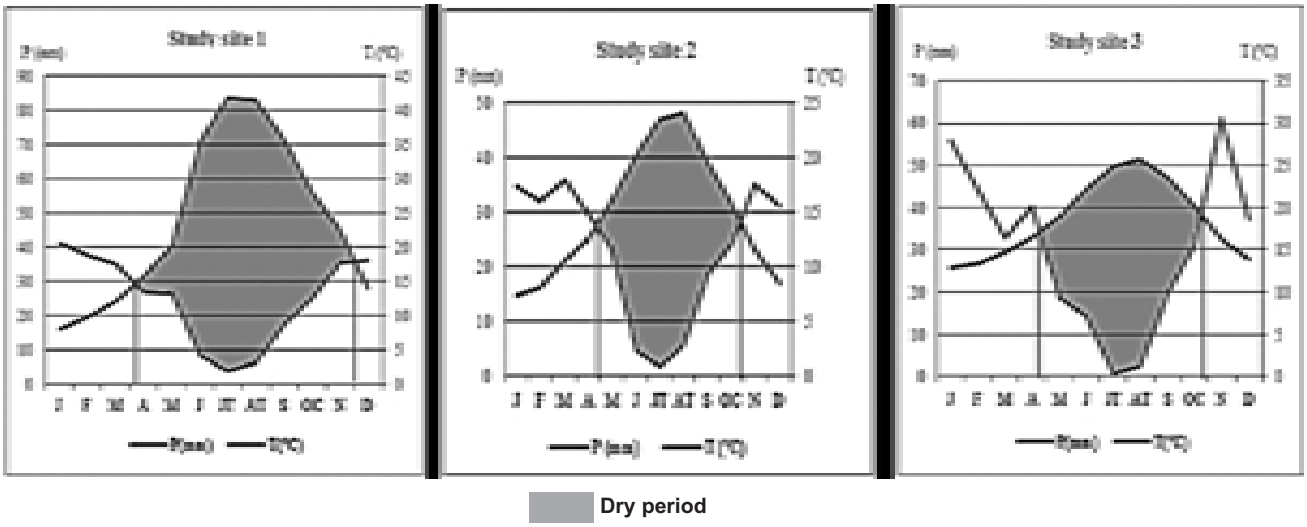

Fig. 2. Bagnouls and Gaussen ombrothermal diagram

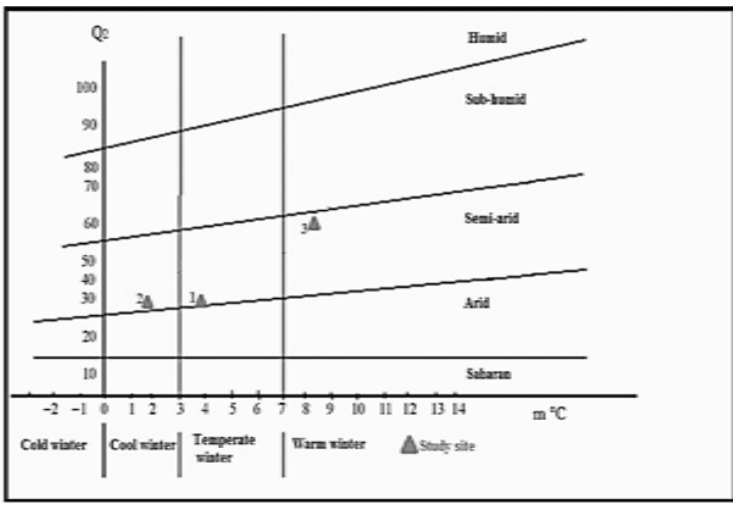

Fig. 3. Emberger climagram

glandular hypogyal disc more or less lobed. 3 styles more or less wide; the capsule is opened by three valves. Seeds topped with an egret and are frequent, and easily colonize land, especially salty.

Tamarix africana: 5-8mm wide inflorescence; obtuse anthers at the top. Pentamer flowers, sessile kittens, born of the previous year's wood, dense and scattered, short (2-3 mm), long style, almost linear narrow bract, short-tipped lanceolate leaves; 5x3 mm ovoid capsule; white flowers, pink or red **(**Fig. 4, Plate 1**).**

Fig. 4. The different parts of *Tamarix africana* (1: fruit; 2: kitten; 3: leaves; 4: twigs; 5: ovary; 6: stamens; 7: the petals of the flower)

Table 1. Comparative character of the two species of *Tamarix*

Tamarix africana	*Tamarix gallica*
Shrub of 2 to 3 m and mature of 3-5 m	Shrub of 1 to 8 m
The trunk has a large width	No main trunk
Green sepals	Purple sepals
Large flowers	Small globular flowers
Flowers have a pink and white color	Flowers have a pink color
Presence of 5 stamens	5 stamens with inserted net
3-4 mm wide kitten born on the shoots of the previous year	Kitten is 5-8 mm nascent on old woods
5 lobed disc	10 lobed disc
Very common species in Algeria	Very common species except in the Sahara
Biogeographic type: /W-Med/	Biogeographic type: /N-Trop/

Plate 1. *Tamarix africana* inflorescence branch (Source: plank 194 of the great flora)

The characteristics observed on our samples are very similar to the characteristics of the species *Tamarix africana*, the leaves are lanceolate with a narrow bract, the capsule is ovoid, wide inflorescence, up to eight mm. These characteristics differ mainly at the flower level, they are pentameric and dense, with sessile kittens, scattered and short. The stamens are non-salient and the anthers are obtuse. Finally, we have noticed that the flowers are pink in the site 3, and they are white in the site 1 and 2.

CONCLUSIONS

Field observations of genus *Tamarix*, with its careful laboratory identification, indicate the presence of the species *Tamarix africana*. This presence is certainly due to the amount of rainfall and average temperatures. *Tamarix africana* dominates all the banks of Tafna wadi in the region of Tlemcen.

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Population Dynamics of Midrib Folder, *Banisia myrsusales elearalis* (Walker) in Sapota and its Rootstock, Khirnee

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Abstract: The population dynamics of midrib folder, *Banisia myrsusales elearalis* (Walker) was studied for three consecutive years on sapota and its rootstock, Khirnee. The results showed that the peak incidence of the midrib folder was commenced from October onwards on tender leaves after monsoon period and reached maximum (7.69-9.48%) on sapota and (9.87-11.39%) on Khirnee, during November to January and October-November, respectively under favourable ecological circumstances at new foliage flush phase. The damage intensity reduces from February onwards at peak flowering and advance fruiting phase. The correlation data was unlike during all the three years in both crop hosts generally, there was negative influence of minimum temperature and evaporation on midrib folder incidence on sapota and Khirnee, but not consistent all three consecutive years. The regression coefficient data showed non-significant results on midrib folder damage, however, few ecological factors showed significant effect.

***Keywords*:** *Banisia myrsusales elearalis* (Walker), Midrib folder, Population dynamics, Sapota

Sapota *Manilkara zapota* (L) P. Royan is vital fruit in Indian horticulture farming and also has attained the status of major fruit crop under south Gujarat agro-system due to its continuous flowering and fruiting pattern throughout the year. Currently, the Gujarat state produces about 325.15 thousand MT from an area of 25.56 thousand ha having productivity of 11.0 MT ha^{-1} (Anonymous 2017). During last five year, Gujarat has stable area with slight increase in production and productivity. Previously, sapota was not much damaged by insect pests and not a serious problem in orchards, but now incidence of major insect pests along with many minor and sporadic pests have been reported during last two decade. Earlier, about 16 insect pests and mites from sapota recorded in Gujarat (Patel 2002) and that numbers reached to 23 pests in sapota orchard with expansion in the acreage. There are about 33 pests have been reported on sapota tree in India (Bisane et al 2018). Among different foliage insect pests, midrib folder (leaf folder), *Banisia myrsusales elearalis* (Walker) (Lepidoptera: Thyrididae) is a regular and major pest (severity of incidence) of sapota particularly in newly planted orchards in south Gujarat agro-ecological situation. Midrib folder is major pest on sapota and Khirnee (rootstock of sapota) under nursery and field condition, which retard the growth and development of new grafts twig. Recently, the pest was also recorded for the first time and becoming a serious at ZHRS, Mudigere under hill zone of Karnataka (Ravulapenta et al 2013). Therefore, the approach of present study was to assess the present seasonal status of this foliage feeder and damage intensity in relation crop stages in recent varying ecological situation.

MATERIAL AND METHODS

The seasonal pest succession study was conducted during three consecutive years of 2015-16, 2016-17 and 2017-18 at Fruit Research Station, Navsari Agricultural University, Gandevi, Gujarat (20.807545º N 73.022260º E). The study on per cent leaf damage due to midrib folder was noted on sapota cv. Kalipatti planted at 10 x 10 m spacing kept free from insecticidal application. For investigation, 20 new aged trees (9 years old trees) from sapota cv. Kalipatti orchard was randomly selected and observed at fortnightly interval. On each tree, randomly selected three twigs were observed critically, from which the damaged and healthy leaves were counted and per cent infestation worked out. The damage intensity was also recorded on alternate host *i.e.* Khirnee (*Manilkara hexandra*), a rootstock of sapota (*Manilkara zapota*) on randomly selected ten plants by counting total leaves and damage leaves at fortnightly interval. The age of rootstock seedlings was between 2-3 years which were used for grafting. To assess the influence of various ecological factors on succession of foliage feeder, the linear correlation coefficient was determined for previous and current fortnight's weather parameters collected from same location of FRS, NAU, Gandevi. The fortnightly leaf damage (Y) was correlated with different meteorological parameters and simple correlation was determined for preceding and current fortnightly weather condition. The leaf damage was further analyzed with regression equation to

measure the per cent variability in foliage pest elucidated by each weather variables for previous and for current fortnight weather condition. Furthermore, again regression equation prepared with major five weather parameters *viz.*, maximum (X_1) and minimum (X_2) temperature; morning (X_3) and evening (X_4) relative humidity and rainfall (X_6) to check crucial weather factors (s), which were significantly associated with midrib folder infestation level. The prediction trend of the pest was calculated on current fortnight's weather data along with the per cent error variation between observed and predicted midrib folder incidence during each year of investigation.

RESULTS AND DISCUSSION

In regards to midrib folder damage behaviour, the caterpillar infests leaves by making the leaf fold and feed within single larvae feed by folding the single leaves looks like 'pea pod' or bunch 2-3 leaves of a twig and damaged up to 5 to 10 leaves during its larval period. Leaves infestation due to midrib folder was found round the year on sapota and Khirnee (rootstock of sapota) with varying degree of intensity (Table 1). The leaf infestation due to midrib folder was reached crest phase during November (7.59-9.52%) and December (8.05-8.49%) in sapota cv. Kalipatti, whereas on Khirnee, it peaked (9.32-14.47%) between long spell of August to December coinciding with emergence of fresh foliage after monsoon during 2015-16. During 2016-17, the midrib folder infestation was low (less than 7 per cent) throughout the year on sapota cv. Kalipatti as compare to previous cropping year 2015-16. However, maximum damage (4.46-6.31%) was noted during November and December. Similarly, its main damage intensity on Khirnee also decreased during 2016-17 and observed between 6.50 to 8.59 per cent restricted to November and December months only. In later months, leaf damage was not so severe

Table 1. Seasonal abundance of midrib folder on sapota cv. Kalipatti and Khirnee

Month	FN	Leaves damaged by midrib folder on sapota *(%)*								Crop stage
		Kalipatti				Khirnee				
		2015-16	2016-17	2017-18	Average	2015-16	2016-17	2017-18	Average	
April	I	2.22	4.23	3.59	3.35	4.35	3.37	4.44	4.05	Peak flowering and fruiting stage
	II	2.40	3.71	5.05	3.72	5.88	2.30	4.60	4.26	
May	I	2.58	3.24	4.65	3.49	4.95	2.15	4.76	3.95	
	II	2.65	2.90	6.56	4.04	5.05	2.06	4.55	3.89	
June	I	2.32	3.32	9.83	5.16	7.00	2.11	6.06	5.06	
	II	2.01	2.97	10.78	5.25	5.49	2.08	8.40	5.33	
July	I	2.22	2.91	9.71	4.94	7.55	3.96	9.60	7.04	Fruit setting and development stage
	II	2.18	2.50	6.15	3.61	6.45	3.88	10.16	6.83	
August	I	3.44	2.93	7.73	4.70	10.68	3.57	11.48	8.58	
	II	3.11	3.14	7.13	4.46	9.32	4.31	9.60	7.74	
September	I	3.82	4.34	8.46	5.54	11.11	5.69	12.82	9.87	
	II	4.15	5.33	6.93	5.47	12.03	5.93	11.38	9.78	
October	I	5.20	5.39	7.88	6.16	12.73	5.60	13.49	10.61	New foliage and fruiting initiation stage
	II	6.39	6.22	9.81	7.48	14.47	7.83	11.86	11.39	
November	I	7.59	5.28	11.15	8.00	12.17	6.50	11.01	9.89	
	II	9.52	4.46	12.13	8.70	13.03	6.98	10.57	10.19	
December	I	8.49	5.73	13.85	9.36	11.47	7.69	8.57	9.24	
	II	8.05	6.31	14.07	9.48	10.78	8.59	7.27	8.88	
January	I	7.95	4.94	12.05	8.32	8.12	7.22	7.34	7.56	Peak fruiting and flowering initiation stage
	II	6.01	4.36	12.70	7.69	8.00	6.54	8.33	7.63	
February	I	4.41	4.55	11.42	6.79	4.55	4.95	7.14	5.55	
	II	4.05	3.07	11.11	6.07	3.45	4.21	6.14	4.60	
March	I	4.06	2.63	10.48	5.72	3.30	4.35	6.48	4.71	
	II	3.72	2.10	9.94	5.25	2.25	4.40	5.61	4.08	

FN = Fortnight

(<5%). The seasonal occurrence of pest was found prominently during 2017-18 on sapota with 9.81-14.07 per cent leaf damage between long spell of October to March and between 9.60-13.49 per cent from July to November on Khirnee. The pooled percentage of seasonal occurrence of midrib folder showed leaf damage was observed throughout the year, but at the last phase of monsoon, the trend of leaf infestation was augmented from October onwards in sapota and from July in Khirnee on initiation of new foliage flush. The peak leaf damage due to midrib folder was exhibited during November (8.00-8.70%), December (9.36-9.48%) and January (7.69-8.32%) on sapota cv. Kalipatti while on Khirnee, incidence was maximum in September (9.78-9.87%), October (10.36-10.61%) and November (9.89-10.19%). The incidence declined January onwards on both crops and remains low (<6%) during summer and monsoon period of flowering and fruit developmental phase.

In earlier records of same location, there was infestation level of midrib folder below 5 per cent on sapota cv. Kalipatti till 2001 (Anonymous 1995, 1998 and 2001 and Deshmukh 2001) and increased above 10 per cent in succeeding years (Anonymous 2007 and 2010). Recently during 2013-14 and 2014-15, the midrib folder peak incidence on sapota and Khirnee was noted during November and December at new foliage flush phase (Bisane 2017). The similar type of trend of amplified damage was noted in current investigation period, which confirms that it is became a regular and major foliage pest on sapota and Khirnee under agro-ecosystem of south Gujarat region. The present findings are also in close agreement with the results other locations, wherein Ravulapenta et al (2014) found peak activity of midrib folder of more than 10 per cent in November and December under hill zone of Karnataka after monsoon. The effect of ecological factors on incidence of midrib folder in sapota during 2015-16 showed significant negative correlation with preceding and current minimum temperature, morning RH and evaporation, while only current evening RH had negative influence on leaf damage (Table 2). However during 2016-17 in contrast to earlier year, current minimum temperature caused significant negative impact on leaf damage on sapota and other weather factors didn't showed any role may be due to low infestation level. However, during both the years, current bright sunshine hrs showed significantly positive role on midrib folder on sapota. Again in 2017-18, preceding and current minimum temperature negatively influenced midrib folder damage in sapota, while current maximum temperature negatively and bright sunshine hrs positively had slight effect on infestation level. In case of midrib folder on Khirnee, leaf incidence influenced only by evaporation negatively during 2015-16. While during 2016-17, preceding and current minimum temperature and evaporation rate had significantly negative role in increasing infestation on Khirnee. Similarly, current bright sunshine hrs had slight positive impact on leaf damage. However during 2017-18, preceding and current morning RH positively and evaporation negatively showed correlative response with leaf damage. Also, preceding evening RH and rainfall had positive responses on seasonal occurrence.

This indicated that the current weather situation particularly minimum temperature and evaporation along with morning RH partially were more favourable to boost leaf damage which was coupled with new foliage phase after monsoon in sapota while in Khirnee, there was no strong

Table 2. Correlation of midrib folder on sapota cv. Kalipatti and Khirnee with weather factors

Year	Weather parameters						
	Temperature (^{0}C)		Relative Humidity (%)		Bright sunshine hrs.	Rainfall (mm)	Evaporation (mm day^{-1})
	Maximum	Minimum	Morning	Evening			
Midrib folder on sapota							
2015-16	0.084 (-0.089)	-0.480* (-0.663)**	-0.496** (-0.457)*	-0.380 (-0.515)**	0.331 (0.430)*	-0.241 (-0.379)	-0.430* (-0.412)*
2016-17	-0.084 (-0.305)	-0.261 (-0.456)*	0.321 (0.184)	-0.075 (-0.314)	0.220 (0.405)*	-0.188 (-0.301)	-0.360 (-0.307)
2017-18	-0.366 (-0.445)*	-0.500** (-0.661)**	0.259 (0.243)	-0.220 (-0.280)	0.367 (0.469)*	-0.169 (-0.229)	-0.311 (-0.397)
Midrib folder on Khirnee							
2015-16	0.393 (0.369)	0.267 (0.036)	-0.201 (-0.302)	0.283 (0.004)	-0.268 (-0.132)	0.197 (-0.067)	-0.380 (-0.438)*
2016-17	-0.351 (-0.365)	-0.515** (-0.705)**	0.290 (0.175)	-0.168 (-0.372)	0.262 (0.445)*	-0.089 (-0.163)	-0.633** (-0.564)**
2017-18	0.065 (0.093)	0.402 (0.181)	0.753** (0.723)**	0.603** (0.361)	-0.233 (0.000)	0.447* (0.217)	-0.755** (-0.724)**

* Significant at 5% level and ** at 1% level
# Value in parentheses are current weekly data and values in outside are preceding fortnight data

influence to enhance leaf incidence by midrib folder. This indicated that the crop stage which pronounced after monsoon was generally coupled with higher prevalence of leaf damage. In few previous reports of midrib folder correlation with weather parameters in sapota (Anonymous 1995, 1998), the present investigation results is not match may be due to difference in ecological situation as well as there was low incidence of this pest.

The regression equation model of midrib folder incidence on sapota cv. Kalipatti (Table 3) indicated that the regression coefficients corresponding to all the preceding and current weather parameters were found significant only

Table 3. Regression equations of midrib folder on sapota cv. Kalipatti and Khirnee

Year		Regression equation	R^2
Midrib folder on sapota			
2015-16	Preceding (All weather factors)	$Y = 4.598 + 0.418X_1 - 0.191 X_2 - 0.100 X_3^* + 0.048 X_4 + 0.239 X_5 - 0.002 X_6 - 1.051 X_7 + 1.198$	0.82
	Preceding (Five major weather factors)	$Y = - 2.657 + 0.722 X_1^* - 0.639 X_2 - 0.126 X_3^* + 0.173 X_4^* - 0.001 X_6 + 1.297$	0.76
	Current (All weather factors)	$Y = 5.958 + 0.507 X_1 - 0.525 X_2 - 0.088 X_3 + 0.071 X_4 - 0.182 X_5 - 0.004 X_6 - 0.261 X_7 + 1.165$	0.83
	Current (Five major weather factors)	$Y = - 1.575 + 0.560 X_1^* - 0.604 X_2 - 0.104 X_3^* + 0.138 X_4^* - 0.003 X_6 + 1.183$	0.80
2016-17	Preceding (All weather factors)	$Y = 1.558 + 0.035 X_1 + 0.128 X_2 + 0.032 X_3 - 0.016 X_4 + 0.115 X_5 - 0.008 X_6 - 0.701 X_7 + 1.063$	0.49
	Preceding (Five major weather factors)	$Y = - 3.891 + 0.017 X_1 - 0.084 X_2 + 0.100 X_3 + 0.015 X_4 - 0.005 X_6 + 1.122$	0.36
	Current (All weather factors)	$Y = 3.782 + 0.006 X_1 + 0.135 X_2 + 0.028 X_3 - 0.037 X_4 + 0.091 X_5 - 0.007 X_6 - 0.684 X_7 + 1.024$	0.53
	Current (Five major weather factors)	$Y = - 2.324 - 0.012 X_1 - 0.065 X_2 + 0.102 X_3 - 0.007 X_4 - 0.004 X_6 + 1.058$	0.43
2017-18	Preceding (All weather factors)	$Y = 2.101 + 0.017X_1 - 0.399X_2 + 0.212X_3 - 0.018X_4 - 0.332X_5 - 0.004 X_6 - 0.174X_7 + 2.545$	0.46
	Preceding (Five major weather factors)	$Y = - 1.656 - 0.003X_1 - 0.363 X_2 + 0.192 X_3 + 0.031X_4 - 0.003 X_6 + 2.448$	0.44
	Current (All weather factors)	$Y = 16.625 + 0.101 X_1 - 0.623X_2 + 0.011X_3 + 0.082X_4 - 0.212X_5 - 0.008X_6 - 0.650X_7 + 1.752$	0.74
	Current (Five major weather factors)	$Y = 3.422 + 0.065 X_1 - 0.673 X_2^* + 0.110 X_3 + 0.138 X_4 - 0.006 X_6 + 1.785$	0.70
Midrib folder on *Khirnee*			
2015-16	Preceding (All weather factors)	$Y = - 11.801 + 0.782 X_1 + 0.031 X_2 - 0.141 X_3 + 0.209 X_4 + 0.674 X_5 - 0.002 X_6 - 1.752 X_7^* + 2.156$	0.75
	Preceding (Five major weather factors)	$Y = - 20.994 + 1.319 X_1 - 0.756 X_2^* - 0.175 X_3^* + 0.381 X_4 - 0.001 X_6 + 2.259$	0.69
	Current (All weather factors)	$Y = 0.131 + 0.735 X_1 - 0.029 X_2 - 0.097 X_3 + 0.055 X_4 + 0.05 X_5 - 0.010 X_6 - 1.906 X_7 + 2.343$	0.70
	Current (Five major weather factors)	$Y = - 17.150 + 1.265 X_1^* - 0.793 X_2^* - 0.163 X_3^* + 0.339 X_4^* - 0.007 X_6 + 2.698$	0.56
2016-17	Preceding (All weather factors)	$Y = 19.023 - 0.008 X_1 + 0.175 X_2 - 0.106 X_3 - 0.016 X_4 + 0.107 X_5 - 0.013 X_6^* - 1.749 X_7^* + 1.126$	0.78
	Preceding (Five major weather factors)	$Y = 3.890 - 0.063 X_1 - 0.332 X_2^* + 0.056 X_3 + 0.083 X_4 - 0.006 X_6 + 1.598$	0.50
	Current (All weather factors)	$Y = 13.788 + 0.073 X_1 + 0.014 X_2 - 0.040 X_3 - 0.039 X_4 + 0.009 X_5 - 0.009 X_6^* - 1.308 X_7^* + 1.083$	0.80
	Current (Five major weather factors)	$Y = 0.439 + 0.029 X_1 - 0.343 X_2^* + 0.099 X_3 + 0.034 X_4 - 0.003 X_6 + 1.265$	0.69
2017-18	Preceding (All weather factors)	$Y = 1.157 - 0.03X_1 + 0.532X_2 - 0.029X_3 - 0.002X_4 + 0.798 X_5^* + 0.001 X_6 - 1.222X_7^* + 1.348$	0.84
	Preceding (Five major weather factors)	$Y = -21.940 - 0.024 X_1 + 0.182 X_2 + 0.345 X_3^* - 0.040X_4 + 0.002 X_6 + 1.952$	0.61
	Current (All weather factors)	$Y = - 2.550 + 0.042X_1 + 0.523X_2^* + 0.072 X_3 - 0.083 X_4 + 0.608X_5^* - 0.002X_6 - 1.443X_7^* + 1.450$	0.81
	Current (Five major weather factors)	$Y = -30.551 - 0.009 X_1 + 0.198 X_2 + 0.373 X_3^* - 0.093 X_4 - 0.001 X_6 + 2.039$	0.58

* Significant at 5% level.
X_1 = Maximum temperature; X_2 = minimum temperature; X_3 = morning relative humidity and X_4 = evening relative humidity; X_5 = bright sunshine hrs; X_6 = rainfall and X_7 = evaporation

with morning relative humidity" instead of only with maximum temperature along with morning-evening relative humidity particularly during 2015-16 and non-significant in other years. There was high variability in midrib folder infestation to the extent of 82 and 83 per cent during 2015-16 against all preceding and current fortnightly weather factors, respectively with significant effect of morning relative humidity under preceding ecological situation. In case of five major ecological factors, parallel 76 and 80 per cent variation noted against preceding and current fortnightly weather factors, respectively with significant influence of maximum temperature and morning-evening relative humidity. The R^2 value was low as 49 and 53 per cent during 2016-17 against all the preceding and current fortnightly weather factors, respectively and effect was found non- significant. Over five major ecological factors, here also very lower 36 and 43 per cent variation noted against preceding and current fortnightly weather data, respectively and effect was found non-significant in both cases. As well, the variability was low to the extent of 46 and 74 per cent against all the preceding and current weather parameters, respectively during 2017-18 and effect was found non-significant. In five major ecological factors regression, here also slightly lower 44 and 70 per cent variation noted against preceding and current fortnightly weather data, respectively with only significant influence of current minimum temperature condition. Here, five major ecological factors influence was found more on midrib folder incidence.

The regression equation model of midrib folder leaf damage on Khirnee (Table 5) indicated that the all the regression coefficients corresponding to all preceding and current weather parameters were showed varying significance during each year. The extent of variation of midrib folder damage against all the preceding and current

Table 4. Foliage damage prediction variability due to midrib folder in sapota cv. Kalipatti

Month	FN	Predicted incidence in 2016-17	Per cent error variation between observed and predicted incidence	Predicted incidence in 2017-18	Per cent error variation between observed and predicted incidence	Predicted incidence in 2018-19	Per cent error variation between observed and predicted incidence	Crop stage
April	I	1.64	26.34	4.12	2.65	5.85	-62.86	Peak flowering and fruiting stage
	II	3.77	-57.28	2.92	21.17	6.22	-23.23	
May	I	2.86	-11.11	3.50	-8.28	6.60	-42.11	
	II	1.89	28.57	2.48	14.37	4.47	31.87	
June	I	1.91	17.66	2.46	25.84	6.54	33.51	
	II	2.90	-44.49	3.70	-24.80	9.27	14.01	
July	I	3.17	-42.81	3.42	-17.78	9.01	7.19	Fruit setting and development stage
	II	2.23	-2.65	3.22	-28.61	6.76	-9.90	
August	I	3.42	0.73	2.58	11.98	9.96	-28.95	
	II	2.77	11.11	4.65	-48.14	8.51	-19.37	
September	I	3.68	3.59	3.89	10.26	8.12	3.94	
	II	3.85	7.03	3.95	25.85	8.75	-26.34	
October	I	5.90	-13.44	5.21	3.36	8.91	-13.13	New foliage and fruiting initiation stage
	II	5.80	9.21	5.33	14.36	7.77	20.86	
November	I	8.66	-14.12	4.98	5.67	11.24	-0.87	
	II	6.26	34.23	4.66	-4.53	12.15	-0.22	
December	I	7.33	13.69	5.20	9.17	12.33	10.97	
	II	8.76	-8.74	4.58	27.42	13.38	4.87	
January	I	7.66	3.69	4.36	11.77	12.82	-6.35	Peak fruiting and flowering initiation stage
	II	5.67	5.62	4.89	-12.08	13.00	-2.37	
February	I	5.39	-22.23	5.19	-13.94	10.70	6.26	
	II	5.06	-24.94	3.93	-28.15	11.47	-3.19	
March	I	3.96	2.50	3.81	-44.78	10.14	3.28	
	II	3.99	-7.24	3.51	-66.96	9.16	7.86	

FN = Fortnight

fortnightly weather factors was found moderate up to 75 to 70 per cent during 2015-16 with significant impact of preceding evaporation. In five major ecological factors regression model, here also slightly lower 69 and 56 per cent variation noted against preceding and current fortnightly weather data, respectively with only significant influence of minimum temperature and morning relative humidity in both weather circumstances addition to current minimum temperature and evening relative humidity. The R^2 value moderate high up to 78 and 80 per cent noted during 2016-17 against all the preceding and current fortnightly weather factors, respectively with significant effect of rainfall and evaporation in both circumstances. Under situation of five major ecological factors, here lower 50 and 69 per cent variation noted against preceding and current fortnightly weather data, respectively with significant influence of minimum temperature. Here during 2016-17, more influence of five major ecological factors was distinguished as compare to all parameters.

As well during 2017-18 in *Khirnee*, the variability was high up to 84 and 81 per cent against preceding and current weather parameters, respectively along with significant impact of bright sunshine hrs and evaporation under both weather circumstances. Also, current minimum temperature was also showed effect on midrib folder infestation level. In five major ecological factors regression model, here lower 61 and 58 per cent variation noted against preceding and current fortnightly weather data, respectively with only significant influence of morning relative humidity condition. The prevailing morning relative humidity between 70-80 per cent was noted during high infestation period with more or less in few weeks and only showed effective correlation and regression equation. This indicated that the relative humidity during monsoon and winter season is more favourable to

Table 5. Foliage damage prediction variability due to midrib folder in *Khirnee*

Month	FN	Predicted incidence in 2016-17	Per cent error variation between observed and predicted incidence	Predicted incidence in 2017-18	Per cent error variation between observed and predicted incidence	Predicted incidence in 2018-19	Per cent error variation between observed and predicted incidence	Crop stage
April	I	2.21	49.23	3.54	-4.93	4.28	3.73	Peak flowering and fruiting stage
	II	7.66	-30.17	2.38	-3.36	4.35	5.40	
May	I	6.53	-31.95	2.95	-37.08	4.02	15.64	
	II	4.22	16.44	1.11	46.07	4.26	6.22	
June	I	5.27	24.70	1.14	45.84	7.54	-24.44	
	II	9.31	-69.47	3.76	-80.43	9.30	-10.62	
July	I	8.44	-11.79	4.41	-11.37	10.00	-4.21	Fruit setting and development stage
	II	6.98	-8.24	4.17	-7.50	9.34	8.02	
August	I	10.56	1.12	3.52	1.37	11.78	-2.64	
	II	8.90	4.51	5.48	-27.11	10.26	-6.92	
September	I	8.63	22.31	4.84	14.89	11.75	8.36	
	II	9.47	21.28	4.85	18.32	11.23	1.36	
October	I	13.01	-2.18	5.60	-0.02	11.96	11.34	New foliage and fruiting initiation stage
	II	12.24	15.36	6.31	19.35	11.73	1.11	
November	I	13.16	-8.13	6.20	4.67	8.58	22.04	
	II	11.15	14.47	7.02	-0.68	8.70	17.72	
December	I	10.40	9.31	6.57	14.61	8.33	2.77	
	II	10.41	3.47	7.64	11.16	7.13	2.03	
January	I	9.18	-12.97	6.78	5.99	9.07	-23.53	Peak fruiting and flowering initiation stage
	II	4.41	44.90	6.50	0.60	8.40	-0.78	
February	I	6.75	-48.41	6.75	-36.34	6.58	7.88	
	II	6.80	-97.27	5.53	-31.26	6.05	1.41	
March	I	4.50	-36.61	4.74	-9.00	8.90	-37.39	
	II	3.99	-77.52	4.48	-2.01	8.13	-44.96	

FN = Fortnight

midrib folder incidence coincide with peak foliage phase of sapota and Khirnee. All the above regression equations values revealed that the foremost minimum temperature as well as morning relative humidity and ultimately correlative effect of bright sunshine hrs and evaporation alternatively have augment the midrib folder incidence in sapota and Khirnee. The regression with absence of bright sunshine hrs and evaporation showed lower variability and proved its role under seasonal occurrence. This showed that complimentary stipulation of major ecological factors is more sensitive to pest damage along with crop stage in midrib folder activity. There were no major references available on regression models of midrib folder on sapota and Khirnee to compare the current data.

The prediction trend model was prepared on the basis of regression coefficient and compared with current year incidence data (Table 4). The higher leaf damage prediction indicated in few fortnight of April to July months as well as in February and was actually recorded during 2016-17 at moderate level intensity in sapota cv. Kalipatti. Similarly, he moderate to high altitude prediction was calculated in leaf damage incidence due to midrib folder in Kalipatti during 2017-18 in June-July and January to March, which was actually reported during 2017-18 with more leaf damage. The higher leaf infestation was also predicted during 2018-19 in the months of April-May and August-September. Under Khirnee (Table 5), the prediction and actually observed incidence was found comparable from January to March during 2016-17, but showed mismatch results April-May months. The leaf infestation prediction in the months of April-May, July-August and February-March during 2017-18 was more or less similar with actual data recorded. The prediction of 2017-18 indicated lesser incidence of midrib folder in upcoming season of 2018-19. This indicated that the weather factors persuade parallel leaf damage and favourability under sapota and Khirnee. There was no major role of ecological parameters and incidence restricted to new foliage flush phase of Khirnee.

CONCLUSION

The data on succession of midrib folder indicated that the crest infestation segment of the leaf damage on sapota and *Khirnee* was commenced from September-October onwards on tender twigs after monsoon period and reached peak during November and December on new foliage flush of crop. The damage intensity remains moderate to low during April to June at flowering stage as well as in July-August at fruit development span. Among ecological factors, minimum temperature and morning relative humidity as well as correlative bright sunshine hrs and evaporation had major role to persuade the midrib folder incidence in sapota and Khirnee.

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Development of Ecological Regional Maximum Permissible Concentrations of Fuel Oil in Arid Soils of South of Russia

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Abstract: Soil contamination with oil and petroleum products, including fuel oil is often found in the South of Russia. The growth of oil production and transportation leads to increased soil pollution in the region. It is established that contamination of the studied soils with fuel oil leads to deterioration of their biological properties: the total number of bacteria, activity of catalase and dehydrogenase, cellulolytic ability, abundance of bacteria of the genus *Azotobacter* decreases, indicators of germination and initial growth of plants deteriorate. A series of soil resistance of arid ecosystems of the South of Russia to fuel oil pollution has been obtained. (number-averaged doses, the soil located at least reduce their resistance): ordinary black ≥ dark brown soil > chestnut soil > light chestnut soil > brown desert-steppe soil > sandy soil. The study allowed us to propose regional standards for the maximum permissible content of fuel oil in the arid ecosystem of the South of Russia on the basis of violations of environmental and agricultural soil functions.

Keywords: Arid soils, Brown semi-desert soils, Chestnut soil, Fuel oil, Maximum permissible concentrations, Pollution, Resilience, Sandy soil

Currently, oil and oil products are one of the main soil pollutants. Sources of soil pollution with oil products can be leaks from underground tanks and pipelines, accidental spills during transportation, irregularities when drilling wells and improper waste disposal methods, unauthorized tapping into oil pipelines, gas stations, boiler houses, etc. (Rakowska et al 2012, Vodyanitsky et al 2016, Hewelke et al 2018). Soil contamination by oil and oil products causes a great damage to soil fertility (Yeung et al 2011, Anikwe et al 2019). This is due to the fact that petroleum hydrocarbons are mixtures of organic compounds with low bioavailability, and in addition are potentially carcinogenic and mutagenic (Janbandhu and Fulekar 2011, Souza et al 2012, Kaczyńska et al 2015). Oil products are characterized by high toxicity, scale of pollution and high ability to migrate (Bandura et al 2015, Bieganowski et al 2018). In assessing the eco-toxicity of heavy metals and oil products, biological indicators of the state of the soil play a primary role **(**Adesina and Adelasoye 2014, Kazeev et al 2016). Soil pollution by oil and oil products, including fuel oil, is often found in southern Russia. Volgograd and Astrakhan regions, Krasnodar Territory, Ingushetia and the Chechen Republic have great potential of hydrocarbon raw materials. An increase in oil production and transportation leads to increased soil pollution in this region (Atlas of socio-economic development of the South of Russia 2011). Soil conservation in arid ecosystems is important to maintain the biodiversity and sustainability of natural ecosystems.

The soil cover of arid ecosystems in the South of Russia is represented by zonal chestnut and brown semi-desert soils, as well as intrazonal sandy brown semi-desert soils (National Atlas of Soils of the Russian Federation 2011). These soils differ significantly in ecological and genetic properties (Val'kov et al 2008), and accordingly, in resistance to fuel oil pollution (Kolesnikov et al 2010). Accordingly, the maximum permissible concentration of pollutants in these soils should also differ. The aim of the work is to develop regional standards for fuel oil content in arid soils of the South of Russia.

MATERIAL AND METHODS

Fuel oil pollution was simulated in the laboratory conditions. The soils of arid ecosystems of the Southern Russia (dark chestnuts, chestnuts, light chestnuts soils (arenosolscalcaric), as well as ordinary chernozems (chernozemschernic), were used as objects of study. Soil samples for model experiments were selected from the top layer from the 0-10 cm surface. In the non-arable soils, the major amount of the pollutants is accumulated in this particular layer (Tables 1, 2).

Soil contamination by fuel oil was simlated as a percentage 1, 5, 10 per cent of the soil mass, Contamination of soil by fuel oil in such concentrations is often found in areas of oil extraction, transportation and processing of gasoline, even after the liquidation of pollution. The soil was incubated in the vegetation vessels at a room temperature (20-22°C) and the optimal moisturizing (60% of the field moisture capacity) in a three-fold replication. The biological status of the soil was determined 30 days after the pollution. For the

assessment of the chemical effect on the soil, this period is the most informative (Kolesnikov et al 2011).The laboratory and analytical studies were performed using the conventional methods (Soil Microbiology and Biochemistry Methods 1991, Kazeev et al 2016). In this work, we determined the total number of bacteria, the activity of catalase and dehydrogenases, cellulolytic ability, the abundance of bacteria of the genus *Azotobacter*, phytotoxic properties. To combine a large number of indicators, a method was developed for determining the integral indicator of the biological state of the soil (IIBS) (Kazeev et al 2016). This method allows evaluating the biological state of the soil as a whole.

To assess the statistical reliability, analysis of variance was used, with the subsequent determination of the littlest significant difference (LSD): $LSD_{05} = Md \times t_{0.5}$ where Md is the difference error; $t_{0.5}$- student criterion.

RESULTS AND DISCUSSION

The research has shown that the soil pollution of arid ecosystems by fuel oil in the South of Russia leads to a deterioration of their biological properties (Table 3). In most cases, there is a significant decrease in all the studied parameters: The total number of bacteria, the activity of catalase and dehydrogenases, cellulolytic ability, the abundance of bacteria of the genus *Azotobacter*, phytotoxic properties, (IIBS).

As a rule, the degree of the decrease in the biological indicators is directly dependent on the concentration of a pollutant in the soil. The obtained sequence of soils resistance of arid ecosystems in the south of Russia during fuel oil pollution: Ordinary chernozem ≥ dark chestnuts soils > chestnuts soils > light chestnuts soils > brown semi - desert soils > sandy soils. The biological indicators, which used in the study (the total number of bacteria, the activity of catalase and dehydrogenases, cellulolytic ability, the abundance of bacteria of the genus *Azotobacter*, radish root length), confirmed their compliance with the necessary requirements for the indicators used for monitoring, diagnostics and regulation chemical pollution of the soil. They are distinguished by high information content and sensitivity, sufficient reproducibility, permissible variation of the indicator, small experience error, low laboriousness and high detection speed, widespread methods, etc. The resent

Table 1. Soils of arid ecosystems in the South of Russia for the model experiment

Ecological and genetic classification of the Russian soils	World reference base for soil resources (WRB), 2015	Type codes	Ecosystem	Site of selection	Coordinates
Ordinary chernozem (North Priazovsky area)	Haplicchernozem	Che_O	True steppe	Rostov Region, Oktyabrskii District, Persianovskii Village	47°30'18.11"N 40° 9'10.95"E
Dark chestnut alkaline	Kastanozems haplic	Ch_D	Dry steppe	Rostov Region, Orlovskii District, Maiorskii Farm	47° 2'13.91"N 42° 5'23.53"E
Chestnut	Kastanozems haplic	Ch	Dry steppe	Rostov Region, Remontnoe Village	46°34'23.24"N 43°36'28.64"E
Light chestnut	Kastanozems haplic	Ch_L	Dry steppe	Republic of Kalmykia, Elista	46°18'58.77"N 44°22'53.96"E
Brown semidesert	Calcisols haplic	B_{Sd}	Semidesert	Republic of Kalmykia, Yashkulskii District, Khulkhuta Village	46°19'16.71"N 46°19'42.86"E
Sandy brown semidesert	Arenosols calcaric	S	Semidesert	Astrakhan Region, Narimanovskii District, Novokucherganovka Village	46°15'54.02"N 47°49'3.59"E

Table 2. Ecological -biological characteristics soils of the arid ecosystems in the South of Russia

Soil	Amount of the organic matter (%)	pH	Granulometric composition	Activity of catalase, ml O_2 g^{-1} of the soil per 1 minute	Activity of dehydrogenases activity, mg triphenylformazan g^{-1} per 24
Ordinary chernozem	3.8	7.6	Heavy loam	15.8	28.9
Dark chestnut	3.5	7.6	Heavy loam	13.5	25.9
Chestnut	2.8	7.8	Heavy loam	11.4	23.0
Light chestnut	1.4	8.1	Medium loam	9.8	20.6
Brown semidesert	1.2	8.3	Light loam	6.8	20.1
Sandy brown semidesert	0.8	8.3	Sandy	4.6	17.7

Table 3. The impact of pollution by fuel oil on the biological properties of the soils of arid ecosystems in the South of Russia

Fuel oil dose	Soil					
	Ordinary chernozem	Dark chestnut	Chestnut	Light chestnut	Brown semidesert	Sandy brown semidesert
Number of bacteria, billion g^{-1} (n = 720: 3 incubation vessels with soil x 3 soil samples x 4 square centimeters on glass slides x 20 fields of view)						
Control	5,7	5,3	4,9	5,4	2,5	2,5
1 %	5,6	5,0	2,6	3,5	2,3	1,4
5 %	4,1	3,0	2,3	2,9	1,4	1,1
10 %	3,3	1,0	2,0	2,3	1,1	0,7
LSD_{05}*	0,7	0,5	0,4	0,5	0,3	0,2
Abundance of bacteria of the genus *Azotobacter*,% of control (n = 241: 3 incubation vessels with soil x 3 soil samples in Petri dishes x 25 lumps of fouling)						
Control	100	100	100	100	100	100
1 %	100	100	95	94	97	88
5 %	100	98	100	86	40	50
10 %	92	93	48	57	30	38
LSD_{05}	11	11	11	11	9	9
Activity of catalase, ml O_2 g^{-1} of the soil per 1 minute (n = 36: 3 incubation vessels with soil x 3 soil samples x 4 analytical replicates)						
Control	15,5	13,9	14,6	12,0	6,1	3,9
1 %	10,4	12,6	11,7	9,0	4,7	3,5
5 %	5,5	5,6	4,4	4,8	2,3	1,7
10 %	2,7	2,8	2,1	1,7	1,4	0,8
LSD_{05}	1,1	1,1	1,1	0,9	0,5	0,3
Activity of dehydrogenases activity, mg triphenylformazan g^{-1} per 24 hours (n = 36: 3 incubation vessels with soil x 3 soil samples x 4 analytical replicates)						
Control	27,2	20,1	21,1	18,6	19,5	17,2
1 %	24,0	19,5	19,6	11,1	18,0	16,9
5 %	16,5	15,5	15,8	10,3	14,7	12,2
10 %	9,9	7,4	5,0	8,6	6,3	4,9
LSD_{05}	2,9	2,4	2,3	1,8	2,2	1,9
Cellulolytic activity, % of control (n = 9: 3 incubation vessels with soil x 3 cellulose webs)						
Control	100	100	100	100	100	100
1 %	71	50	48	32	29	25
5 %	30	22	11	3	2	2
10 %	1	1	1	1	1	1
LSD_{05}	13	11	10	8	8	8
Root length (phytotoxicity),% of control (n = 241: 3 incubation vessels with soil x 3 soil samples in Petri dishes x 25 radish seeds)						
Control	100	100	100	100	100	100
1 %	99	84	80	75	71	59
5 %	76	75	69	54	50	49
10 %	69	60	60	57	53	35
LSD_{05}	22	20	19	18	17	15
Integral indicator of the biological state of the soil (IIBS),% of control						
Control	100	100	100	100	100	100
1 %	87	86	75	67	77	70
5 %	62	61	55	49	44	43
10 %	46	38	31	36	30	25

*LSD — The least significant difference

observations allowedto establish quantitative landmarks to development the regional standards for maximum permissible concentrations of fuel oil in arid ecosystems of southern Russia based on the violation of the ecological and agricultural functions of the soil.

Kolesnikov (2002) observed that the violation of the ecological functions of the soil occurs in a certain order. As the concentration of the soil polluting chemical increases, the disruption of ecosystem functions performed by it occurs in the following sequence: informational ®biochemical, physico-chemical, chemical, and holistic ®physical (The classification of soil ecosystem functions) given by Dobrovolsky and Nikitin (1990). The different ecological functions of the soil are disturbed at different concentrations of the pollutant in the soil may use as underlie for the environmental regulation of soil pollution. As a criterion for the degree of disturbance of the ecological functions of the soil, it is proposed to use the IIBS. It has been established that if the IIBS values have decreased by less than 5 per cent, then the soil will perform its environmental functions normally, while reducing the IIBS values by 5-10 per cent, there is a violation of information eco-functions, by 10-25 per cent - biochemical, physic-chemical, chemical and holistic, more than 25 per cent - physical (Kolesnikov 2002). Based on the results of the study, the regression equations were constructed, which reflect the dependence of the decrease in the values of IIBS on the content of fuel oil in the soil. Using these equations, the concentrations of fuel oil, that cause a violation of one or another group of soil eco-functions, were calculated, and a scheme of environmental rationing of pollution of arid soils by fuel oil was proposed (Table 4). If the concentration of fuel oil in dark chestnut (haplickastanozems) soil does not exceed 0, 23 per cent by weight of the soil, then the soil functions normally. If the concentration of fuel oil is between 0,23 to 0,30 per cent, there will be a violation of informational ecological functions of the soil, from 0,30 to 0,80 per cent - in addition to information, chemical, physico-chemical, biochemical and integral functions will breakdown, more than 0,80% - a breakdown will occur and physical functions of the soil. The violation of chemical, physico-chemical, biochemical, and most importantly, integral functions of the soil should not be allowed, to ensuring soil fertility. Consequently, the concentration 0, 30 per cent of fuel oil should be considered as maximum permissible concentration (MPC) of fuel oil in the dark chestnut (kastanozemshaplic) soil of the arid ecosystems of southern Russia or regional maximum permissible concentration (rMPC).

The most effective methods of sanitation of arid soils of the South of Russia in case of their pollution with fuel oil in a certain concentration is presented in Table 4. The higher the concentration of fuel oil in the soil, the more “radical” the method of rehabilitation should be. For example, if the content

Table 4. Scheme of environmental regulation of pollution arid soils in the south of Russia by fuel oil according to the degree of violation of ecological functions

The content of fuel oil in the soil (%)						The degree of reduction of the integral index 1	Impaired environmental functions2	soil pollution degree	The most appropriate methods for the rehabilitation of soils contaminated by fuel oil
Che_O	Ch_D	Ch	Ch_L	B_{Sd}	S				
< 0.23	< 0.23	< 0.19	< 0.15	< 0.19	<0.18	< 5 %	–	Not polluted	Remediation is not required
0.23 – 0.32	0.23 – 0.30	0.19 – 0.24	0.15– 0.20	0.19 – 0.23	0.18 – 0.22	5 – 10 %	Informational	Slightly-polluted	Activation of native hydrocarbon-oxidizing micro flora by optimizing the agrophysical and agrochemical properties of contaminated soils
0.32 – 1.0	0.30 – 0.80	0.24 – 0.60	0.20 – 0.45	0.23 – 0.50	0.22 – 0.40	10 – 25 %	Chemical, physico-chemical, biochemical; holistic	Medium-polluted	The use of preparations with hydrocarbon-oxidizing microorganisms, the use of mineral or organo-mineral fertilizers, the sowing of perennial leguminous herbs
> 1.00	> 0.80	> 0.60	> 0.45	> 0.50	> 0.40	> 25 %	Physical	Strong-polluted	Removing contaminated soil and replacing it with a new environmentally and agriculturally one

1. Determination of the integral index according to Kolesnikov (2002).
2. Classification of environmental functions according to Dobrovolsky and Nikitin(1990).

of fuel oil in dark brown soil is less than 0.23 per cent and there is no violation of its ecological functions, then soil sanitation is not required in this case. If the concentration of fuel oil is 0.23-0.30 per cent, then activation of the native hydrocarbon-oxidizing micro flora by optimizing the agro-physical and agrochemical properties of contaminated soils is sufficient to reduce its concentration to 0.23 per cent or less. If the concentration of fuel oil reaches 0.30-0.80 per cent, then the use of preparations with hydrocarbon-oxidizing microorganisms, the use of mineral or organic-mineral fertilizers, and the sowing of perennial leguminous herbs will be required. If the fuel oil content exceeds 0.80%, land reclamation measures will be less effective than removing the upper contaminated soil layer.

CONCLUSION

The soil pollution of arid ecosystems by fuel oil in the South of Russia leads to a deterioration of their biological properties: decreases the total number of bacteria, the activity of catalase and dehydrogenases, cellulolytic ability, abundance of bacteria of the genus *Azotobacter*, deteriorating indicators germination and initial plant growth. In most cases, for all the studied soils, the degree of the decrease in the biological indicators is directly dependent on the concentration of pollutant in the soil. Used in the work indicators of the biological state of the soil can be recommended for widespread using in for monitoring, diagnostics, indication and regulation of chemical pollution of the arid soils. According to the degree of resistance to fuel oil pollution soils of arid ecosystems of Southern Russia form the following row: Ordinary chernozem ≥ dark chestnuts soils > chestnuts soils > light chestnuts soils > brown semi - desert soils > sandy soils. Suggested quantitative landmarks to development the regional standards for the maximum permissible concentrations of fuel oil in arid soils based on the violation of their ecological functions.

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Effects of Overgrazing on the Physico-chemical and Biological Properties of Semi-arid Forest Soils in Western Algeria

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Abstract: In Algeria, in recent years long periods of drought have forced several breeders to ride with their herds to the north of the country to find food for their flocks. The semi-arid zone that represents the last barrier against desertification is fragile and vulnerable. The pressures exerted by these animals have an effect on the soil. In present study, the impact of overgrazing on the quality of semi-arid soils in western Algeria was estimated on the physicochemical and biological properties of a grazed area were compared with that of a protected area in an Aleppo pine forest in wilaya of Saida. The physical properties like bulk density, moisture and retention capacity are negatively affected by overgrazing. The overgrazing has a negative effect on organic matter. Microbial biomass and basal respiration decreased in the grazed area compared with the witness. The metabolic quotient recorded a higher rate in the area affected by overgrazing than the protected area. This research shows us that overgrazing can affect certain soil characteristics and irreversibly degrades the soil continuum of the semi-arid zones.

Keywords: Aleppo pine, Forest, Overgrazing, Soil quality, Semi-arid

The conservation of forests in the mediterranean basin is a complex problem because of the heterogeneity of the situations, the multiple uses and anthropic pressures practiced by the various cultural entities of the Mediterranean for millennial (Quézel and Médail 2003). Grazing is an important factor in the structuring and functioning of ecosystems (Rossignol 2006). The degradation of ecosystems in Algeria by the drought encountered in recent years is associated with the impact of sheep grazing (Slimani et al 2010). Statistics have shown that, 60 to 80% of the flock sheep population is concentrated in the steppe and between the 1960 and 2000 the herd multiplied by four. This growth, among the fastest in North Africa, at the same time, forage production in the steppe was reduced about 30% during one of the longest periods of rainfall deficiency of the century (Aidoud et al 2006).

Soil has long been a "black box" in the functioning of the ecosystem, so taking into account the regulatory role of soil in ecosystems only appears late in the 20th century (Andrews et al 2004). Changes in use and intensive exports are among the major causes of soil degradation and directly impact or threaten human well-being (Stallman 2011). This recent and slow conscience of their rapid global destruction has led to the emergence of the need to define soil quality, coupled with the need to protect (Robinson et al 2012). Considered a mineral environment, the soil is also a place of life. It is home to a very high diversity of species (23%), macro organisms and microorganisms that participate in the operation and the supply of ecosystem services necessary for our survival (vegetable production, biogeochemical cycles, biodegradation of organic matter, purification of pollutants, etc.) (Lucas et al 2007). Different studies have shown that herbivores, through the removal of plant biomass, soil trampling and the deposition of urine and feces, have important effects on vegetation characteristics (Fournier et al 2001, Zoffoun et al 2013) and on soil functioning (Silveira et al 2013). In the arid and semi-arid zones of North Africa, many studies (Amghar et al 2012 in Algeria, Abdallah et al 2012 in Tunisia, Acherkouk and El Houmaizi 2013 in Morocco) have described the positive effects of grazing control on biodiversity and soil properties. Most scientific research in Algeria have been oriented towards the study of overgrazing and its effects on vegetation, but studies on the impact of this pressure on the soil have been completely neglected. Therefore, the objective of this study is to estimate the effect of overgrazing on the physicochemical and microbiological properties, of forest soils populated mainly by Aleppo pine in two stations of the semi-arid zone of western Algeria.

MATERIAL AND METHODS

Study area: The study was carried out in forest (Djebel Keroua) dominated by Aleppo pine which covers an area of 760 ha and is located in the town of Ouled Khaled Saïda with an average altitude of 900 m. For reasons of homogenization,

the same environmental conditions were chosen for the two stations (slope, exposure, altitude, bedrock). The first station is a protected zone and is considered a witness with an area of approximately 300 ha (34° 55'12.79 "N; 0 ° 7'23.77" E). This station is marked much more by the tree and shrubby strata such as the aleppo pine (*Pinus halepensis* mill), mastic pistachio (*Pistacia lentiscus* L), juniper oxycèdre (*Juniperus oxycedrus* L), olive tree (*Olea europaea* Mill italique). The second station covers an area of 460 ha (34°54'56.26 "N; 0 ° 7'12.16" E). The livestock that use this station as range land is more than 37012 heads. The composition of this flock shows an overwhelming predominance of small livestock, especially sheep which occupy about 94% of the total, 3% for goats and 3% for cattle (ASB2017). In this station, grazing has strongly influenced the plant cover, which is very open with the abundance of alfa (*Stipa tenacissima* Mill italique), diss (*Ampelodesmos mauritanicus* Poir italique) and asphodel (*Asphodelus albus Mill*), which are signs of environmental degradation. As well as the soil, that is characterized by the appearance of the bedrock.

The study area is characterized by a Mediterranean-type climate belonging to the semi-arid fresh, wet period spans two months (January and December) while the dry period starts from February until November. The area is characterized by an annual rainfall of 345.16 mm with a seasonal regime of winter, spring, summer and autumn (WSSA) type; the maximum temperature is 24.6°C and minimum 11°C with thermal amplitude of 19.9°C (SMS 2017).

Soil sampling methods: In each station, five sites were selected, in which five soil samples were randomly collected with a shovel at the 0-10 cm horizon, the total number being 25 samples at each station. These soil samples were sieved to 2 mm, then packaged in plastic bags, and stored at 4°C before proceeding to microbiological analysis.

Physical analysis: Soil moisture was obtained by subtracting the mass of a kiln dried soil sample (105°C, 24h) from that sample before drying. The retention capacity was obtained using the protocol described by Saetre (1998). The permeability of a soil is the measured water elevation per centimetre that infiltrates per unit time, in the soil. (Mathieu and Pieltain 1998). The bulk density (bd) corresponds to the dry weight of a volume of soil whose structure has not been disturbed and was. measured by the cylinder method using undisturbed samples, knowing the constant dry weight of the samples at 105°C and the volume of the cylinders of the samples used (Blake and Hartage 1986). The measurement of the real density (rd) was determined by the pycnometer method, which consists of determining the volume of benzene displaced by the solid phase of a known mass sample in a known volume. From bulk density and real density, total porosity was estimated as (rd - bd) / rd × 100.

Chemical analysis: The measurement of the pH water and the electrical conductivity of the soil is an empirical measure in which 20 g of fine soil dried in the open air are mixed in a beaker with a volume of 50 ml of distilled water. Both measurements are performed in the same solution. While KCl police is measured in a separate solution which contains 50 ml of potassium chloride. The total limestone ($CaCO_3$) was estimated by the Bernard calcimeter method. The organic matter was measured by loss mass of a dry sample at calcination at 550°C for 16 hours.

Microbiological analysis: Basal respiration (µg C-CO2/g dry soil) was measured according to the protocol described by Anderson and Domsch (1978) to assess the physiological status of soil microbial communities. 10 g (dry equivalent) of fresh soil kept at 4°C were weighed in a glass vial (117 mL). The vials were closed with a hermetically sealed plug immediately after the replacement (4 minutes) of their internal atmosphere by a stable CO2 concentration atmosphere and incubated 4 hours at 25 °C. After incubation, an aliquot of atmosphere of the vial (1 mL) was injected using a syringe into a gas chromatograph (Chrompack CHROM3 – CP 9001). The chromatograph was equipped with a TCD detector and a filled column (Porapack) in which helium circulates at a flux of 60 mL h^{-1}. The values obtained were adjusted to 22°C according to the law of the gases perfect at Q10 = 2. Ambient CO_2 concentrations were subtracted from the CO_2 concentrations measured after incubation to obtain the amount of CO_2 produced by the heterotrophic microorganisms contained in the sample.

Microbial biomass (MB) was estimated using substrate-induced respiration (SIR) rates (Anderson and Domsch 1978). Ten grams (dry weight equivalent) of sub-samples were placed in 117 ml glass jars and amended with powdered glucose (1000 µg C g^{-1} soil). One ml of air was sampled in the head space with a syringe and injected into a gas chromatograph (Chrompack CHROM 3 – CP 9001) equipped with a thermal conductivity detector and a packed column (Porapack) to analyse CO_2 production. The CO_2 concentration of flushed air was subtracted from CO_2 concentrations of each samples and resulting values were adjusted to 22°C according to Ideal Gas Laws using a Q10 = 2. SIR rates were converted into MB (Beareet al1990).The metabolic quotient for CO_2 (qCO_2) was obtained by dividing basal respiration by the microbial biomass calculated from SIR (Anderson and Domsch1978).

Statistical analysis: Statistical analyses were conducted using Minitab software version 17. All data were checked for normality before applying suitable testing method (test-t for student to compare the averages).

RESULTS AND DISCUSSION

The results of the physical properties show a significant decrease of moisture, bulk density and retention capacity in the grazed area compared to their witnesses, whereas for the real density and total porosity, no significant difference was recorded. The results of the chemical properties show a significant decrease in the organic matter content in the grazed soils compared to the witnesses, whereas for the ph water, ph_{KCl}, electrical conductivity and the total limestone, the statistical analysis showed no significant difference between the two areas (Table 1). Statistical analysis shows that overgrazing significantly decreased all basal respiration and microbial biomass compared to the ungrazed area (0.61-1.35 µg CO_2-C/g sol h^{-1} ; 0.06- 0.47 masse µg C-mic g^{-1} MS respectively). Conversely, the metabolic quotient increased significantly in the grazed area than the protected zone (Fig. 2).

Effect of overgrazing on the properties of forest soils: The overgrazing in the forest affects negatively the soil by increasing its bulk density, a reduction of the volume of the soil without modification of the mass (Renouf 2009). This modification results from the physical action exerted by the herd during its displacement which compact the soil. Earlier studies have shown that conversion of forest soil into pasture causes its compaction, largely due to trampling by animals (Krishnaswamy and Richter 2002, Milne and Haynes 2004). Steffens et al (2009) mentioned that in the arid and semi-arid tropics, the increase in soil bulk density is related to the increase of animal load due to overgrazing. This soil compaction also significantly reduced soil moisture and its retention capacity in the grazed area compared to the control. Barik et al (2004) observed soil compaction, affects its moisture. Pietola et al (2005) have shown that soil compaction reduces water retention in pastures. The high bulk density recorded in the surficial horizons decreases the moisture and the retention capacity of grazed soils, which promotes surface water runoff as that their infiltration into the soil.

Soil permeability showed that overgrazing has increased the infiltration capacity of water in the grazed area than that of the protected area. Literature is contradictory for this property of the soil. Studies have noted the increase in permeability in pasted soils, while others have found the opposite. The present study suggest that this increase in permeability in the grazed area is due to the nature of the soils. Statistical tests have shown that overgrazing has no significant effect on the rest of the physical properties. A small decrease in total porosity in the grazed area means that the voids are reduced by the high apparent density recorded in this zone. For the real density, a slight increase was recorded in the area affected by overgrazing. The origin of this increase is unknown, so a granulometric study could indicate whether this slight difference in real density is due solely to the texture of the two soils or not.

The overgrazing has influenced soil organic matter, but not other chemical parameters. The rates of organic matter recorded in the pasted area are lower than the protected area. Several authors observed that organic matter starts to

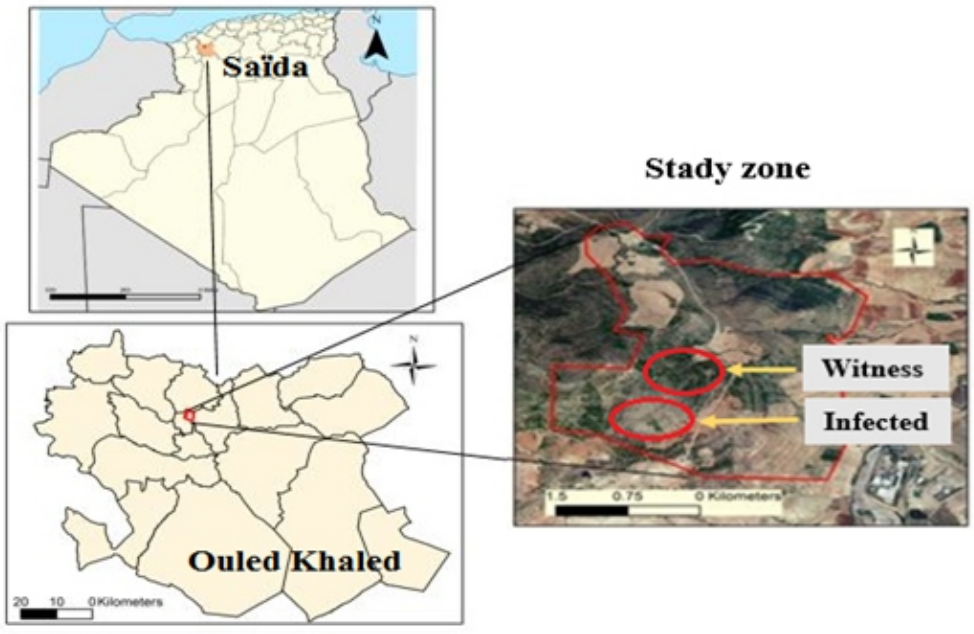

Fig. 1. Location of the study zone

increase as soons as soils are protected from grazing. Amghar et al (2016) in Algerian arid course showed that the organic matter increased significantly after four years in the protected zone compared to the grazed area. Jeddi and Chaieb (2010) concluded that, in the degraded steppes of southern Tunisia, organic matter begins to increase after 6 to 12 years of exclusion from grazing. Su et al (2005) report that in semi-arid soils in northern China, organic matter decreases in grazed soils compared with protected areas older than 5 years. The high rate of organic matter in present study in protected area is the result of stopping overgrazing, which allowed to preserve the primary production of the plants, and to ensure soil amendment with a large quantity of litter. Statistical analysis has shown that overgrazing has no significant effect on the following chemical parameters. The pH water of the two stations is basic (slightly alkaline) with almost equal values. Similarly tend was for ph_{KCl}. The electrical conductivity in the two stations showed that the soil is not salty (≤ 0.6 m/s). For total limestone, the grazed area has non-calcareous soil (≤ 1%), while its witness is moderately calcareous (5 <$CaCO_3$ <25%), this difference is due to the depth of the bedrock relative to the superficial horizon.

That the overgrazing negatively affected basal respiration and microbial biomass. The growth and activity of microorganisms that control the processes of soil nitrogen decomposition and mineralization depend on the quantity and quality of organic matter intake to the soil (Knops et al 2002). The present study showed that overgrazing decreased soil organic matter, and this had a negative impact on bacterial respiration and microbial biomass. Therefore, this shows that there is a dependent relationship between these two properties of the soil (organic matter/biological properties). Wang et al (2003) observed that growth of basal respiration and microbial biomass are generally limited by the carbon availability of organic matter in soil. Reduction of this in the soil can lead to a decrease in microbial biomass, which will reduce the quantity of nitrogen immobilized in the microbial biomass. The results also corroborate those obtained by Lambiénou et al (2016) which showed that the reduction of microbial activity in the soil is a consequence to unfavourable conditions resulting from overgrazing. Shahzad et al (2012) indicate that defoliation of plant species decreased the respirometric activity of soils. The metabolic quotient is used as an indicator of the physiological state of soil microorganisms (Mbonigaba et al 2009). The result in present study vary significantly between the grazing area where the highest values were recorded compared to the witness which reveals a significant change in the respirometric activities of microbial communities in soils

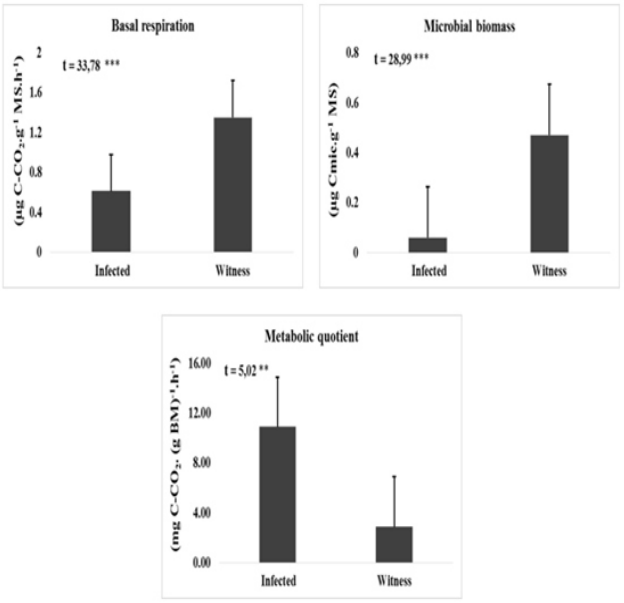

Fig. 2. Variation of basal respiration, microbial biomass and metabolic quotient in the grazed soils and are witnessed; mg: milligram; µg : microgram

Table 1. Physicochemical properties of grazed soils and their witnesses

Properties		Grazing	Witness	Signification
Physical	Bulk density (g cm^{-3})	1,451	1,073	**
	Real density (g cm^{-3})	3,186	2,786	NS
	Total porosity (%)	52,8	61,44	NS
	Moisture (%)	2,757	7,83	**
	Retention capacity (%)	45,17	72,8	**
	Permeability (mm h^{-1})	3,03	2,69	*
Chemical	pH water	7,600	7,700	NS
	pH_{KCl}	7,360	7,440	NS
	Electrical conductivity (m s^{-1})	0,142	0,204	NS
	Organic matter (%)	8,210	11,870	***
	Total limestone (%)	0,600	7,92	NS

This table records the mean values with its significance threshold (*: P<0,05 ; ** : P<0,01 ; *** : P<0,001 ; NS: not significant)

affected by overgrazing. Zaller et al (2004) and Fließbach et al (2007) indicate that, high values of qCO_2 reflect growing microbial communities with high energy needs to sustain themselves, while low values of qCO_2 indicate less disturbed soils, harboring communities more diversified which interact strongly between them. Böhme et al (2005) indicate that high qCO_2 values reflect a poor quality of the substrate and low metabolic efficiency. Lower values recorded of metabolic quotient in the protected area are the results of microorganisms stability and, the higher content of organic

matter in the soil. The high efficiency of use of available soil carbon by microbial communities in agroforestry systems could be due to a greater diversity of microbial communities in these soils (Lacombe et al 2009).

CONCLUSION

Overgrazing has negatively affected the physical properties of the soil such as apparent density, moisture and retention capacity. As for the chemical properties, it only reduced the organic matter. Biological properties are also adversely affected by overgrazing, which has decreased basal respiration and microbial biomass in these soils. As a result, the metabolic quotient has increased, confirming that the microbial community of these soils is under stress.

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Preparation of Activated Charcoal from Wood Sawdust

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Abstract: The research included the production of activated charcoal from sawdust containing a large amount of phenolic and lignin compounds, where wood sawdust is available locally. The constant amounts of the sawdust is mixed with different amounts of the carbonizing agent (NaOH), the material was carbonized by smelting without adding water. The produced activated charcoal after drying was studied for its physical and adsorption specifications. The increase in the percentage of carbonized material leads to an increase in the moisture content of the resulting samples, the density showed decreasing and fluctuating sometimes and there has been a marked increase in iodine adsorption from it's aqueous solution with the increase in the percentage of carbonized material, as well as for the adsorption of the methylene blue-dye. This is comparable to quality imported from known international companies and the resulting material is acceptable both scientifically and commercially.

Keywords: Sawdust, Charcoal, Adsorption

Activated charcoal is known as a porosity carbon substance prepared from carbonization and activation organic matter of living origin such as wood, bones, coconut shells, heavy oil residues, etc. Activated charcoal is prepared from many wood as raw material, wood is one of the substances, which enter into production of activated charcoal and is known as a natural substance consisting of cellulose, lignin and hemicellulose. Several studies have been carried out on wood, the most important of which is the production of petrochemicals and industrial fuels (Davida 2012). The importance of activated charcoal since World War has been shown where used as an adsorption material in the manufacture of gas masks from poisonous gases. In general, the appropriate raw material for this industry is preferred to have high carbon content (Abdul-Jabbar et al 2017). Activated charcoal has many uses, where it is used in adsorption of gases and vapors such as adsorption of ammonia gas (Takashi et al 2006), nitrogen dioxide gas from combustion gases (Robert et al 2007) and adsorption of carbon dioxide and methane gases and hydrocarbon gases (Mohammad-Khah et al 2009). It is also used in the treatment of industrial waste water in which the activated charcoal remove chemicals, organic and inorganic materials, such as H_2S, Cl_2, I_2, CN, Cu, Pb, Zn, Co, $HgCl_2$ and others (Reza et al 2015). Pods of *Thespesia populnea* were used as a raw material for the preparation of activated charcoal (Arulkumar et al 2011). The prepared activated charcoal was used for the adsorptive removal of orange G dye from aqueous system. Activated charcoal prepared from rice husk using phosphoric acid activation has been used by chemical activation (Somasundaram et al 2013). The surface area, pore volume, and pore size distribution of carbon samples activated at 700, 800, and 900°C were measured. Temperature 800°C was found to be optimum for the increased production of pore volume especially mesopore volume. De-Yuso et al (2014) synthesized activated charcoal from almond shell by chemical activation with phosphoric acid. The effect of activation atmosphere on property of the activated charcoal produced was examined. Largitte and Lodewyckx (2014) has investigated the adsorption property of activated charcoal from Bois carre seeds for the absorption of lead recently. The influence of temperature on the adsorption property is examined. Activated charcoal, prepared from African biomass residue is found to be a good sorbent for removing hexavalent chromium Cr (VI) from wastewater (Gueye et al 2014). The synthesis of activated charcoal from coconut husk with H_2SO_4 activation and its ability to remove textile dyes from aqueous solutions has been investigated (Aljeboree et al 2014).Results show that the adsorption of both GRL and DY 12 dyes was favorable at acidic pH. The effects of variable parameters such as activation temperature, activation time and chemical impregnation on the preparation of the activated charcoaland for the removal of pesticides: bentazon, carbofuran and 2, 4-Dichlorophenoxyacetic acid (2,4-D) were investigated. Angin investigated the application of activated charcoal obtained from sour cherry (*Prunus cerasus L.*) stones for the removal of a basic textile dye, which is Yellow 18, from aqueous solutions (Angin 2014). The influence of different contact times, pH values and solution temperatures was investigated. Activated charcoal and liquid compound fertilizer were prepared from rice husk by activation of H_3PO_4 and etching by KOH (Li et al 2014). The resulting activated charcoal exhibited excellent

properties such as low ash content, large surface area, high adsorption and electrochemical performances. The waste water produced in this process was used to produce compound fertilizer containing Si, K and P. Different pretreatments (wet, oxidation and complex pretreatments) to modify activated charcoal honeycomb monolith to investigate the role of surface properties of support in CO oxidation over Pd/ACHM catalysts have been carriedout (Elena et al 2014). Pretreatment was an efficient way to introduce oxygen groups, especially by complex pretreatment. Activated charcoal has been produced from grape seed using either potassium carbonate (K_2CO_3) or potassium hydroxide (KOH) (Okman et al 2014). The carbonization experiments were accomplished at 600 and 800°C. The effects of the experimental conditions on the yields and properties of these activated charcoals were analyzed under identical conditions. An increase in temperature at same concentrations for both K_2CO_3 and KOH led to a decrease in yields of activated charcoals. The lowest activated charcoal yields were obtained at 800°C at the highest reagent concentration (100 wt %) for both K_2CO_3 and KOH. The obtained activated charcoals were mainly microporous. Low-cost activated charcoal from the sour cherry (*Prunus cerasus L.*) stones was prepared by chemical activation using zinc chloride (Kang et al 2011). The effects of the activation temperature and the impregnation ratio on the surface and chemical properties of activated charcoal were investigated.

MATERIAL AND METHODS

Preparation of Activated Charcoal

Preparation of raw material: The raw material (sawdust) was taken in its dry natural form, then grinded and turned into powder to react fully with the carbonized substance and to obtain good results.

Carbonization and activation processes: Mix 10 gm of sawdust powder with different proportions of sodium hydroxide (1:0.5), (1:1), (1:1.5), (1:2) (sawdust: sodium hydroxide)and mix well with casserole mortar and then heated to direct flame at a temperature approaching of 550 ± 25°C and for a period of three hours (Mohd et al 2016).

Purification of activated charcoal: After the completion of carbonization and activation in previous step, the samples are washed several times with distilled water to removing the residual base and metal contamination, make sure that the product of the washing process is neutral using sunflower paper then dried in air, the samples were then taken and added 10ml of 0.1 N hydrochloric acid solution for each sample and heated for half an hour with stirring so as to remove the remaining sodium ions, the samples then washed with distilled water for several times until the acid residue disappears then dried and kept away from the air and humidity.

Measurement of internal surface area by adsorption of iodine from its water solution: This method is one of the most common methods to give information about internal surface area of activated charcoal and It is expressed by the number of mg of iodine which adsorbed from the solution by 1g of activated charcoal, where 1g of activated charcoal was taken and 10 ml of HCl (5%) solution is added and heated for half an hour, then cooled to laboratory temperature. Add 100ml of 0.1N iodine solution and stir for half an hour using an electric shaker device. The sample is filtered, then 50ml of the filtrate was taken and titrated with 0.1N of anhydrous sodium thiosulfate solution in presence of starch Indicator and the volume of sodium thiosulfate is calculated from the burette. The iodine number I.N. is calculated using the following equations(Alaa 2012):

$X = A - [2.2B * V]$

$A = N_1 * 12693$

$B = N_2 * 126.93$

where:

X=Iodine weight (measured in milligrams) adsorbed by activated charcoal.

V=The volume of sodium thiosulfate from the burette.

N_1=Normal concentration of iodine solution (0.1N).

N_2=Normal concentration of sodium thiosulfate solution (0.1N).

The iodine number is calculated from the following equation:

I.N. =X/M D

Table 1. Characteristics activated charcoal samples

Samples	Ratio of wood: NaOH	Iodine NO. mg g^{-1}	Methylene blue mg g^{-1}	Ash (%)	Density g $/cm^3$	Humidity (%)
1	1: 0.5	843.6	32.33	0.33	0.28	6.5
2	1: 1	866.8	48.36	0.35	0.22	7.1
3	1: 1.5	892.4	119.52	0.39	0.26	7.6
4	1 : 2	955.2	136.93	0.41	0.23	8.2
Custom (BDH)		908.2	90.00	3.21	0.32	0.8

Where :

M=The weight of used activated charcoal sample.

D=Correction Factor (value close to one).

Measurement of external surface area by adsorption of methylene blue-dye from its water solution was done after following Jun-jie et al (2013). This method is also a common method where 0.1g of prepared activated charcoal is taken and placed in a conical flask and added to a specified amount of concentration (20 ppm) of the dye solution, and placed in an electric shaker for twenty four hours at laboratory temperature. When the color of the dye disappears and the solution color became steady, the solution is separated by the stagnation method. The fine solution is then taken into absorption cell, and the absorbance is measured at a wavelength of 665nm.

Moisture content: This method involves exposing the activated charcoal to the laboratory atmosphere for 24 hours and weighing, then drying it at 110°C for two hours, then cooling and weighing. Through the weight difference, moisture content was calculated as a percentage (ASTM, 2009).

Percentage of ash:1g of activated charcoal is placed in a ceramic vase and put it in an oven at 1000°C for an hour, then cooled to the laboratory temperature in a dessicator and calculated the weight of the remaining sample that represents the weight of the ash and calculate its percentage (Ramadhan et al 2008).

Charcoal density (ISO 1981): A certain amount of activated charcoal is placed in a 5ml volumetric flask, the material is gently and accurately pressed to remove the pores between the particles so that activated charcoal is occupies its size. Note that charcoal particles are made at one level at the label boundary, the activated charcoal in the volumetric flask is weighed by a sensitive balance and the density is calculated as follows:

Density = Mass / Volume (gm / cm^3).

RESULTS AND DISCUSSION

The dry primary raw material (sawdust)with high lignin content has been carbonized by mixing it with sodium hydroxide for removing hydrogen in the form of water and thermal disposal, this means that the process of carbonization in this case is a fusion process followed by the loss of water and other gases, where a black mass was obtained, which is washed and activated by the mineral acids (Ramadhan et al 2005). The aim of the study was to retain the oxygen groups present in the formula for their proximity to oxygen surface groups which help to adsorption and has already been treated (sawdust)with ratios ranging from 0.5-2 of the carbonized substance into one of the primary material. It has been noted that the increase in the percentage of carbonized material leads to an increase in the moisture content of the resulting samples and it is not a research or scientific problem that can be overcome by mediation heat in isolation from air, and the density showed decreasing and fluctuating sometimes, and when studying the adsorption of iodine from its aqueous solution which represent the internal surface area, there has been a marked increase in iodine adsorption from its aqueous solution with the increase in the percentage of carbonized material, as well as for the adsorption of the methylene blue-dye from its aaqueous solution where ranged between 32.33-136.93, which represents the external surface area of the activated charcoal and thus outperformed on commercial samples, while the content of ash was within the allowable percentages in scientific and commercial fields.

CONCLUSIONS

On comparing the traditional production methods and their use in the removal of gases in the masks and the material of the activated charcoal catalysts that were prepared in this study was found suitable for all purposes in which activated charcoal is used taking into account the time and cost of the production. In addition, these types of activated charcoal are free of sulfur, nitrogen and various toxic substances and may be of great benefit when used with pharmaceuticals or food industries. The increase in the percentage of carbonized material leads to an increase in the moisture content of the resulting samples and it is not a research or scientific problem that can be overcome by mediation heat in isolation from air, and the density showed decreasing and fluctuating sometimes, and there has been a marked increase in iodine adsorption from its aqueous solution with the increase in the percentage of carbonized material, which represent the internal surface area, as well as for the adsorption of the methylene blue-dye from an aqueous solution, which represents the external surface area of the activated charcoal, while the content of ash was within the allowable percentages in scientific and commercial fields.

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Study on Some Threatened, Rare and Endangered Plant's Species in Reserve Forest Area of Jhunjhunu District, Rajasthan

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Abstract: An extensive field survey of the Beed Jhunjhunu was conducted to reveal the many threatened, rare and endemic plants, which were used by rural people and local vaidya for the medicinal treatment and their daily needs. A total of 325 species of flowering plants including one gymnosperm were documented from the study area. Among the founded 38 species were rare, endemic and threatened, 14 species were found to be medicinally use from the area. The threatened, rare, endemic status of the plant's species were confirmed with IUCN Red List and other standard publications on rare and threatened taxa of the country. The rare, endemic and threatened categories listed in Red Data Book, those struggling for survival in their natural habitats due to enormous anthropogenic activities such as overgrazing, habitat fragmentation, illegal harvesting, over exploitation of economically important plants, smuggling of plant's and encroachment by nearby local community, pollution due to sewage and dumping of solid waste, alien species invasion, deforestation and unplanned developmental activities at study area. Endemic and rare species of the area are more vulnerable than widespread species because they occupy small geographic ranges and specific habitats. Due to destruction of habitat, so many plants' species have been depleting from this area since last few decades.

Keywords: Jhunjhunu Beed, Endemic, Rare, Threatened, Threats

India, a mega-diverse country with only 2.4 per cent of the world's landmass, harbours a total of 47,513 species of plants representing as much as 11.4 per cent of the world flora (Singh and Dash 2014). About 28 per cent of the plants in India are endemic in the country. Unfortunately, a number of taxa has been lost and going to be lost due to not having proper care by concerned authorities, in this concern, a lot of plants are going to lose their existence as they are under threatened category. The effects of biodiversity include habitat loss and fragmentation, introduction of non-native organisms, over-harvesting, and pollution, changes in geo-chemical cycles and climate change (Polasky et al 2005). It is a growing global concern regarding the loss of biodiversity due to unplanned human activities (Dirzo and Raven 2003). Due to human activity, the rate of plant's species have disappeared and accelerated largely from the Earth and the current rate of species loss will increase by an order of magnitude over the next century. Although the loss of plant's species directly alerts the remaining community by lowering its diversity, there is a considerable debate as to whether reductions in plant diversity will affect the manner in which terrestrial ecosystem function (Loreau et al 2001). In India, the work on threatened plants was first published by Botanical Survey of India in a booklet entitled “Threatened Plants of India- A State of the Art Report” in which a total of 134 threatened plants from all over India have been listed (Jain and Sastry 1980). Principally, threats to species are due to decline in the areas of their habitats, fragmentation of habitats and decline in habitat quality (Kumar et al 2000). A publication has been published a list of rare taxa of western region of Rajasthan (BSI Jodhpur - Arid zone circle2008). Almost same content have also been published depleting 65 taxa with their present status and conservation in Rajasthan (Pandey et al 2012). Eleven plant's species of Angiosperms are documented as threatened and 86 species as rare in Southern Rajasthan (Meena 2012). In Rajasthan state, such studies have also been carried out by many workers (Pandey et al 1983, Sharma 1983, Meena and Yadav 2006, Kasera and Mohammed 2007). Considering the importance of floral wealth of the country, the Environmental Information System (ENVIS) Centre of the Wildlife Institute of India published a compilation work in a bulletin entitled “Special Habitats and Threatened Plants of India” covering various bio geographic zones of the country (Rawat 2008). Many researches and documentation on threatened, rare and threatened taxa have been recorded in different region of the Rajasthan, but no such work has been done in the Jhunjhunu region of Rajasthan. Therefore, the present study was undertaken to document the threatened plant's species work in the Beed Jhunjhunu district with their conservation status.

MATERIAL AND METHODS

Jhunjhunu district is a part of Shekhawati region of Rajasthan and covering 5928 sq. km of total of geographic

area. The district lies between 27º38 to 28º31 N latitude and 75º02 to 76º06 E longitude (Fig. 1). Although, the Aravalli hills are enlarged to a small area in the district but it influenced the vegetation of the district as per its surroundings. The study area is a protected forest area and situated about 2 km in the east of the Jhunjhunu city and the total area of study area is 1047.48 hectare. The area is almost plain with semi-arid climate. Study area is very hot in summers and very cold in winters that falls up to freezing pointith and poor rainfall during south-west monsoon period in study area. The study area becomes rich and luxurious in vegetation and grow up many rare, threatened, local medicinal species of plants in the rainy season. Temperature in May and June reached up to 46º C in summer season. Average annual rainfall varies from 300-400 mm. The soil of Beed Jhunjhunu is slightly alkaline, sandy and loamy. Soil pH is varies from 7 .2 to 8.8.

The present study was conducted in the Beed Jhunjhunu between January 2016 to December 2018. Weekly visits were made to Jhunjhunu Beed and whole area was thoroughly surveyed for the collection of plant's species. The collected plant's specimens were thoroughly studied on herbarium sheets and identified with the help of literature (Jain and Sastry 1984, Bhandari 1990, Shetty and Singh 1987, Sharma 2002). The present study is the special focus towards the occurrence of some rare, endemic and threatened plants in the Jhunjhunu Beed, which needs to effective conservation immediately. The threatened status of the plant's species were determined according to Red List category strategies (IUCN and criteria 1994-2007) which also helped us for using available Red Data Books, BSI Kolkata 2016 and standard publications (Nayar and Sastry 1987, Walter and Gillett 1998, Rao et al 2003). Rare species of the plant were determined by field survey, visual estimation, literature and herbaria and from discussions with the local people, traditional healers, tribes and the aged citizens.

RESULTS AND DISCUSSION

A total of 325 plant species belongs to 212 genera distributed among 74 families were recorded from the study area. During the field survey, 38 plant species were listed as endangered, rare and threatened from the study (Plate 1). Among these, all of the plants were angiosperm and *Ephedra foliata* Boiss. Ex C. A. Mey was the only gymnosperm. Out of the recorded threatened plants, twenty species were herbs, six species were climbers, seven species were trees, two species were trailing herb and three species were shrubs. The plant's species belonging to twenty one families were enumerated in alphabetical order with local names, family, local name, habit, cause of habitat loss, present status (Table 1). The categories at extinction risk include: EN- Endangered, CR- Critically endangered, VU- Vulnerable, R-Rare, E-Endemic, T-Threatened, NT- Near Threatened. There was occurrence of some rare plants like *Indigofera caerulea* Roxb*, Gisekia pharnacioides* L, *Tephrosia falciformis* Ramaswami*, Trichodesma indicum* (L.) Sm*., Chamaecrista mimosoides*

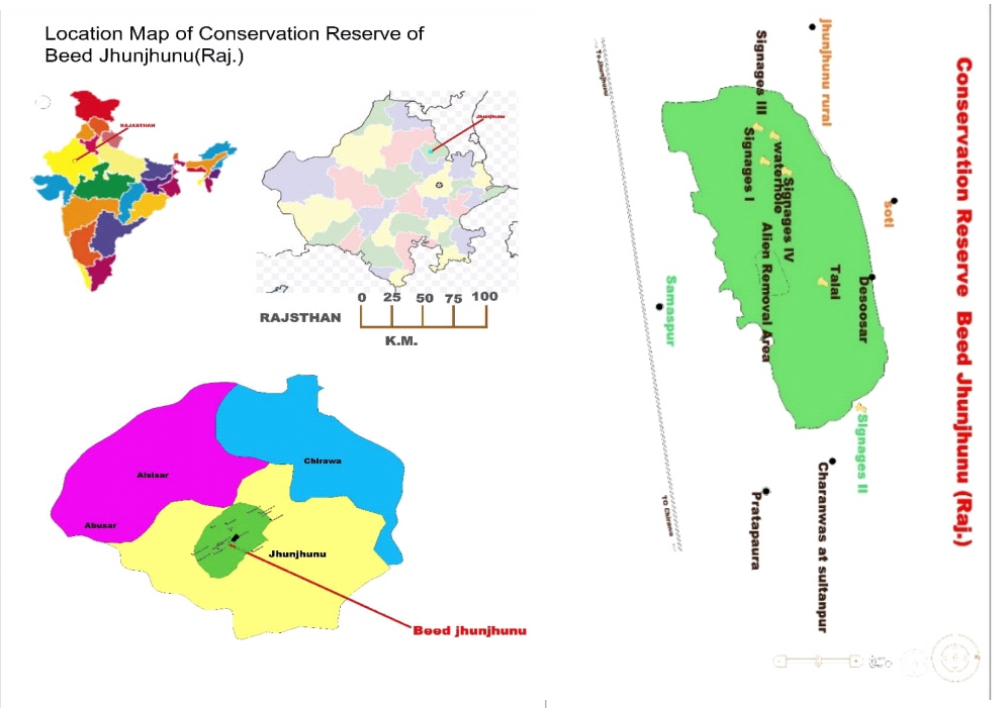

Fig. 1. Study area m of Jhujhunu Beed of Rajasthan, India

Table 1. Threatened plants, rare and endemic species of the study area

Botanical Name	Family	Habit	Cause of habitat loss	Status
Abutilon bitdentatum Hochst. Ex A. Rich.	Malvaceae	Herb	Habitat degradation	En & E
Abutilon fruticosum Guill. & Perr.	Malvaceae	Herb	Habitat degradation	En & E
Acacia catechu (L.f.) Willd.	Fabaceae	Tree	Over- exploitation	LC
Acacia jacquemontii Benth.	Fabaceae	Tree	Over- exploitation	R & T
Acacia nilotica (L.) Willd.ex Delile	Fabaceae	Tree	Over- exploitation	EN
Ailanthus excelsa Roxb.	Simaroubaceae	Tree	Over- exploitation	EN
Albizia procera (Roxb.) Benth	Fabaceae	Tree	Over- exploitation	LC
Alternanthera bettzickiana (Reg.) Nichol.	Amaranthaceae	Herb	Habitat degradation	EX
Alysicarpus monilifer var.venosus Blatt. & Hallb	Fabaceae	Herb	Overgrazing	EN
Alysicarpus vaginalis (L.) DC	Fabaceae	Herb	Medicinal use	EN
Amberboa ramose (Roxb.) Jafri	Asteraceae	Herb	Habitat degradation	R
Aristida funiculata Trin. & Rupr.	Poaceae	Herb	Overgrazing	R & NT
Barleria prionitis var. dicantha Blatt. & Hallb.	Acanthaceae	Herb	Medicinal use	EN
Boerhavia erecta L.	Nyctaginaceae	Herb	Overgrazing	EN
Calligonum polygonoides L.	Polygonaceae	Shrub	Overgrazing & Medicinally use	CR
Cenchrus biflorus Roxb.	Poaceae	Herb	Overgrazing	EN & R
Cenchrus prieurii (Kunth) Maire	Poaceae	Herb	Overgrazing	EN&R
Ceropegia bulbosa var. bulbosa Roxb.	Asclepiadaceae	Climber	Medicinal use	EN
Ceropegia bulbosa var. lushii (Grah.) Hook.f.	Asclepiadaceae	Climber	Medicinal use	EN
Chamaecrista mimosoides (L.) Greene	Caesalpiniaceae	Herb	overgrazing	R
Citrullus colocynthis (L.) Schrad.	Cucurbitaceae	Trailing Herb	Medicinal use	LC
Cleome gynandra var. nana (Blatt. & Hallb.) Bhandari	Capparidaceae	Herb	Medicinal use & overgrazing	EN
Cuscuta chinensis Lamk	Cuscutaceae	Climber	Medicinal use	EN
Cymbopogon citratus (DC.) Stapf	Poaceae	Herb	Habitat degradation	R
Ephedra foliata Boiss. Ex C. A. Mey.	Gnetaceae	Climber	Medicinal use & overgrazing	V & CR
Fagonia indica L.	Zygophyllaceae	Herb	Medicinal use & overgrazing	EN
Gisekia pharnacioides L	Aizoaceae	Herb	Overgrazing	R
Indigofera caerulea Roxb	Fabaceae	Herb	Overgrazing	R
Ipomoea cairica (L.) Sweet	Convolvulaceae	Climber	Overgrazing	EN
Ipomoea triloba L.	Convolvulaceae	Herb	Overgrazing	R
Lasiurus sindicus Henr.	Poaceae	Herb	Over-exploitation	EN
Leptadenia reticulate (Retz.) Wt. & Arn.	Asclepiadaceae	Climber	Medicinally use	EN
Rhynchosia capitata (Roth) DC.	Fabaceae	Trailing Herb	Overgrazing	NT
Salvadora persica L.	Salvadoraceae	Tree	Medicinal use	EN
Solanum elaeagnifolium Cav.	Solanaceae	Shrub	Habitat loss	R
Tecomella undulata (Sm.) Seem.	Bignoniaceae	Tree	Use in Timber	EN
Tephrosia falciformis Ramaswami	Fabaceae	Shrub	Habitat loss	R
Trichodesma indicum (L.) Sm.	Boraginaceae	Herb	Habitat loss	R

EN- Endangered, CR- Critically endangered, VU- Vulnerable, R-Rare, E-Endemic, T-Threatened, NT- Near Threatened Status in the study area- (IUCN Red List 2001) Included in the list of National Medicinal Plant Board

Ephedra foliata. *Alysicarpus vaginalis* *Solanum elaeagnifolium*

Rhynchosia capitata *Alysicarpus monilifer* *Citrullus colocynthis*

Acacia catechu *Tecomella undulate* *Salvadora persica*

Acacia nilotica *Ailanthus excels* *Barleria prionitis* *Ipomoea cairica*

Cleome gynandra *Calligonum polygonoides* *Gisekia pharnacioides* *Leptadenia reticulate*

Ipomoea triloba *Amberboa ramose* *Trichodesma indicum* *Chamaecrista mimosoides*

Plate 1. Some threatened, rare, endangered plant's species of study area

(L.) Greene*, Solanum elaeagnifolium* Cav., *Amberboa ramose* (Roxb.) Jafriat a few spots. Many plants were seen commonly in past. It is an alarming situation for these plants as threatened plant's species are required more and more attention for preserving their genetic diversity. *Albizia procera* (Roxb.) Benth was not observed at any site in the study area as it was reported in the project report of Forest Department, Jhunjhunu (Anonymous 2015). Some climbers were critically & endemic in the study area like *Ceropegia bulbosa* var. bulbosa Roxb.*, Ipomoea cairica* (L.) Sweet*, Leptadenia reticulate* (Retz.) Wt. & Arn. Among these *Ceropegia bulbosa* var. bulbosa Roxb. was particularly vulnerable owing to its edible tubers, which is often eaten by herders and local communities. During the study that the population of plant's species have drastically reduced in the area like *Calligonum polygonoides* L., *Barleria prionitis* var. dicantha Blatt. & Hallb., *Tephrosia falciformis* Ramaswami *and Salvadora persica* L.due to medicinally use. Endemic species like *Ceropegia bulbosa* var. *lushii* (Grah.) Hook. f., *Abutilon bidentatum* Hochst. Ex A. Rich and *A. fruticosum* Guill & Perr., have been recorded from the soti site of Beed at the time of extensive field surveys and plant's exploration trips. In addition to this, a new rare species *Solanum elaeagnifolium* Cav. has also been recorded from the Midst area of the Beed nearby main road. As per recent report about the occurrence of this species, that this species was not reported earlier from Rajasthan (Tiwari et al 2016). Species like *Boerhavia erecta* L. was observed at only few site which was reported as rare (Shetty and Singh 1987). However some plant species considered as critically endangered like *Acacia catechu (L. f.)* Willd, *Ephedra foliata* Boiss. Ex C. A. Mey. and *Citrullus colocynthis* (L.) Schrad*., Fagonia indica* L were not found abundantly in the study area (Anonymous 2015).Extensive field surveys and plant's exploration trips of beed Jhunjhunu it seems that the various number of plants are threatened plants.

CONCLUSION

The flora of Beed Jhunjhunu is rich in plants species before a decade, however, a large number of species have been recorded in the area. Due to various anthropogenic causes the plant's species have been threatened. Among the founded 38, endangered threatened taxa in which species were found to be medicinally use. Of these, *Ephedra foliata* Boiss. Ex C. A. Mey*., Citrullus colocynthis* (L.) Schrad*., Barleria prionitis* var. dicantha Blatt. & Hallb*., Ceropegia bulbosa* var. *lushii* (Grah.) Hook.fand *Salvadora persica L., Fagonia indica L.* are used heavily exploited for the local medicine. *Acacia nilotica* (L.) Willd. Ex Delile and *Tecomella undulate* (Sm.) Seem was threatened due to over-

exploitation for timber. Endemic and threatened plant's species are an important role of component of plant's biodiversity which require immediate conservation. There is an urgent need to conserve the threatened plant's species in the study area before it going to be lost. It is very necessary to stop the cutting to plant's species and to organize a plan to save the beed jhunjhunu by forest department of Jhunjhunu and Govt. There is also a need of some programme which educate the local people to save such species.

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State of Benthic Macroinvertebrate Community in Bhagirathi River Ecosystem Impacted by Hydroelectric Projects

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Abstract: The present work is a part of a larger study to figure out the ecological state of the riverine stretches between Maneri and Devprayag impacted by four Hydro Electric Projects (HEPs) using benthic communities. Stations were sampled at monthly interval for benthic fauna and physicochemical parameters following standard methodology. This study records ecological state of stretches fregmented by Maneri Bhali Stage II and Koteshwer HEP, two in the former and one in later. Benthic macroinvertebrate median density differed significantly between these three stations. Diverse benthic assemblages were recorded depicting unstable riverine ecosystem. FFG ratio (ecosystem attribute) revealed heterotrophic state of the fragmented river stretches. BMWP indicated impacted, moderate to heavily impacted water quality exhibiting severe impact as the river moves from one to another HEP. CCA revealed water temperature (WT), water current velocity (CV) and Phosphate (P) as most important environmental variables explaining maximum variability (26%) in the distribution of benthic macroinvertebrate community. SIMPER showed maximum similarity within the station while ANOSIM showed significant dissimilarity between the stations. Compared to the past study on natural state of the river during 1985-1988, macroinvertebrate density, CV and dissolved oxygen has declined while WT has risen at all the stations.

Keywords: Bhagirathi river, BMWP, FFG, HEPs Benthic macroinvertebrates

Flow is the key characteristic of riverine ecosystem. Diversion of flow for Hydroelectric Projects (HEP) mutilates the natural hydrological regime which modifies the ecosystem structure thereby impairing functions, energy flow patterns, the sediment flow, fine or coarse organic particulate matter and physicochemical quality of the water (Richter et al 2003, Jones et al 2012). One such instance is the Bhagirathi R. (source tributary of the sacred Ganga) in the Indian Himalaya, where four hydroelectric projects (HEP) are operational. The Bhagirathi lies severely fragmented in its lower half (ca. 100 km) due to two diversions for Maneri-Bhali Stage-I (MB-I) and II (MB-II) and two reservoirs for Tehri and Koteshwar dams. This has impaired the river ecosystem from Maneri till its confluence with the other source tributary, Alaknanda at Devprayag, which too is regulated by two diversions. Presently the Bhagirathi river ecosystem carries scanty flow from Maneri to Dharasu (tail of Tehri reservoir) and highly regulated flow below the Koteshwar dam. Here we examine the impacts of these HEPs on the benthic macroinvertebrate communities and use them to assess the current state of the Bhagirathi river ecosystem in the fragmented lotic sections. The benthic macroinvertebrates are widely used to study the impacts of river regulation (Jones et al 2012) and freshwater biomonitoring (Wright et al 2000). Apart from this, the functional traits of benthic macroinvertebrates (Statzner and Bêche 2010) are being increasingly used to track and understand the specific biotic response.

Studies on the benthic macroinvertebrates of the Bhagirathi River are very scarce after the construction of HEPs. Singh and Nautiyal (1990) and Singh et al (1994) studied the macroinvertebrate community of Bhagirathi river downstream (d/s) of the Maneri dam after it became functional. Impacts on the benthic macroinvertebrate communities remained unknown in the riverine stretches since four HEPs became functional. Agarwal et al (2003) and Rajvanshi et al (2012) are the only recent reports that studied the impacts of hydroelectric projects on the aquatic biota in immediate up (u/s) and d/s stations of proposed and commissioned dams on Bhagirathi River. Thus, the present study was conducted with an objective to record impacts on the benthic macroinvertebrate communities in riverine stretches of Bhagirathi river modified by MB-II and Tehri-Koteshwer HEPs. Assessment of impacts on these communities enlightens the importance of environmental flow and will guide the decision makers on water resources to take urgent measures for restoration of riverine ecosystem. Further the data on benthic macroinvertebrate density, assemblages and state of impact can be treated as the feature of the regulated/modified stretches of Bhagirathi river.

MATERIAL AND METHODS

Study area: Three stations (S1 to S3) lie in the MB-I HEP (Kumar and Nautiyal 2019) while the stations S4 to S6 are

located on the fragmented riverine sections of MB-II and Koteshwer HEP (Fig. 1). Stations S4 to S6 selected for present study lie between N 30° 43'46" and E30°08'51" to E 78° 24'24" and 78°35'52 (Table 1). Stations were sampled ca 1km d/s of MB-II barrage (S4), ca. 700 u/s of MB-II Power House (PH) at Dharasu (S5) and at Devprayag (S6). The S5 lies 30 km d/s to S4 and S6 70 km d/s to S5. Station S5 is ca. 30 km from S4 and Station S6 is ca. 77 km from S5. The river bed is shallow at S4 since major discharge is diverted for MB-II PH. As the small tributaries join the river between S4 and S5 the discharge increases at S5 where the river becomes deep and occupies the whole width of the channel. The water marks on the rocks forming the banks clearly show that there is a wide gap between the current depth and that of the unmodified river. The flow at S6 was highly variable owing to the regulated discharge from the Koteshwer PH. Pebbles, cobbles, gravels, sand and silt along with matured boulders at S4 and cobbles, sand and silt along with gravels formed the river bed at S5. Large boulders and rocks formed the river bed at S6. Mixed forests along left bank and Manera village surrounded by agricultural land are situated on right bank at S4. Uttarkashi an urban area is situated along the banks of river 1 km upstream of S4. Mining activities were observed in the lean months of the year (November to April) on the banks of river at S4. Open pine forest and mixed forests along the upper and lower slopes respectively occurred at S5 and scrubs along S6.The difference in gradient fall was 52 m from S4 to S5 while S6 has 551 m fall from S5 (Table 1).

Sampling and analysis: Stations were sampled for physicochemical parameters and macroinvertebrate community at the monthly interval in forenoon hours from November 2016 to October 2017. Water temperature (WT) and potential of hydrogen ions (pH) were recorded with the help of digital pocket meter (PC Tester 35 Multi-Parameter). Current velocity (CV) was measured with the help of the float method. Water transparency (Tr) was measured with a Secchi disc by lowering it into the water and recording the depth at which it was no longer visible. Dissolved oxygen (DO) with the help of Winkler method and free carbon dioxide (CO_2) were analyzed at the site following standard methods outlined by Welch (1948). Water samples were collected at each station and transported to the laboratory for further analysis following standard methods; silicate (Si) and phosphate (P) by Jhingran et al (1969), total hardness (TH) by APHA (1995) and total alkalinity (TA) by Welch (1948). The riffle-pool-riffle sequence was sampled at each station with the help of D-frame kick net sampler (mesh size 500µm) to obtain the macroinvertebrate community. Ten replicates were obtained at each station, 6 in riffle and 4 in the pool. The samples were preserved in plastic vials having 4% formaldehyde and brought to the laboratory for subsequent analysis. The macroinvertebrate fauna was resolved at family level using standard keys (Edington and Hildrew 1995, Dudgeon 1999). Counts from each quadrat were made at family level to obtain total density (indiv.m^{-2}). Mean and median density was computed from total density obtained for

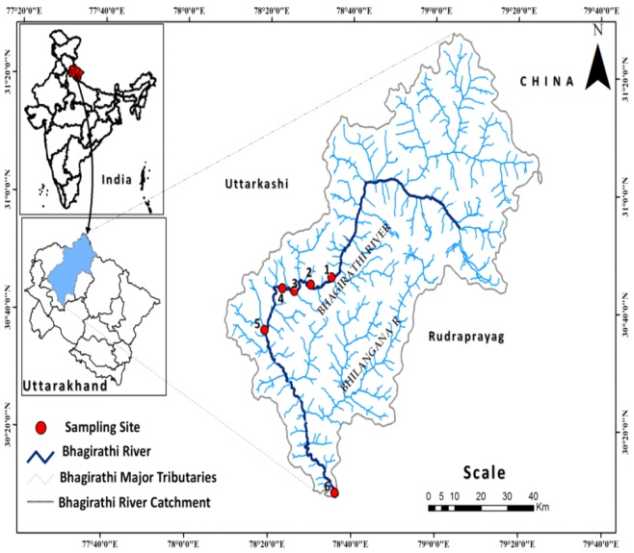


Fig. 1. Geographical coordinates showing sampling stations 4, 5 and 6 for the present study

Table 1. Geographical location, gradient fall, physicochemical (mean±SE) characteristics and mean density (indiv. m^{-2}) of benthic macroinvertebrates at three stations along with previous study

Stations	Singh et al 1990 (near S4)	S4	S5	S6
Lat (°N)		30° 43'46"	30° 36'41"	30°08'51"
Long (°E)		78° 24'24"	78° 18'44"	78°35'52"
Alt		1080	1028	477
Fall			52	551
Substratum		C>P>G>S	C>>G>S	R>B
WT (°C)	11.01	11.81±0.96	13.73±1.21	14.91±1.28
CV (cm s^{-1})	130.5	68.5±6.1	76.25±6.9	82.4±6.4
Tr (cm)		41.2±5.8	48.6±6.2	55.3±6.6
pH		8.2±0.11	8.1±0.15	8.5±0.15
DO (mg l^{-1})	8.2	7.29±0.22	7.53±0.21	7.80±0.16
CO_2 (mg l^{-1})		1.39±0.22	1.46±0.21	1.43±0.23
TA (mg l^{-1})		32.0±3.78	32.5±3.19	38.3±3.31
TH (mg l^{-1})		39.6±3.15	42.3±3.54	45.1±3.82
Density	88-940 (range)	0-433	0-326	0-93

Acronyms: B-Boulder, C-Cobbles, G-Gravels, S- Sand, R-Rock bed

each of 10 quadrates. Percentage composition of each family was calculated from respective counts by taking the sum of ten quadrates for each family to determine the dominants of the assemblages.

Data Analysis: Significant differences in median density of macroinvertebrate community were obtained by non-parametric analyses of variance Kruskal-Wallis test using PAST 3.1. Monthly count data for each family at four stations were used to compute Similarity Percentage Analysis (SIMPER) to determine percentage contribution of each taxa to average percentage similarity within station and analysis of similarity (ANOSIM) using the Bray-Curtis dissimilarity measure to identify differences in macroinvertebrate distribution between the stations using CAP 4.0. Canonical correspondence analysis (CCA) using CANOCO 4.5 was applied to identify the association of macroinvertebrate families to environmental variables along with three supplementary environmental variables (elevation, landuse and substrate) and monthly samples from each station with a subsequent Monte-Carlo permutation test, using 999 unrestricted permutations under full model with automatic forward selection only for 9 variables. Biological Monitoring Working Party score (BMWP) (Armitage 1983) was obtained from monthly samples and pooled data to determine the quality of the water. Functional state of the river was obtained using Functional Feeding Groups (FFG) ratios (Cummins et al 2005).

RESULTS AND DISCUSSION

Physicochemical characteristics: A series of dams disrupt the upstream–downstream connectivity and alter the natural periodicity of flow of a fluvial ecosystem (Romania et al 2010). A similar situation prevails in the lower half of the Bhagirathi R. A barrage and two dams in succession have altered the natural hydrological regime, by diverting the river for MB-II and regulating the river below Tehri and Koteshwer dams according to the peaking requirements. Among physicochemical parameters mean WT, DO, CV, Tr, TA, TH and P increased from S4 to S6. pH was alkaline and slightly decreased from S4 to S5 but increased at S6 (Table 1). CO_2 mildly increased from S4 to S5 and decreased at S6. Increase in CV and consequently DO occur due to increased discharge from small tributaries which enhance flow. Increase in WT is obvious as water moves from high to low altitude. Here a +ve relationship was observed between WT-DO in contrast to –ve (inverse) relationship in unimpacted rivers (Singh et al 1994). Possibly flow argumentation in the channel causes increase in DO. WT-DO relationship becomes weaker and is overwhelmed by CV-DO relationship due to +ve relationship. Tr was least at S4 as the mining activities along the bank of rivers continuously bring sediment into the channel. TH, TA and P were low but showed a mild increasing trend from S4 to S6. Compared to the characteristics of the river in natural state (Singh et al 1994), the diversion for MB-II has resulted in decline of CV from 130.5 cm s^{-1} (1985-87) to 68.5 cm s^{-1} (2016) showing a reduction of 62 cm s^{-1} at S4. Similarly the CV regime at S5 and S6 has witnessed a reduction of 92 cm $s^{-1}$and 102 cm s^{-1} respectively. Compared to the natural state, WT has risen by 0.8°C at S4, 1.2°C at S5 and 0.2°C at S6. DO has also shown reduction in its concentration by 0.9 mg l^{-1}, 1.57 mg l^{-1} and 1.3 mg l^{-1} at S4, S5 and S6 respectively (Table 1). Dewson et al (2007) and Nautiyal et al (2018) also observed reduction in CV and DO and rise in WT below the dams attributed to low flow.

Macroinvertebrate density (indiv.m^{-2}): The median density differed significantly (p=0.003) between the three stations. It showed peak during November at S4 and S6. At S4 density declined gradually upto February and underwent alternate increase and decrease to attain minima during July. However, the density after attaining peak during February declined in March and slightly increased upto May. It sharply declined from May onward and attained minima during July at S5 (Fig. 2). Except for November to January the median density was higher at S5 than S4. The median density increased from S4 to S5 but declined at S6. Lowest density and monthly alternate increase and decrease in regime at S4 depicted the perturbed state of the river at S4 while the increased density and stabilizing regime at S5 was ascribed to stable river channel also predicted by FFG ratio for channel stability (an ecosystem attribute). Below S5, in reservoir section Ayoade et al (2009) observed increased WT (Lentic-13.5 ± 2.12ºC; Lotic-23 ±5.15°C) and plankton density (Lentic-367±463 u/l; Lotic-997± 624 u/l) from lotic

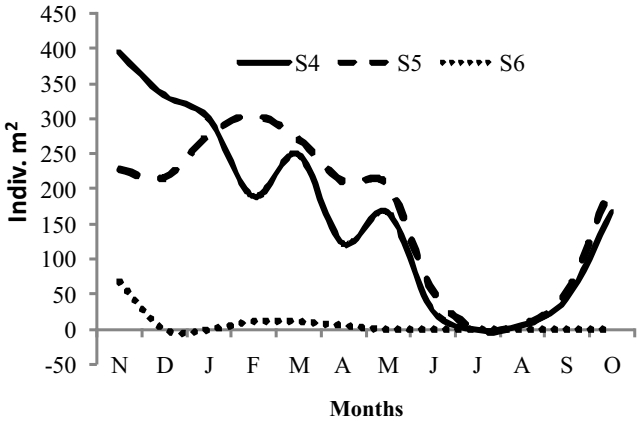


Fig. 2. Monthly variations in median density (Indiv.m^{-2}) of benthic macroinvertebrate community at different stations

(near S5) to lentic section (Tehri reservoir) of the Bhagirathi river. Lowest density at S6 is attributed to the homogenous substratum formed by large boulders and bedrock restricting the colonization of diverse macroinvertebrate community. Mishra and Nautiyal (2011) reported substratum as major determinant of macroinvertebrate community structure. In comparison to the past natural state of the river, slight decline in benthic density (55-603 indiv. m^{-2} to 0-433 indiv. m^{-2}) was observed at S4. This decrease is attributed to the low and regulated flow leading to loss of substrate heterogeneity during lean season (October to May). Macroinvertebrate density exhibits variable responses downstream the dams (Dewson et al 2007); i) reduced density due to low flow immediately below the Maneri dam on Bhagirathi river and Bhimgoda barrage on Ganga (Nautiyal et al 1988, Bahuguna et al 2004); ii) enhanced density below weir on Dulace river attributed to low flow (Leiva et al 2017).

Macroinvertebrate assemblage: The benthic assemblage was primarily formed by Baetidae-Heptageniidae except Baetidae-Chironomidae (November), Ephemerillidae-Baetidae (January), Baetidae-Glossosomatidae (March) and Baetidae-Hydropsychidae (September) at S4. At S5, Baetidae-Hydropsychidae (November-January, March) Baetidae-Heptagenidae, (February, April) Heptagenidae-Baetidae (May, October) and Hydropsychidae-Heptagenidae (June, August) occurred in the assemblage. Baetidae was only the taxa found at S6 along with Psychomidae that occurred only once in the assemblage during April (Table 2). Total 13, 21 and 2 macroinvertebrate families were found at S4, S5 and S6 respectively, throughout the year (Table 3). Five benthic macroinvertebrate assemblages (Table 2) occurred at S4 as compared to three at S5. Baetidae dominated the assemblage while subdominants varied from month to month at S4. At S5, Baetidae along with Hydropsychidae formed the assemblage for most of the months. Baetidae predominated the assemblage at S6. Lack of consistency in benthic assemblages at S4 is attributed to scarce discharge making habitat unstable. Nautiyal et al (2018) also reported variable benthic assemblages indicating unstable river ecosystem in Alaknanda river below dam. However, occurrence of the consistent assemblages shows the tendency of the river to stabilize.

When compared to the past studies on river, benthic families viz. Ameletidae, Leptidae, Coenagrionidae, Psychodidae, Nemouridae and Perlidae have disappeared at S4 causing decline in richness at S4. The faunal composition at S4 comprised of Ephemeroptera (69%) largely represented by Baetidae and Heptagenidae; Diptera (23.98%) largely represented by Chironomidae and Chironomidae red worm; Trichoptera (6.84%) represented by Hydropsychidae, Glossomatidae and Coleoptera (0.89%) by Psephenidae at S4. S5 witnessed the dominance of Ephemeroptera (64.14%) represented by Baetidae and Heptagenidae while Trichoptera (27.65%) represented by Hydropsychide and Philopotamidae; Diptera (7.19%) represented by Chironomidae and Tipulidae, Plecoptera (0.19%) represented by Perlidae, Coleoptera (0.51%) represented by Psephenidae and Odonata (0.02%) by Gomphidae in the community. At S6, Ephemeroptera (87.09%) predominated by Baetidae and Trichoptera (12.9%) by Psychomidae form the community. In contrast to the past (Singh and Nautiyal1990), the community colonizing at S4 to S6 exhibited a higher variation in the faunal

Table 2. Monthly variations in percentage composition of macroinvertebrate taxa forming assemblage and BMWP scores at different station

S4	N	D	J	F	M	A	M	J	J	A	S	O
Baetidae	**60**	**54**	**52**	**22**	**35**	**45**	**82**	**18**		**50**	**40**	**50**
Ephemerellidae	Nil	Nil		32	11	4						
Heptageniidae	3	**13**	**13**	21	9	**28**	4	82		**50**	**40**	**32**
Chironomidae	22		1	8	4	2	**6**					4
Chironomidae acro	10			8	10	5	2					
Hydropsychidae	2	3	3	4							**20**	5
Glossosomatidae					**19**	5	2					
BMWP	**34**	**33**	**38**	**38**	**55**	**55**	**28**	**14**		**14**	**21**	**28**
S5												
Baetidae	**46**	**58**	**40**	**34**	**52**	**57**	**30**	17			**45**	**28**
Heptageniidae	14	15	12	**17**	7	**17**	46	**25**		**45**	19	**33**
Chironomidae	4	2	4	7	1	1	1	0		0	0	0
Hydropsychidae	**24**	**19**	**27**	16	**9**	11	10	**58**		**55**	**35**	16
Philopotamidae	3	1	5	1	2	2	1					20
BMWP	**38**	**32**	**37**	**60**	**67**	**48**	**42**	**19**		**15**	**19**	**49**
S6												
Baetidae	**100**			**100**	**100**	**56**				**100**		**100**
Psychomidae						**44**						
BMWP	**4**			**4**	**4**	**13**				**4**		**4**

composition. Ephemeroptera has replaced the dominants Diptera at all the stations. The increased share of Ephemeroptera (Baetidae) signifies the more detritus in the river and hence heterotrophic rather than autotrophic. This is validated by heterotrophic state of the river at all stations depicted by P/R ratio of FFG.

Metrics: SIMPER showed 44, 51 and 14 % average similarity within the stations at S4, S5 and S6 respectively. Baetidae (66.53%) and Heptagenidae (25%) had 91.5% cumulative contribution to average similarity at S4 while at S5 Baetidae (44%), Heptagenidae (24.5%) along with Hydropsychidae (27.3%) had 94.5% cumulative contribution to average similarity. Baetidae (100%) solely contributed to 14% average similarity at S4 (Table 4). Contribution of Hydropsychidae to the average similarity at S5 indicates the availability of suspended FPOM depicted by FFG ratios. Apart from this, ANOSIM showed significant difference between the groups (S4, S5 and S6) in macroinvertebrate distribution. In pair-wise test, maximum dissimilarity in benthic distribution was observed for S5-S6 (R=0.90) followed by S4- S6 (R= 0.80) and S4-S5 (R=0.396). R value is close to 1 for S4-S6 and S5-S6 and hence more similar samples are within the group (Table 5). However, R value for S4-S5 close to 0 indicates high and low similarities were of mixed type between stations. CCA is frequently used to identify the environmental variables influencing the distributional pattern of the benthic macroinvertebrate assemblage (Mishra and Nautiyal 2017, Leiva et al 2017). In our study, the CCA eigen values of the first axes account for 18% of the explained variance and was positively correlated to CV and DO and negatively to Si. Axes 2 accounted for 14% of the variance and positively corelated to TA and TH and negatively to WT. The conditional effect reveals higher Lamda value for WT (0.10, p=0.002), CV (0.08, p=0.02), P (0.08, p=0.002) and TA (0.05, p=0.058) that were significant (Table 6). These variables explained (31%) more than half of the total variance (52%) explained by all variables. Grouping of most of the monthly samples of S4 and S5 was clearly reflected by CCA plot (Fig. 3). Most of the samples of S4 and S5 were grouped with little mixing revealing resemblance in

Table 3. Macroinvertebrate families and Pooled BMWP score at different stations under study

Taxa name	Singh et al (1990)	S4	S5	S6
Baetidae	+	+	+	+
Caenidae	-	-	+	-
Ephemerellidae	+	+	+	-
Heptageniidae	+	+	+	-
Ameletidae	+	-	-	-
Athericidae	-	+	+	-
Tipulidae	+	+	+	-
Leptididae	+	-	-	-
Psychodidae	+	-	-	-
Tabanidae	-	+	+	-
Blepharoceridae	+	+	+	-
Chironomidae	+	+	+	-
Simuliidae	+	-	+	-
Deutrophlebidae	-	-	+	-
Hydropsychidae	+	+	+	-
Philopotamidae	-	+	+	-
Limnephilidae	+	+	+	-
Leptoceridae	+	-	+	-
Glossosomatidae	+	+	+	-
Psychomidae	-	-	+	+
Psephenidae	+	+	+	-
Gyrinidae	-	-	+	-
Coenagrionidae	+	-	-	-
Gomphidae	-	-	+	-
Nemouridae	+	-	-	-
Perlidae	+	-	+	-
Total families	18	13	21	2
Pooled BMWP	115	80	131	10

Table 4. SIMPER showing percentage contribution of major taxa to the average similarity within stations

Name	Average abundance	Average similarity	Per cent contribution	Cumulative (%)
S4	Average similarity = 44%			
Baetidae	42.3	29.9	66.53	66.53
Heptageniidae	24.53	11.24	25	91.5
S5	Average similarity = 50%			
Baetidae	34	22.7	44	44
Hydropsychidae	23	13.3	27.3	71.4
Heptageniidae	20.5	12.6	24.5	94.5
S6	Average similarity = 14%			
Baetidae	40	14	100	100

Table 5. Results of ANOISM with >1000000 permutations

ANOISM			Significance level	R statistics
All defied groups			0.001	0.372206
Pair wise tests	Group 1	Group 2		
	S4 (12)	S5 (12)	0.001	0.396166
	S4 (12)	S6 (12)	0.001	0.804438
	S5 (12)	S6 (12)	0.001	0.900971

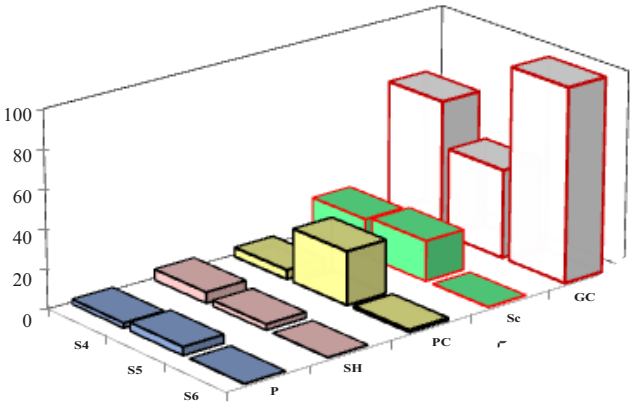
macroinvertebrate community. Samples of S6 were observed away from those of S4 and S5 indicating dissimilar community structure. Macroinvertebrate families Chironomidae, Chironomidae red worms, Blepharoceridae, Glossosomatidae, Baetidae, and Athericidae and most of the samples of S4 were located in the same quadrant of CCA plot governed by supplementary variables (land use and elevation) while S5 samples and Hydropsychidae, Heptagenidae, Philopotamidae and governed by CV, DO, pH and substrate. Samples of S6 were governed by substrate only. Beyene et al (2009) reported the Chironomidae associated to urban land use in rivers of Ethopia. Further, Mishra and Nautiyal (2011) reported association of Heptageniidae, Hydropsychidae and Caenidae with CV in plateau river of Central India.

Bioassessment: BMWP scores indicated Impacted/polluted biological quality throughout the year except moderately impacted (March-April) at S4 which is attributed to the organic waste from the urban area Uttarkashi as evidenced by the presence of Chironomidae red worm/ Chironomidae blood worms (Chironomidae RW) and other Chironomidae in the assemblage. Singh and Nautiyal (1990) recorded enhanced Chironomidae larvae due to sewage from urban land use at Uttarkashi. This is also supported by land use as a supplementary environmental variable in CCA in the present study. The water quality was impacted/polluted (November-January, June and August- September) and moderately impacted (February-May) at S5. BMWP scores indicate heavily impacted water quality at S6 throughout the year. Here the scores were low because only two benthic families predominated by Baetidae occurred, attributed to the homogenous substrate. Since Baetidae scores low in BMWP it indicated heavily impacted state, although it may be moderately impacted, revealing weaknesses of BMWP index. Pooled BMWP score of the past data (Singh et al1994) indicated good water quality as compared to moderately impacted at S4 and S6 and good at S5.

Functional analysis: Although Gatherer Collectors (GC) dominated among all the groups at all stations, however their percentage share differed (Fig. 4). The share of GC decreased from S4 to S5 while the share of Filter Collectors

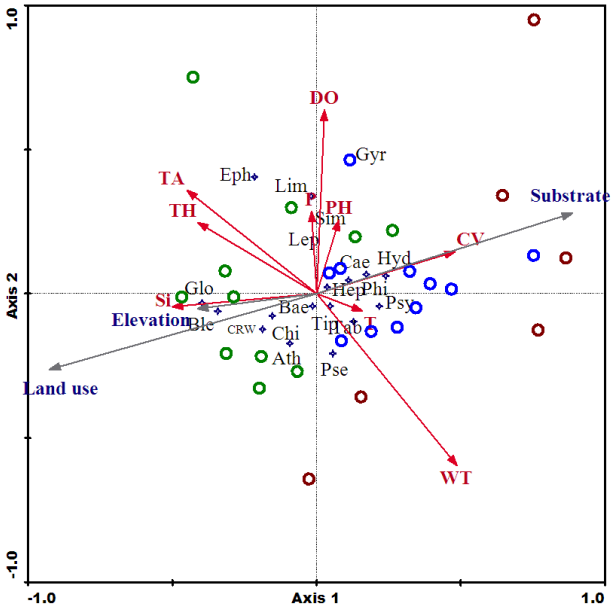
Table 6. Marginal and conditional effects for environmental variables

Variable	Marginal effects		Conditional effects		
	Var.N	Lambda 1	Lambda A	P	F
WT	1	0.1	0.1	**0.002**	3.07
CV	3	0.07	0.08	**0.02**	2.39
P	8	0.05	0.08	**0.002**	2.77
Si	9	0.07	0.07	0.11	2.25
T	2	0.03	0.04	0.092	1.58
TA	6	0.08	0.05	0.058	1.91
DO	5	0.08	0.04	0.16	1.49
PH	4	0.03	0.04	0.196	1.4
TH	7	0.06	0.02	0.346	1.09



Acronyms: GC- Gatherer Collectors; Sc-Scrapers; FC- Filter Collectors; SH- Shredders; P- Predators

Fig. 3. Percentage composition of macroinvertebrate functional feeding groups at different station



Acronyms: Bae-Baetidae, Hep- Heptageniidae, Ephe- Ephemerillidae, Cae-Caenidae, Chi- Chironomidae, CRW- Chironomidae red worms, Psy-Psychomidae, Hyd- Hydropsychidae, Lep-Leptoceridae, Glo-Glossosomatidae, Lim- Limnephilidae, Phi-Philopotamidae, Tip-Tipulidae, Tab- Tabanidae, Ath- Athericidae, Sim-Simullidae, Gyr- Gyrinidae

Fig. 4. CCA triplot showing the distribution of macroinvertebrate taxa and monthly samples in relation to environmental variables

Table 7. Results of functional feeding groups (FFG) analysis (Cummins et al 2005)

Ecosystem attributes	Station	FFG ratio	Threshold	Interpretation
P/R	S4	0.218	>0.75	Heterotrophic
	S5	0.286	>0.75	Heterotrophic
	S6	0	>0.75	Strongly Heterotrophic
CPOM/FPOM	S4	0.090	>0.25	Poor shredder link
	S5	0.065	>0.25	Shredder very underrepresented
	S6	0	>0.25	Shredder very underrepresented
TFPOM/BFPOM	S4	0.03	>0.50	very poor quality of FPOM
	S5	0.51	>0.50	Above normal suspended FPOM Load
	S6	0.01	>0.50	Very light suspended load
Channel stability	S4	0.26	>0.50	Stable substrate, sub adequate, recent flooding
	S5	0.89	>0.50	Stable substrate abundant
	S6	0	>0.50	

P/R=Scrapers/Total Collectors + Shredders; CPOM/FPOM=Shredders/total Collectors; TFPOM/B/FPOM= Filtering Collectors/ Gathering Collectors; Channel Habitat Stability= Scrapers + Filtering Collectors/Gathering Collectors + Shredders

(FC) increased. GC contributed 99% to the assemblage at S5. Functional feeding group ratios autotrophy to heterotrophy index (P/R) was less than 0.75 indicating heterotrophic state at S4, S5 and S6 of the river. However, S6 was the most heterotrophic and S4 and S5 were least heterotrophic. Heterotrophy at S4 and S5 is reflected by the dominance of Baetidae (GC) while its share reduced along with increase in Hydropsychidae (FC) at S5. Transport fine particulate organic matter/benthic fine particulate organic matter (TFPOM/BFPOM) ratio at S4 (0.07) and S5 (0.6) revealed sufficient amount of BFPOM at S4 which could be attributed to hindrance to sediment transport by MB-II barrage, while TFPOM at S5 was possibly from tributaries in this stretch. The stability of the river channel is reflected in terms of relative permanence (stability) of various bottom materials. Channel stability ratio was 0.89 above the threshold (0.50) at S5 indicating stable channel which can be confirmed by highest richness, density and stable benthic assemblages at S5 while 0.32 ratio at S4 predicts unstable channel and hence disturbed river ecosystem.

CONCLUSION

The change in the physicochemical regime below MB-II barrage include, disappearance of macroinvertebrate families and disturbed community assemblages at S4 and S5 in comparison to the past studies depicting the river ecosystem has changed after the construction of MB-II HEP. Moreover, in combination with significant difference in benthic density between stations, 52% explained variations of the CCA results and the significant dissimilarities in macroinvertebrate assemblage between stations depicted by ANOSIM reveals the disturbed macroinvertebrate structure in HEP modified riverine stretches of Bhagirathi river.

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Capsule Maturation Timing in *Rhododendron arboreum* Smith in the Central Himalayan Region

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Abstract: The main aim of the study was to assess the time of capsule/seed maturation and germination in view of warming climate in *Rhododendron arboreum* Smith (2500-2800 m) an important under canopy tree species of Central Himalayan Region. The capsules of *R. arboreum* were collected at ten days interval from the month of December up to the availability of capsules from selected sites located at different altitudes. The colour of capsule was initially green and finally turned brown. The seed moisture content was negatively correlated with germination in *R. arboreum*. Flowering period ranged between 7-8 weeks. The periodicity in flowering was one month earlier in comparison to other studies. The seeds remain viable for approximately 10 months and the viability decreases gradually. The change in capsule colour and seed moisture content appears to be the major indicators of seed maturation in selected species. Shifts in timing of capsule/seed maturation can affect the germination and regeneration of the species.

Keywords: Capsule maturation, Germination, Moisture content, Phenology, Viability

The Indian Himalayan region is vulnerable to the impacts of global warming and studies suggest that the forest ecosystems have been seriously impacted by global warming. Temperature rise of 1-2ºC will impact most ecosystems and landscapes (Ravindranath et al 2006). The genus *Rhododendron* belongs to family Ericaceae with over 900 species and numerous cultivars worldwide (Davidian 1992). It is indigenous mainly to the Northern Hemisphere, with large concentrations in the mountain ranges of India, China, Tibet and upper Burma as well as to Japan and the Eastern United States. Altitudinally, it occurs in vegetation zones that range from a few hundred meters to about 5500m above sea level. In India, the species are mostly confined to the Himalayan region, particularly in Eastern Himalaya. A total of 87 species, 12 subspecies and 8 varieties of *Rhododendron* have been recorded in IHR, among these 6 species and one subspecies are reported from Western Himalaya (Sekar et al 2010). Due to rising winter- spring temperature the flowering time is advancing that suggests that *Rhododendron* might expand its distributional range in response of global warming (Ranjitkar et al 2012). The flowering in *R. arboreum* was 15 days earlier than the previously reported time (Shah et al 2014). The phenological responses of plants, particularly the early flowering is considered among the prominent biological indicators of climate change. Seed maturation in many species is often accompanied with recognizable changes in size, colour, taste, odour and texture of the fruit and seed. In certain species maximum seed quality is achieved when seeds reach maximum dry weight (Singh et al 2010). A relationship is often established between seed colour and maturity which is often used to identify physiological maturity of tree seed in various species (Majeed et al 2009). Seed maturation studies help in fixation of optimum stage of maturity that will yield abundant seeds higher germination and vigor. The maturity stages have been found to induce changes in moisture percentage, physical and chemical properties of seed during their growth and development (Ahmad et al 2014).

Rhododendrons are one of the most exploited species due to its multifarious nature (Sekar et al 2010). The regeneration of various such multifarious species is very poor in nature due to their over exploitation (Tewari 2005) and other climatic causes. To synchronize artificial regeneration of species the exact knowledge of the time of capsule maturation is essential for the collection of mature and viable seeds just before the opening of capsules to avoid seed dispersal as seeds are very minute. The main objective of the present study is to assess the time of capsule/seed maturation and germination of *Rhododendron arboreum* in view of warming climate.

MATERIAL AND METHODS

Study site: For the study two sites of *R. Arboreum* were selected at Chaubatia (2000 m) and Dwarsaw (1725 m). Site I was located on northern aspect, site II at North eastern aspect of the lesser Himalayan zone in Kumaun (Table 1). The climatic data were taken from Kalika Research Range, Ranikhet. The mean maximum temperature ranged from 13.02 °C (January) to 28.05°C (May) and mean minimum temperature varied from 3.6°C (January) to 17.32°C

(August). The average annual precipitation was1347mm in the study site.

Method: Ten healthy superior trees of the selected species of approximately same height and diameter were marked in 100×100m at each selected site (Table 2). Collection of capsules of *R. arboreum* was started in December up to the availability of capsules from both the sites in 2014-15. Capsule collection was at ten days interval till the capsules were available. The capsules were directly collected from the selected trees at each collection date and placed under shade till their opening, afterwards seeds were extracted from them. Moisture content of capsule was expressed on a fresh weight basis at each collection date using five replicates of 100 capsules oven dried at 103 ± 2˚C for 16 ± 1 hrs (ISTA 1981) and then reweighed. The Petri-dishes and germination paper were sterilized at high temperature (130˚C) for 4 hours to make free from fungal infection. Five replicates of 100 seeds were placed for germination at 25 ± 1˚C on top of the paper in seed germinator for each collection date. Germination was monitored for 25 days. Germination was counted when visible radical had developed. Water was added as required during the experiment.

Phenological studies: Phenological observations were made for two major phenophases viz. flowering and fruiting of *R. arboreum*. At the study site, 10 individual of similar size were marked for each species. The observations were made at weekly intervals from the first week of January to last week of August, the period of high phonological activity for species. During the remaining part of the year observations were made at 3-4 week intervals. Every phenophase was considered to be at its peak when more than 70 per cent of the marked tree showed the phenological event. The phenophases was taken to have initiated when less than 15 per cent the event was recorded on the trees (Verma 2012).

Viability retention: For the viability retention seeds of *R. arboretum* collected at maturity were stored in plastic containers and placed at room temperature. The viability was checked by germinating 3 replicates of 100 seeds after every 30 days for two years (March 2015-February 2016 and March 2016-February 2017) following Bisht (2006).

RESULTS AND DISCUSSION

The mean tree height of selected *R. arboreum* trees varied between 5.8 m and 6.5 m and mean tree circumference at breast height (cbh) varied between 74 cm and 90.6 cm. (Table 2).

Table 2. Tree characteristics of *Rhododendron arboreum* at selected sites

Sites	Species	Mean tree height (m)	Mean tree cbh (cm)
Site I	*Rhododendron arboreum*	5.8 ± 0.2	74 ± 0.5
Site II	*Rhododendron arboreum*	6.5 ± 0.5	90.6 ± 1

Maturity indices: The colour was initially green and finally turned brown. The mean fresh weight of capsule ranged between 10.3 and 24.75 g at site I and 9.5 g and 23.1g at site II. The number of seed per capsule varied between 875 and 1015. The weight increased gradually and finally attained a maximum at 4th collection date at site I and 3rd collection date at site II. The average moisture content of capsule ranged between 8.05 % and 50.5 % across both the sites. The moisture content of capsule was maximum during Ist collection at site I and decreased gradually and was minimum in last collection at site II. In *R. arboreum* the mean seed germination ranged between 0 and 51.8% across both the sites. The germination was maximum during IIIrd collection at site II (Table 3).

Phenology: Flowering started in second week of January and maximum was in third week of March in *R. arboreum.* Flowering period range between 7-8 weeks approximately. The periodicity in flowering was one month earlier in comparison to other studies. Capsule initiation started from end of January while seeds matured within capsule between December and January after 10-12 months of flowering.

Viability: The seeds of *R. arboretum* were stored at full maturity in plastic bags at room temperature. The mean germination ranged between 60.1 per cent and 20. The viability across both the sites decreases gradually across both the sites (Fig. 1). The seeds remain viable for approximately 10 months but viability declined at the rate of 7 – 11 per cent per month.

The fresh weight of capsule varied significantly across dates of collection and the moisture content of seed was significantly different across sites and dates of collection. Fresh weight of capsule was correlated positively with date of collection (r = 0.827) and germination (r = 0.627). Similarly negative correlation was between fresh weight and moisture content (r = 0.706). The stage and time of maturity of

Table 1. Site characteristics of *Rhododendron arboreum* for different selected sites

Sites	Species	Altitudes (m)	Latitude	Longitude	Aspect	Associate species
Site I	*Rhododendron arboreum*	2000	29º37´ N	79º27´ E	Northern	*Quercus leucotrichophora, Myrica esculenta*
Site II	*Rhododendron arboreum*	1725	20º40´ N	79º29´ E	North– eastern	*Quercus leucotrichophora, Acer oblongum*

Table 3. Variation in physical parameters of capsule and seeds of *R. arboreum* (Mean±SE)

Site	Collections of seed	Fresh weight of capsule (g)	Moisture content of capsule (%)	Mean Germination (%)
Site I	Ist collection	10.3 ± 0.1	50.5 ± 0.4	00 ± 0
	IInd collection	12.3 ± 0.5	45 ± 0.6	23 ± 2
	IIIrd collection	23 ± 0.4	34 ± 0.7	29.8 ± 3.2
	IVth collection	24.75 ± 0.4	11.15 ± 0.2	38.3 ± 0.5
Site II	Ist collection	9.5 ± 0.1	47.4 ± 0.5	14.3 ± 0.5
	IInd collection	12.3 ± 0.2	37.3 ± 0.5	44.2 ± 0.4
	IIIrd collection	23.1 ± 0.6	23 ± 2.7	51.8 ± 0.5
	IVth collection	20.5 ± 0.3	8.05 ± 0.5	38.1 ± 0.6

Mean of 2 years

capsules/seeds is essential for collection of abundant quantity of healthy and vigorous seeds (Ahmad et al 2014). The physical characters of fruits/seeds have played a significant role in maturity indices. The physical parameters as moisture content and specific gravity are interrelated and more objective. Both have been reported as reliable maturity indices by numerous researchers. The change in capsule colour from green to brown and decline in moisture content appear to be good indicators of seed maturity in *R. arboreum.* The moisture content of seeds declined as the fruits/capsules matured. Change in fruit colour and decline in fresh weight moisture content percent from maturing seeds is closely related to seed maturity. Maximum germination occurs at 30.11 per cent moisture content in *P. cerasoides*, 13.59 per cent moisture content in *Albizia lebbeck,* 23.4 and 36.1 per cent moisture content in *Pyracantha crenulata*, 58.37 per cent moisture content and 0.82 specific gravity in *Aesculus indica* and 36.4 and 37.6 per cent moisture content in *Quercus leucotrichophora* (Shah et al 2010, Mazeed et al 2010, Tewari et al 2011, 2016). Negative correlation existed between germination and seed moisture content. Similarly Tewari et al (2016) could not find any relationship between germination and seed moisture content.

Climate change affects the distribution, population structure and regeneration of tree species at high altitudes (Rana et al 2016). In an earlier study Ralhan (1985) has shown flowering between February and April while fruiting initiation between March and May in *R. arboreum*. Negi (1989) has reported capsule formation time in May in *R. arboreum*. In the present study the flowering was one month earlier and occurred between January and mid March. Capsule initiation started from end of January while seeds matured within capsule between December and January in *R. Arboretum* after 10-12 months of flowering. Due to the unavailability of previous data studies regarding capsule maturity time we hypothyze that the capsule would also open earlier because of early flowering. Verma 2012, Badola 2010 and Ranjitkar et al 2012 also observed similar trend of capsule maturation in *R. arboreum*. Gaira et al (2014) that annual mean maximum temperature is responsible for shifts in flowering dates of *R. arboreum*.

Table 4. Comparative table of flowering and fruiting time of *R. arboreum* in Kumaun Central Himalaya

Flowering (month)	Capsule initiation (month)	Capsule maturation (month)	References
2-4	3-5	-	Ralhan (1985)
-	5	-	Negi (1989)
2 - 3	-	-	Maikhuri et al (2003)
1-2	2-3	12 – 1	Verma (2012)
1 - 3	2-3	12 – 1	Present study

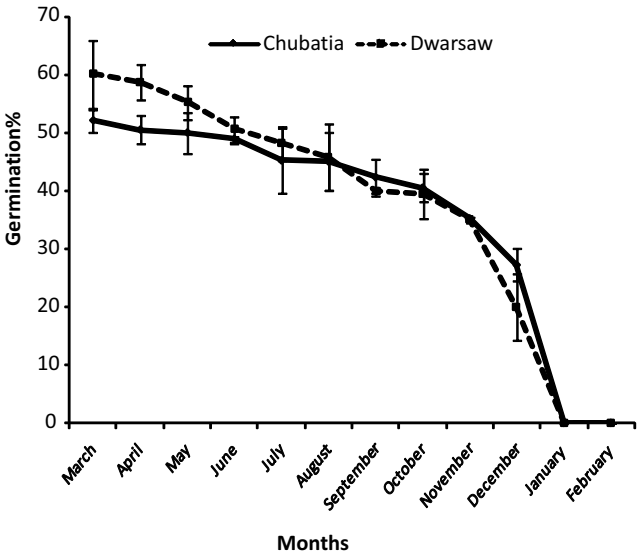

Fig. 1. Loss of viability of *R. arboreum* (Mean of two years)

CONCLUSION

In *R. arboretum* the colour change of capsule from green to brown is a reliable indicator of maturity. The seed moisture content coincided with maximum germination. The seed moisture content and capsule colour change appears to be

the major indicators of seed maturation in the selected species. Negative correlation existed between germination and seed moisture content.

There was advancement in flowering initiation time and culmination of flowering. Shift in flowering would directly impact timing of capsule/seed maturation and result regeneration of the species which loses seed viability at the rate of 7 – 11 per cent per month under laboratory conditions.

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Physico-chemical Properties of Soils Underneath Tuberous Medicinal Plants from Sitamata Wildlife Sanctuary

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Abstract: The present paper focus on physico-chemical properties of soil at surface and depth (20-25 cm) beneath three important tuberous medicinal plants, *viz. Arisaema tortuosum* (Wall.) Schott*, Chlorophytum tuberosum* (Roxb.) Baker and *Curculigo orchioides* Gaertn. from the Sitamata Wildlife Sanctuary, Pratapgarh district of Rajasthan. The soil sample were collected to characterize their chemical properties such as soil texture, moisture, pH, EC, organic carbon, nitrogen, and available phosphorus during June-October 2014-2017**.** The maximum soil moisture was present on surface soil during September in all selected plants. OC and P were maximum during October, whereas N during September at both levels underneath *A. tortuosum*. The N and P were highest during June and October, respectively at both levels underneath *Curculigo orchioides*. Maximum OC and N were observed during August at surface soil whereas P in September beneath *Chlorophytum tuberosum*.

***Keywords*:** *Arisaema tortuosum, Chlorophytum tuberosum, Curculigo orchioides,* Soil physico-chemical properties

A natural medium for the growth of plants on the immediate surface of the earth, comprising of unconsolidated mineral and organic matter, is referred to as soil. It supports the growth of plants by providing nutrition for photosynthesis through harboring different minerals and nutrients required for the fixation and reduction of atmospheric carbon dioxide. Besides, its role in the plants growth, soil impacts the life including humans to a greater extent. It acts as an indirect source of nutrition for humans as it ensures the supply of nutrients to humans through the plants and their products consumed by them. Plant growth, habitat of various microorganisms, sustenance conditions for the fauna and flora are determined by the quality of soil (Barthakur 2018). Ecosystems suffer considerable degradation and destruction due to both natural as well as anthropogenic causes that ruin biotic as well as abiotic environment. Increasing trend in the frequency of natural events like earthquakes, floods, cyclones, etc. due to increasing population has led to degradation of the ecosystems (Middha et al 2015).

Soil has a certain distinctive physical, chemical and biological qualities which permit it to support plants growth. Soil quality, thus may be defined as the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries to sustain plant and animal productivity, maintain or enhance water and air quality and support human health and habitation (Karlen et al 1997). It depends on soil texture, soil pH, nutrients, organic matter, soil moisture, microorganism, structure, microclimate, land fragmentations, soil erosion, diseases and insects, consumption of nutrients by plants, leaching of nutrients, etc. In the present investigations, physico-chemical properties of soil parameters underneath three tuberous plants were estimated during June to October 2014-2017.

MATERIAL AND METHODS

The soil samples were collected from surface (0-5 cm) and 20-25 cm depths beneath *Arisaema tortuosum, Chlorophytum tuberosum* and *Curculigo orchioides* in natural habitats nearby Sitamata Wildlife Sanctuary, Paratapgarh district Rajasthan during June-October 2014-2017 and analyzed for various parameters. The mean values of six replicates of all above-mentioned soil parameters for three consecutive years were estimated. Soil texture was measured with the help of sieve series of different sizes. For this, 1 kg air-dried soil was taken in six replicates and the soil particles for each fraction such as stone & gravel, coarse sand, fine sand, silt and clay were weighed and calculated in percentage. The soil moisture was estimated immediately after the sampling was done, while other parameters were analyzed from air-dried samples sieved through 2 mm sieve except organic carbon, which was sieved through 0.02 mm. The percentage of soil moisture was measured on oven dry weight basis (Pandeya et al1968). The water suspension of soil (1:5 ratio; 5g soil: 25 ml water) was used to measure EC and pH with the respective µP based water and soil analysis kit ESICO Model 1160 and Digital pH meter 335 Systronic at room temperature as per USDA Handbook No. 60 (1954). Organic carbon was determined by modified Walkley and Black's method (Jackson 1973). Total nitrogen in the soil samples was estimated by Microkjeldahl method as described by Jackson (1973). Available phosphorus estimation was based on the development of molybdenum

blue colour as per Olsen et al (1954). All the analysis of soil samples was carried out at Jai Narain Vyas University, Jodhpur, Rajasthan.

RESULTS AND DISCUSSION

In the present studies, temporal variations in various physico-chemical properties of soil underneath different plant species indicate that the patterns of soil organic C, N and available P were heterogeneously distributed. The rhizospheric soils of *A. tortuosum* and *C. tuberosum* have highest amount of stone and gravel followed by coarse sand and lowest for clay, whereas *C. orchioides* soil contained highest amount (54.03%) of coarse sand followed by stone and gravel (41.56%) and lowest was clay (0.05%) (Table 1). Soil moisture in semi-arid areas plays an important role in ecological hydrological processes, including evapotranspiration, infiltration, run-off and erosion. Maintaining a high level of soil moisture content (SMC) can improve the capacity of ecological systems to conserve water. Variations in soil moisture can be highly influenced by plant-soil interactions (Zheng et al 2015). In the present study, maximum moisture content was observed at surface and 20-25cm depth in *A. tortuosum* and *C. orchioides* during September (Tables 2, 4), respectively whereas in *C. tuberosum* during August at 20-25 cm depth (Table 3). The variations in soil moisture at surface and depth (20-25 cm) may be due to fine texture of soil, vegetation cover and environmental factors such as intensity of light, temperature, rainfall, etc. In all selected plant species, surface soil retains more moisture as compared to depth. Zheng et al (2015) reported that surface soil have more moisture content as compared to depth in *Quercus mongolica*, which is conformed from the present study.

Among the various chemical properties of soil, pH is highly important for the normal growth of fauna and flora. Since the optimum pH for the growth of plants is between 5.5 - 7.5 and fluctuations in the pH directly or indirectly affects the availability of nutrients to the plants. The pH range of 6.8 to 8.0 has been recommended optimum for plant's growth (Jain et al 2015). The soil pH of beneath the all selected plant species was slightly acidic in nature (6.5). Overall, soil reaction was nearly neutral under all selected plant species with lesser variability which showed pH stability. The similar results were also reported by Panwar and Gupta (2014) underneath *Morus alba.*

Soil electrical conductivity (EC) is the ability of soil to

Table 1. Soil properties underneath selected plants

Soil particles	Particle size (mm)	Particle (%)		
		Arisaema tortuosum	*Curculigo orchioides*	*Chlorophytum tuberosum*
Stone and gravel	>2.00	51.93±1.95	41.56±1.48	50.3±2.20
Coarse sand	0.2-2.00	42.96±1.96	54.03±1.80	43.83±1.72
Fine sand	0.02-0.2	4.93±0.12	4.46±0.32	5.5±0.95
Silt	0.002-0.02	0.08±0.008	0.09±0.037	0.12±0.04
Clay	<0.002	0.01±0.001	0.05±0.016	0.03±0.004

± = Standard deviation

Table 2. Various soil parameters during different months underneath *Arisaema tortuosum*

Parameters	Depth (cm)	July	August	September	October	CD (P=0.05)
Soil moisture (%)	0-5	3.71	15.52	20.18	19.57	NS
	20-25	5.97	4.36	12.29	11.12	4.77*
pH	0-5	6.51	6.4	6.32	6.58	NS
	20-25	6.42	6.67	6.51	6.50	0.05*
EC ($mScm^{-1}$)	0-5	0.0031	0.002	0.0074	0.0101	0.00034*
	20-25	0.0013	0.0019	0.0021	0.0042	0.00027*
Organic carbon (%)	0-5	1.40	1.44	1.30	1.63	0.05*
	20-25	1.13	0.73	1.37	1.60	0.17*
Nitrogen (%)	0-5	0.1353	0.1102	0.2228	0.1228	0.01601*
	20-25	0.1206	0.0499	0.1853	0.1291	0.0227*
Phosphorus ($\mu g\ g^{-1}$)	0-5	21.76	24.10	13.96	34.50	10.70*
	20-25	11.06	6.62	4.76	8.26	NS

* = Significant at (P<0.05) level

conduct electrical current. It has generally been associated with determining soil salinity; however it also can serve as a measure of soluble nutrients for both cations and anions and is useful in monitoring the mineralization of organic matter in soil (De Neve et al 2000). It is evident from Tables 2 & 4, that maximum EC was recorded at surface soil in *A. tortuosum* and *C. orchioides* habitats during October, *i.e.* 0.0101 and 0.0052 $mScm^{-1}$, respectively, which show presence of more ions during October as compared to other months, whereas in *C. tuberosum* during July, *i.e.* 0.0055 $mScm^{-1}$at surface soil (Table 3). Joshi et al (2006) reported mean EC values of 0.47 $mScm^{-1}$ at Narwa site, Rajasthan at surface. Sahoo (2011) reported that habitats of *Barleria acanthoides*, *Citrullus colocynthis* and *Grewia tenax* from Indian Thar desert showed higher EC in surface soil than deeper layers. In the present investigations, EC was more at surface layer in all soils collected underneath selected plants as compared to deeper layers.

Soil organic carbon (SOC) is the carbon associated with soil organic matter. Soil organic matter is the organic fraction of the soil that is made up of decomposed plant and animal materials as well as microbial organisms, but does not include fresh and un-decomposed plant materials such as straw and litter, lying on the soil surface. Soil carbon can also be present in inorganic forms, e.g. lime or carbonates in some soils in the drier areas. In the present studies, it ranged from 1.30 to 1.44 and 0.73 to 1.60, 1.39 to 3.09 and 0.94 to 1.93 and 1.36 to 3.26 and 1.29 to 2.40 per cent beneath *A. tortuosum*, *C. orchioides* and *C. tuberosum* at surface and 20-25 cm depth, respectively (Tables 2-4). Maximum amount of OC was recorded in surface soil of *A. tortuosum* and *C. tuberosum*, whereas in *C. orchioides* at deeper layer. According to Raza et al (2011), the OC content in mangrove sediment varied significantly among sampling stations with values ranging from 13.6 to 26.0 mg g^{-1} (1.36-2.60%). In desert soils, the OC ranged from 0.07- 0.32 per cent, whereas in mixed red and black soils from 0.14 to 1.15 per cent (Seth et al 2012). The soils of Sagar village in Bikaner district (Rajasthan) have highest OC at top surface (Parihar and Choudhary 2017). Das and Bindi (2014) observed organic carbon in soil ranged from 0.30 to 0.59 per cent in Jaisamand, Rajasthan. The present studies also confirm the results of above researchers.

The soil N content showed the similar trend as that of OC. In the present investigations, N contents varied from 0.11 to 0.22 and 0.089 to 0.18, 0.10 to 0.23 and 0.074 to 0.106 and 0.12 to 0.19 and 0.108 to 0.154 per cent underneath *A. tortuosum, C. orchioides* and *C. tuberosum* at surface and 20-25 cm depths, respectively (Tables 2-4). Nitrogen contents were higher at surface than deeper ones during different months except in September beneath *C. tuberosum*. Like OC, N contents also decreased with the depth. Bhat et al (2011) observed that concentrations of N and OC beneath the soil of *Ulmus villosa* and *Fraxinus excelsior* were high in surface soil and gradually decrease with soil depth**.** Soil N concentration is regulated mainly by soil moisture, which results in strong variation in N dynamics and mineralization (Fisher et al 1987). The total nitrogen in soils generally varies from 0.02 to 0.44 per cent due to tropical climate, The Indian soils are poor in total N, which varies from 0.04 to 0.12 per cent. The total N content of the soil depends on several factors like soil type, texture, soil pH, climate, topography, vegetation, etc. Among these factors, climate has the most striking effect on nitrogen content of soil. The total N content in the soil decreases with depth in soil profile (Mohanty and Singh 2002, Singh et al 2016), which is

Table 3. Various soil parameters during different months underneath *Chlorophytum tuberosum*

Parameters	Depth (cm)	June	July	August	September	CD (p=0.05)
Soil moisture (%)	0-5	4.11	3.23	16.50	19.57	2.74*
	20-25	5.975	4.369	12.295	8.029	2.15*
pH	0-5	6.27	6.430	6.8	6.48	0.18*
	20-25	5.25	6.603	6.596	6.566	0.15*
EC ($mScm^{-1}$)	0-5	0.0019	0.0055	0.0048	0.0029	0.0011*
	20-25	0.0033	0.0022	0.0020	0.0019	0.00017*
Organic carbon (%)	0-5	2.07	1.36	3.26	1.88	0.13*
	20-25	1.20	2.40	1.45	2.12	0.14*
Nitrogen (%)	0-5	0.1312	0.1395	0.1957	0.12283	NS
	20-25	0.1187	0.1082	0.152	0.1541	0.0077*
Phosphorus (µg g^{-1})	0-5	21.6	14.2	15.0	32.66	8.60*
	20-25	4.706	4.26	5.603	8.17	1.20*

* = Significant at (P<0.05) level

Table 4. Various soil parameters during different months underneath *Curculigo orchioides*

Parameters	Depth (cm)	June	July	August	September	October	CD (p=0.05)
Soil moisture (%)	0-5	4.77	1.14	6.37	25.14	1.18	3.82*
	20-25	8.94	3.43	8.68	10.89	8.09	2.24*
pH	0-5	6.47	6.70	6.60	6.50	6.47	0.10*
	20-25	5.81	6.35	6.43	6.59	6.40	0.09*
E.C. ($mScm^{-1}$)	0-5	0.0021	0.0036	0.0030	0.0026	0.0052	0.00016*
	20-25	0.0013	0.0013	0.0017	0.001943	0.002104	0.00027*
Organic carbon (%)	0-5	3.07	1.42	1.88	1.74	1.39	0.14*
	20-25	1.66	1.15	0.940	1.93	1.15	1.52*
Nitrogen (%)	0-5	0.2311	0.1019	0.1603	0.1249	0.1457	0.02245*
	20-25	0.1061	0.0749	0.0895	0.06448	0.09579	0.01869*
Phosphorus ($\mu g\ g^{-1}$)	0-5	18.4	09.46	10.80	.8.86	25.6	8.0*
	20-25	11.98	5.94	3.04	9.61	13.47	3.8*

* = Significant at (P<0.05) level

accordance to our results. The availability of N depends to a large extent upon the quantity and properties of OC (Haan, 1977). Hence, in the present studies, available N followed similar trend as that of OC.

Phosphorus is the second most important macronutrient available in the biological systems, which constitutes more than 1 per cent of the dry organic weight. It is also a second most limiting factor often affecting plant growth, which exists in the soil in both organic and inorganic forms. In the present studies, maximum available P was observed at surface soil of *A. tortuosum* and *C. tuberosum* during October and September, respectively. The available phosphorus ranged from 8.86 to 34.5 $\mu g\ g^{-1}$ and 3.04 to 13.47 $\mu g\ g^{-1}$ surface and 20-25 cm depth soils underneath all three selected plants (Tables 2-4), which show that phosphorus content is very low at Sitamata Wildlife Sanctuary. Karia and Kiran (2004), Kumar et al (2013) and Singh et al (2016) reported higher concentration of P in surface soil as compared to subsurface ones. Atofarati et al (2012) observed maximum soil P at surface and they further stated that with increasing depth, values reduced drastically. The present results are in accordance with above researchers as higher phosphorus contents were recorded at surface than deeper layers from soils underneath selected plants during different months.

CONCLUSIONS

The values of moisture contents were high at surface as compared to 20-25 cm depth in soils underneath selected plants during different months. Soils underneath selected plants were found to be slightly acidic according to their pH values. The values of OC, N and available P were higher at surface as compared to 20-25 cm depth. Soils underneath *C. tuberosum* contained more OC and N as compared to that of remaining plant species. Soil collected beneath *A. tortuosum* and *C. orchioides* habitat exhibited highest values of P during October, whereas in September underneath *C. tuberosum*. Soils underneath all three plants were low in available P contents.

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Effect of Abiotic Factors on Seed Germination of *Anacyclus pyrethrum* (L.) Link, and Modeling of Habitat Suitability in Saida (Algeria)

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Abstract: *Anacyclus pyrethrum* (L.) Link is a vulnerable medicinal plant, in order to provide basic information for its conservation and reintroduction, the impact of saline stress and water stress on seed germination was studied and mapping of the habitat suitability of this species in the Saida region was predicted using the Maxent method. The salinity treatments used were 0, 50, 100, 200 m M l^{-1} of NaCl, while water deficits of 0, -2, -4, -6 and -8 MPa were induced using polyéthylène glycol 6000. Water stress impact test results indicate that *A. pyrethrum* seeds are highly tolerant to water stress, with a germination capacity of 68.88 per cent when exposed to a PEG solution of -2 MPa. Altitude and 19 bioclimatic variables, along with 34 points of presence of the species, were used to predict the habitat suitability of *A. pyrethrum* in an area of 6,765 km^2. This model obtained has shown to be accurate. The results can serve as guidelines for the propagation protocols of this species and present the most appropriate areas to promote their cultivation, and provide a useful reference for the implementation of conservation and management strategies for this species.

Keywords: Anacyclus pyrethrum, Abiotic factors, Conservation, Germination, Habitat suitability

Anacyclus pyrethrum (L.) Link is a perennial herbaceous plant of the Asteraceae family (Fig. 1) with restricted distribution in the western Mediterranean, native to Algeria, Morocco and southern Spain (Greuter 2006–2009). This species is very local and fairly rare in most of its known sites and abundance varies from rare to occasional and sometimes dominant in some localities (Rankou et al 2015). The population of *A. pyrethrum* and its habitats are decreasing locally due to numerous threats such as collection for domestic and commercial uses (Rankou et al 2015). *Anacyclus pyrethrum* is a medicinal plant widely used to treat many diseases (Puri 2003, Ghrabi 2005) and is on the Red List of the International Union of Conservation of Nature with a vulnerable status (Rankou et al 2015). One of the pragmatic ecological measures for the rehabilitation of medicinal plants is the restoration and cultivation of habitats (Sharma et al 2018). The basic information on the germination of seeds of these wild medicinal species in response to several environmental constraints was essential (Abbad et al 2011).

In the arid natural environments that characterize many regions of Algeria, many uncontrolled factors can affect germination, especially drought. It has been recognized that water stress is the most limiting factor for plant germination and productivity in arid regions (Rodrigues et al 2009). In addition, understanding drought-resistant plant species is important for plant selection during restoration (Lai et al 2019). On the other hand, most of the world's salt water is found in these arid regions (Abbasi and Kouchaki 2008). In order to provide basic information for its preservation and reintroduction, the impact of saline stress and water stress on seed germination was studied and the mapping of the potential geographic distribution of this species in the Saida region was predicted using the Maxent method.

MATERIAL AND METHODS

Effect of abiotic factors on seed germination: The ripe seeds of *A. Pyrethrum* that were collected in July 2018 in the province of Saida located in the northwest of Algeria. The seeds were surface sterilized in a sodium hypochlorite solution for 0.5 min to prevent fungal attacks and washed with distilled water and air-dried before being used in germination experiments. Seed germination was studied under different concentrations of NaCl 0, 25, 50, 100 and 200 mm l^{-1} and under different osmotic potentials of polyethylene glycol (PEG 6000) at 0, -2, -4, -6 and -8 MPa). The seeds were germinated in Petri dishes containing two Whatman No.1 filter paper discs in the dark in a 20°C because pilot experiments have shown that optimum germination temperatures are between 15°C and 25°C and light does not affect germination. Each trial consisted of 90 seeds, 3 replicates of 30 seeds per Petri dish and the number of seeds germinated was counted daily for 15 days. Germination percentages were calculated with Germina Quant Software (Marques et al 2015), and were subjected to

analysis of variance (normal distribution and homogeneity of variance were satisfied) and the differences between the mean values were tested using Duncan's test with, SPSS software version 24.

Mapping the Potential Geographic Distribution

Study area: The study area covers a total area of 6765 km^2, located in the north-west of Algeria, between 34.317024 at 35.165605 latitudes north and -0.348270 at 0.933616 longitudes. The altitude varies between 323.5m and 1348.9m.

Species occurrence data: A total of 34 spatially well-distributed presence points in the study area were recorded during the flowering season between March and June for two years 2017 and 2018.

Environmental data: The digital elevation model with a 90 m spatial resolution, downloaded from the USGS website (www.srtm.usgs.gov) and nineteen bioclimatic variables with 1 km spatial resolution downloaded from the Worldclim database (www.worldclim.Org) (Fick and Hijmans 2017), were used for modeling. All variables were re-sampled at a spatial resolution of 1 km in Arc GISv 10.3.To reduce multicollinearity among the 20 variables (Graham 2003). All variables were initially subjected to correlation analysis using the SDM Toolbox (Phillips et al 2009, Brown and Anderson 2014). In order to eliminate those that are correlated to each other at the 80 per cent correlation threshold, all variables with a correlation coefficient value of 80 per cent, only one was selected (Yang et al 2013).

Modeling habitat suitability: Maxent software version 3.4.1 (Phillips et al 2017) was used for this study and selected 75 per cent of the data for model formation and 25 per cent for the test, the other values were kept by default. The area under the receiving operator curve (AUC) was used to assess the quality of the model fit The AUC value varies between 0 and 1. This value is interpreted as proposed by Swets (1988): AUC < 0,75: the model is bad; 0,75≤ AUC ≤ 0,90 : the model is passable; AUC > 0,90 : the model is good. Jackknife analyses were conducted to assess the importance of variables (Phillips et al 2006, Khanum et al 2013). Maxent produced a map of probability of potential presence of the species with a range of values ranging from 0 to 1, these values were classified into four potential habitat classes according to Zhang et al (2018), namely 'high potential' (> 0.6), 'good potential' (0.4–0, 6), 'moderate potential' (0.2–0, 4) and 'not potential' (0.2).

RESULTS AND DISCUSSION

Effect of Abiotic Factors on Seed Germination

Effect of NaCl: The seeds of *A. pyrethrum* were non-dormant and germinated to a maximum (about 78%) in distilled water, which is similar to many other Asteraceae (Van Auken 2013). Based on the results of the analysis of variance, salinity stress significantly affected germination percentage (F=55.4, P <0, 05) (Fig. 2).

A high negative correlation obtained between the percentage of germination and the different concentrations of NaCl. This correlation showed that any increase in salinity led to a reduction in the germination of *A. pyretherum* seeds (Fig. 3), this can be attributed to a decrease in water absorption created by salinity, thus inhibiting germination and radicle elongation (Yang et al 2010, Mohammad Esmaeili et al 2012, Western 2012) and / or the toxic effects of Na + and Cl- on the germination process (Khajeh-Hosseini et al 2003).

Effect of water stress: A statistically significant difference was observed between the five PEG treatments (Fig. 4), the highest percentage of germination (77.77%) was in the control germination test (0.0 MPa). The decrease in the osmotic potential of the PEG6000 solutions resulted in a progressive decrease in the final germination percentage, the percentage of germination of the seeds in a PEG6000 solution of -8 MPa was zero. This osmotic potential totally inhibits germination. A high negative correlation obtained between germination percentage and PEG 6000 concentrations, this correlation

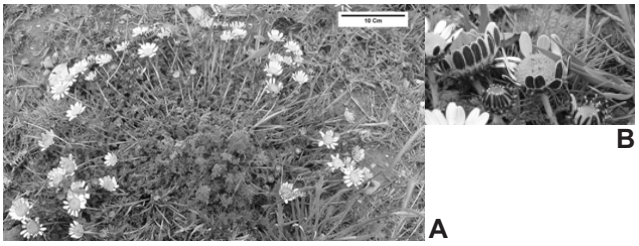

Fig. 1. (A) *A. pyrethrum* in full bloom **(B)** Flowers

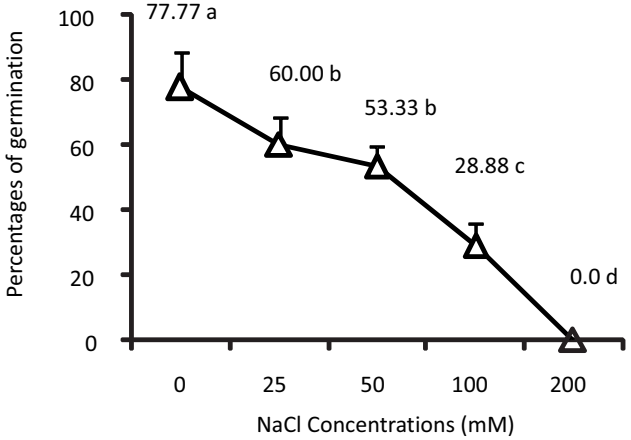

Fig. 2. Percentages of seed germination at different concentrations of NACL. Different letters indicate significant differences (p <0.05) according to Duncan's test

showed that any decrease in osmotic potential resulted in reduced germination of *A. pyrtherum* seeds and vice versa (Fig. 5). This reduction in germination could be due to a lack of hydration of the seeds due to a high osmotic potential resulting in an inhibition of the degradation of the reserves which leads to the exit of the radicls from the integuments and consequently a delay of germination of the seeds (Gill et al 2003, Zhang et al 2011). The results of this study indicate that *A. pyrethrum* seeds are highly tolerant to water stress, that is, their water potential is extremely low, seed radicles have emerged at a water potential as low as -1.5 MPa with a germination capacity of 68.88 per cent when exposed to a PEG solution of -2 MPa (Fig. 4). This is a remarkably low value compared to other Mediterranean herbaceous species tolerant to water stress such as *Tricholaena teneriffae* (Mezghani et al 2017), *Stipa tenacissima* (Krichen et al 2014), *Stipagrostis ciliate* (Fakhfakh et al 2018), *Plantago albicans* (Veiga-Barbosa and Pérez-García 2014).

Habitat suitability: Based on the correlation matrix, seven predictive variables were selected for the model (Table 1).

Maxent is an established ecological model, using presence data only to predict the distribution of a species based on the theory of maximum entropy (Phillips et al 2006, Elith et al 2011), often used because its performance has been shown to be better with smaller samples compared to other modeling methods (Hernandez et al 2006, Elith et al 2006, Pearson et al 2007), It can generate reliable models with only five locations (Pearson et al 2007, Kumar and Stohlgren 2009). In our study a total of 34 species records were used for training and test data, well distributed in space to increase the reliability of this forecast. The generated model based on Maxent method was rated as excellent with an AUC value of 0.966 and 0.906 for training data and test data respectively (Fig. 6) (Shao et al 2009).

Results of the jackknife analysis (Fig. 7); showed that

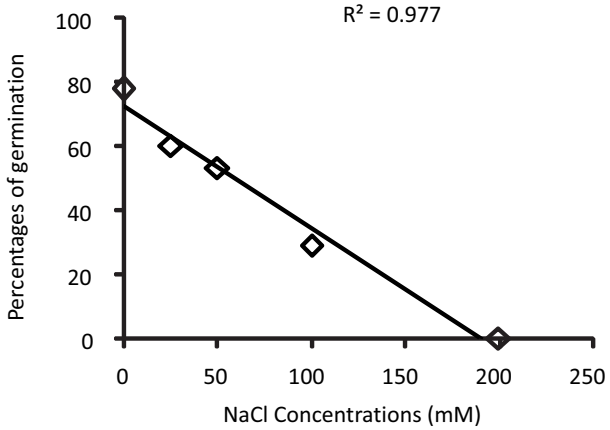

Fig. 3. Correlation between seed germination percentage and NaCl concentration

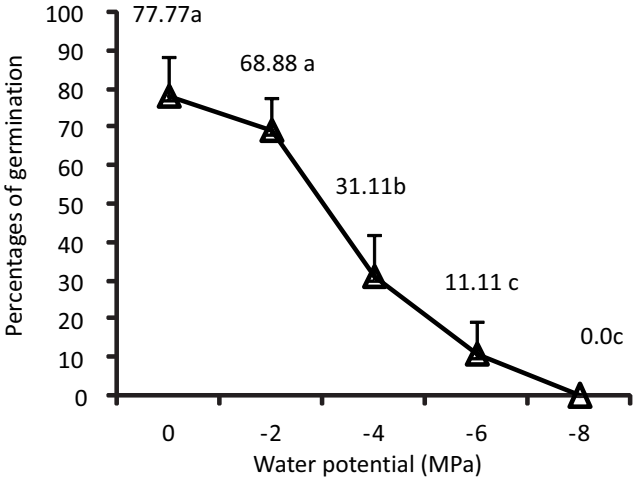

Fig. 4. Percentages of germination under different osmotic potentials induced by PEG. Different letters indicate significant differences at $p < 0.05$ according to Duncan's test

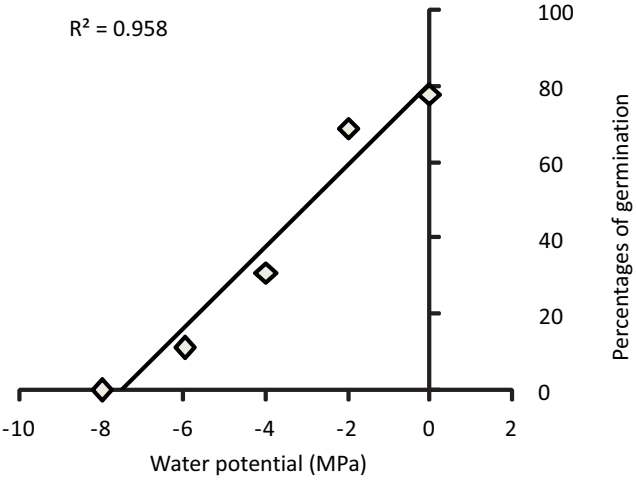

Fig. 5. Correlation between the percentage of seed germination and the different osmotic potentials induced by PEG (polyéthylène glycol)

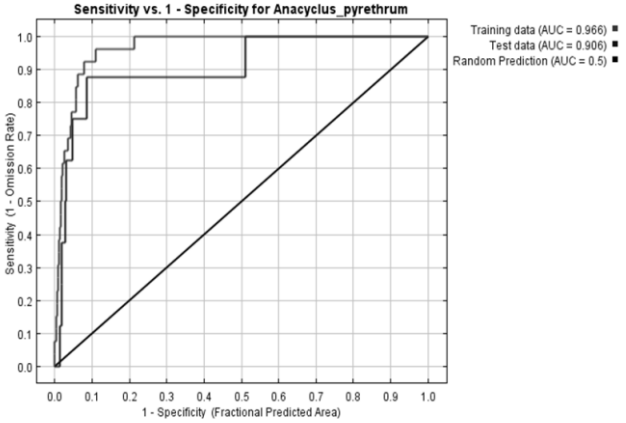

Fig. 6. Receiver operating characteristic curve with area under curve (AUC)

altitude is the most contributing variable to the model (74%) and provided very high gains (1.4), areas or habitat quality are greater than 0, 6 are located at altitudes above 1080 m (Fig. 8), this corresponds well to the fact that the species *A. pyrethrum* is highly specialized in mountain ecosystems.

Maxent produces a continuous raster with values ranging from 0 to 1 representing habitat suitability. The most suitable potential habitats for *A. Pyrethrum* have been predicted in the Saida region (Fig. 9). This map can help find new populations, plan restoration and implement conservation strategies for their natural habitat (Kumar and Stohlgren 2009, Chettri et al 2018).

Table 1. Percentage contributions and permutation importance of the bioclimatic variables included in the Maxent models for *Anacyclus pyrethrum* (L.) Link

Code	Variable	Contribution (%)	Permutation importance
BIO1	Annual Mean Temperature		
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min	11.7	16.9
BIO3	Isothermality (BIO2/BIO7) (* 100)		
BIO4	Temperature Seasonality (standard deviation *100)		
BIO5	Max Temperature of Warmest Month	0.4	0.1
BIO6	Min Temperature of Coldest Month		
BIO7	Temperature Annual Range (BIO5-BIO6)	0	0
BIO8	Mean Temperature of Wettest Quarter	9.3	2.6
BIO9	Mean Temperature of Driest Quarter		
BIO10	Mean Temperature of Warmest Quarter		
BIO11	Mean Temperature of Coldest Quarter		
BIO12	Annual Precipitation	4.6	10.1
BIO13	Precipitation of Wettest Month		
BIO14	Precipitation of Driest Month		
BIO15	Precipitation Seasonality (Coefficient of Variation)		
BIO16	Precipitation of Wettest Quarter		
BIO17	Precipitation of Driest Quarter		
BIO18	Precipitation of Warmest Quarter		
BIO19	Precipitation of Coldest Quarter		
	Altitude	74	70.4

*The bold variables, selected by a multicollinearity test, were used in the modeling

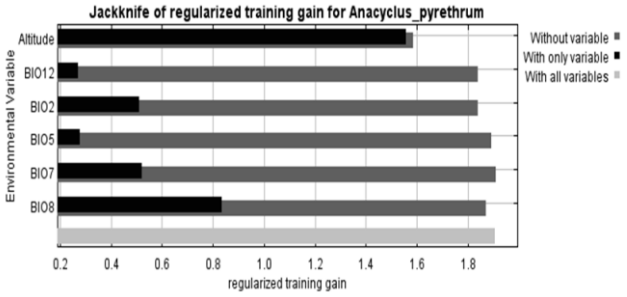

Fig. 7. Jackknife test for variable importance of *A. pyrethrum* habitat suitability

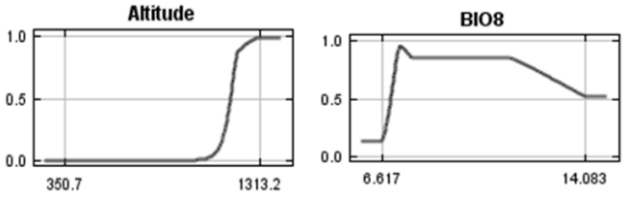

Fig. 8. Response curves of the two most influential predictor's variables in *A. pyrethrum* habitat distribution model

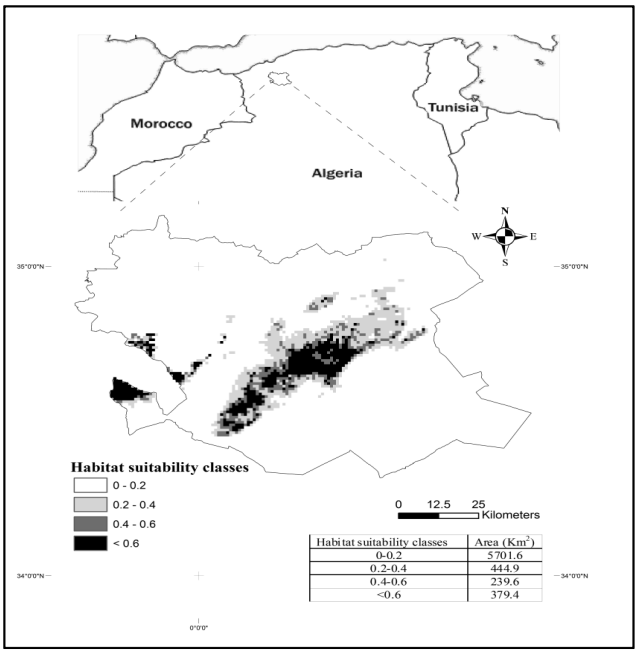

Fig. 9. Potential habitat suitability classes of *A. pyrethrum* within Saida region

CONCLUSIONS

The high concentrations of NaCl inhibit germination of *A. pyrethrum* seeds. The germination capacity of this species under water stress factor is very remarkable and is sufficiently assured that this species can be considered as part of the semi-arid restoration program. The most

appropriate map of potential habitats can still help to select the most appropriate areas to promote the cultivation of this species to expand its range and the creation of protected areas. This will ensure maximum production and protect this over exploited medicinal plant.

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Nutrient Release Pattern in Different Growth Media for Container Cultivation of Elephant Foot Yam

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Abstract: An experiment was undertaken to study nutrient release pattern in different growth media in order to formulate an effective growth medium for container grown elephant foot yam. The experiment was conducted during April to November 2016 with three growth media (M1 - soil : sand : FYM 1:1:1, M2 - soil : coir pith : FYM 1:1:1 and M3 - soil : coir pith : FYM 0.75:1.25:1). Higher pH and lower EC were observed in the growth medium M1 than M2 and M3 throughout the period of incubation. Dehydrogenase activity was found to be higher in the growth medium M1 upto four months of incubation and was on a par with M2 from five months onwards. But soil, coir pith and FYM in 1:1:1 ratio was found superior at end of seven months. Higher contents of organic carbon and available N, P and K were registered in the growth media soil, coir pith and FYM in 1:1:1 ration and soil : coir pith : FYM 0.75:1.25:1 throughout the period of incubation. Thus it can be concluded that the nutrient release pattern in soil, coir pith and FYM in 1:1:1 ration and soil : coir pith : FYM 0.75:1.25:1 is favourable for crop production.

Keywords: Container cultivation, Elephant foot yam, Growth media, Nutrient release pattern, Organic farming

Elephant foot yam *(Amorphophallus paeoniifolius* (Dennst.) Nicolson) is a tropical tuber crop belonging to the family Araceae of order Nudiflorae of Monocotyledonae. In Kerala, elephant foot yam is usually cultivated in the coconut garden as a remunerative intercrop. In the present context of shrinking land area available for cultivation especially in urban areas, the container cultivation is becoming popular. The elephant foot yam can be raised in containers in the available space around houses or on house terraces to ensure safe and fresh produce for household consumption in urban areas. Container cultivation also avoids tedious field work and enables efficient utilization of nutrients and moisture by the plant in the container. An ideal growth medium is necessary for crops grown in containers. Usually soil, sand and FYM are taken in 1:1:1 ratio to prepare the growth medium. Due to non-availability of sand and its high cost, the possibility of substituting sand with coir pith is to be explored. Coir pith is abundantly available in Kerala as a byproduct of coir industry. Besides, use of coir pith as a component of growth medium will reduce the weight of the container which is especially advantageous for farming on house terrace. Due to its high C:N ratio, it is necessary to find out the optimum proportion of coir pith in the growth medium. For achieving high yield the growth medium with higher nutrient release pattern have to be find out. Hence the present study was undertaken in the College of Agriculture, Vellayani to study nutrient release pattern in different growth media.

MATERIAL AND METHODS

The experiment was conducted during April to November 2016 with three growth media (M_1 - soil : sand : FYM 1:1:1, M_2 - soil : coir pith : FYM 1:1:1 and M_3 - soil : coir pith : FYM 0.75:1.25:1), with five replications in completely randomized design. Plastic pots of uniform size (3 ½ L capacity) were used as containers. Different growth media used in the experiment were prepared with soil, sand, FYM and coir pith in different proportions by volume as per treatments. Plastic pots were uniformly filled with different growth media and incubated for a period of seven months. Lime @ 1.33g and neem cake @ 13.33g were applied as basal dose uniformly in all the plastic pots. The growth media were uniformly supplied with the organic sources of NPK as groundnut cake, bone meal and wood ash. Bone meal (1.33 g pot^{-1}) was given as basal dose and, groundnut cake (6.67 g pot^{-1}) and wood ash (13.33 g pot^{-1}) were applied in three equal splits at bimonthly interval starting from 2 months after incubation. Moisture content of the growth media was maintained at field capacity. The organic manures used in the experiment were analyzed for pH, EC and total N, P and K contents using the standard procedures (Table 1, 2).

The samples were collected at monthly interval from each growth media to study the nutrient release pattern from different growth media. The collected samples were air dried, powdered and passed through 2 mm sieve for the analysis of available N, P and K contents and 0.5 mm sieve for organic carbon. The samples were analyzed for pH, EC, organic carbon, available N, available P and available K using standard procedures (Table 3). The dehydrogenase activity of the samples were analyzed by following the procedure outlined by Casida et al (1964). The initial values of parameters of growth media were analyzed (Table 4).

RESULTS AND DISCUSSION

The physico – chemical properties of the incubated growth media were analysed at monthly interval (Table 5, 6 and 7).

Initially, the pH of the growth media was stabilized by adding lime uniformly in all the growth media. Prior to the experiment, the growth media M_1 and M_2 showed pH values above seven and growth medium M_3 showed slightly acidic range (Table 4) which might be due to the presence of coir pith in M_2 and M_3 which is acidic in nature as also reported by Mukherjee (2001) and Jeyseel and Raj (2010). When growth media were incubated, the pH value decreased in all the growth media upto three months (Table 5). Divya (2008) also observed decrease in pH upto 5 months when the rock dust was incubated with FYM. At the end of three months of incubation, pH of all the growth media were below seven with M_2 and M_3 more acidic than M_1. Again, the pH values increased in all the growth media with pH more than seven in M_1 and M_2 and nearly seven in M_3 at the end of five months of incubation. After five months, the pH decreased in all the growth media. Still pH of M_1 was more than seven and the value was maintained at the end of seven months of incubation. But in M_2 and M_3, pH were below seven which showed a slight increase (still<seven) from 6 to 7 months. At the end of the study, the pH of the growth medium M_1 was above seven without much variation than the initial value and pH of M_2 and M_3 were below seven slightly less than initial values. Higher pH was observed in the growth medium M_1 at all stages except 5 month after planting when it was on a par with M_2.The pH of M_2 was on a par with M_3 at all stages of observation except during initial stages and the end of the study. The optimum pH of soils for crop production is considered to be between 6.5 and 7 which mainly affects the nutrient availability. In the present study pH of the different growth media ranged from 6.04 to 7.39 which was expected to have no deleterious effect on the crop.

The growth media M_2 and M_3 had higher EC than M_1 at the start of the experiment (Table 4). Upto 2 MAI, EC was lowered in all the growth media. Afterwards, an increasing trend in EC was observed in all the growth media upto 6 MAI beyond which it showed a slight decrease. At the end of seven months of incubation, EC in all the growth media showed values much higher than the initial values. This is conformity of the findings of Divya (2008) who observed an increase in EC upto 1 MAI when rock dust was incubated with FYM. In general, higher EC values were observed in the growth media M_2 and M_3 than M_1 which might be due to the release of more soluble salts by decomposition of the coir pith present in them. However, the EC values (Table 5) were within the tolerable limits (less than four dSm^{-1}) for crop production.

Dehydrogenase activity was the highest in the growth medium M_1 prior to incubation (Table 4). Dehydrogenase activity increased upto the end of one month of incubation but

Table 1. Procedures followed in the analysis of organic manures

Properties	Method	Reference
pH	pH meter method	Jackson (1973)
EC	Conductivity meter method	Jackson (1973)
Organic carbon	Walkley and Black rapid titration method	Jackson (1973)
Total N	Digestion with H_2SO_4 and micro kjeldahl method	Jackson (1973)
Total P	Digestion with H_2SO_4 and phosphomolybdate yellow colour method	Jackson (1973)
Total K	Digestion with H_2SO_4 and flame photometry	Jackson (1973)

Table 3. Procedures followed in the analysis of growth media

Properties	Method	Reference
pH	pH meter method	Jackson (1973)
EC	Conductivity meter method	Jackson (1973)
Organic carbon	Walkley and Black rapid titration method	Jackson (1973)
Available N	Alkaline potassium permanganate method	Subbiah and Asija (1956)
Available P	Bray colorimeter method	Jackson (1973)
Available K	Neutral normal ammonium acetate method	Jackson (1973)

Table 2. Physico-chemical properties of organic manures

Organic manures	pH	EC (dSm^{-1})	Organic carbon (%)	N (%)	P (%)	K (%)
FYM	7.44	4.10	10.73	1.52	0.72	0.31
Coir pith	3.10	0.36	7.07	0.70	0.37	0.14
Neem cake	7.54	6.70	3.60	1.54	0.93	1.91
Groundnut cake	6.06	5.40	20.62	6.86	0.69	1.24
Bone meal	6.58	11.60	9.97	3.08	19.85	0.10
Wood ash	12.06	0.04	0.75	0.58	0.37	5.16

it showed a decreasing trend afterwards upto 4 months after incubation An increase in dehydrogenase activity was observed from 4 MAI to 5 MAI which further decreased to values lower than the initial values at the end of seven months of incubation. The dehydrogenase activity is an indicator of the biological activity in the soil (Gu et al 2009, Salazar et al 2011), because they occur intracellular in all living microbial cell (Moeskops et al 2010) while all other soil enzymes are mostly extra cellular. Although the highest activity of dehydrogenase was in the growth medium M_1 upto 5 MAI, the growth medium M_2 was superior during later stages. The dehydrogenase activity in the growth medium M_3 was observed to be lower than that in M_2. It might be due to slight temporary inhibitory effect of raw coir pith on microbial activity.

At the start of the experiment, the organic carbon contents in the growth media M_2 and M_3 were higher than that in M_1 (Table 4). When incubated, a decreasing trend in organic carbon content was observed upto 4 MAI in the growth media M_2 and M_3which increased at 5 MAI (Table 6). The organic carbon content in M_1 increased upto 5 MAI. Afterwards, the organic carbon status showed a decreasing trend in all the growth media registering lower values compared to their respective initial values. In general, the organic carbon status followed the trend of the dehydrogenase activity. At all stages of observation, significantly higher contents of organic carbon were observed in the growth media M_2 and M_3 which were superior to M_1 which might be due to the higher content of organic matter (in the form of coir pith) in $M_2$and M_3.

Initially, N content in the growth medium M_1 was the highest followed by M_2 (Table 4). The available N status showed an increasing trend upto 5 MAI which decreased afterwards .This is in agreement with findings of Vipitha (2011) who also noticed increase in available N content upto 3 MAI which decreased afterwards when different organic manure mixtures were incubated for six months. At 7 MAI, M_1 registered lower status of available N and M_2 and M_3 registered higher values compared to the initial status (Table 4). This might be due to decomposition of coir pith releasing nitrogen in available form in M_2 and M_3. Availability of N was observed to be higher in the growth medium M_2followed by M_1 upto 4 MAI and followed by M_3 during later stages. Increased dehydrogenase activity at 5 MAI resulted in higher availability of nitrogen.

Available P content was the highest in the growth medium M_2 initially followed by M_3 and M_1 in that order (Table 4). When incubated available P content in all the growth media showed an increasing trend upto 2 MAI or 3 MAI and then decreased to lower values at 7 MAI when compared to

Table 4. Physico- chemical properties of growth media prior to experiment

Growth media	pH	EC (dSm^{-1})	Dehydrogenase activity (µg TPF $g^{-1}24h^{-1}$)	Organic carbon (%)	Available N (%)	Available P (%)	Available K (%)
M_1	7.25	0.83	320.15	3.68	0.095	0.034	0.015
M_2	7.12	1.78	263.24	5.65	0.084	0.042	0.017
M_3	6.91	1.78	258.09	5.85	0.077	0.038	0.017

Table 5. pH and EC of incubated growth media

Growth media	Months after incubation (MAI)						
	1	2	3	4	5	6	7
pH							
M_1- soil : sand : FYM 1:1:1	7.07	6.98	6.83	6.81	7.39	7.19	7.18
M_2- soil : coir pith : FYM 1:1:1	6.98	6.74	6.26	6.55	7.23	6.82	6.95
M_3- soil : coir pith : FYM 0.75:1.25:1	6.83	6.55	6.04	6.53	6.99	6.66	6.76
CD (p=0.05)	0.09	0.05	0.26	0.18	0.24	0.29	0.03
EC (dSm^{-1})							
M_1- soil : sand : FYM 1:1:1	0.71	0.62	1.30	1.44	1.48	2.16	1.50
M_2- soil : coir pith : FYM 1:1:1	1.36	1.13	1.31	1.82	1.86	2.60	2.32
M_3- soil : coir pith : FYM 0.75:1.25:1	1.64	1.45	1.33	2.02	2.04	2.84	2.52
CD (p=0.05)	0.198	0.187	-	0.262	0.436	0.300	0.702

Table 6. Dehydrogenase activity and organic carbon content in incubated growth media

Growth media	Months after incubation (MAI)						
	1 MAI	2 MAI	3 MAI	4 MAI	5 MAI	6 MAI	7 MAI
Dehydrogenase activity (µg TPF $24h^{-1}$ g^{-1})							
M_1 - soil : sand : FYM 1:1:1	323.20	284.00	264.40	237.00	281.96	203.60	154.00
M_2 - soil : coir pith : FYM 1:1:1	300.20	255.20	176.00	126.40	249.28	245.84	191.00
M_3 - soil : coir pith : FYM 0.75:1.25:1	260.40	184.00	140.00	104.40	150.20	160.40	181.40
CD (p=0.05)	-	58.23	40.57	32.03	36.40	38.63	28.77
Organic carbon (%)							
M_1 - soil : sand : FYM 1:1:1	3.47	4.23	4.34	4.32	4.98	3.37	3.08
M_2 - soil : coir pith : FYM 1:1:1	5.26	5.18	5.19	5.07	5.87	4.54	4.49
M_3 - soil : coir pith : FYM 0.75:1.25:1	5.79	5.27	5.16	5.11	5.95	5.29	4.37
CD (p=0.05)	0.762	0.831	0.687	0.498	0.483	0.542	0.510

Table 7. Nutrient status of incubated growth media (%)

Growth media	Months after incubation (MAI)						
	1 MAI	2 MAI	3 MAI	4 MAI	5 MAI	6 MAI	7 MAI
Available N							
M_1 - soil : sand : FYM 1:1:1	0.076	0.078	0.090	0.137	0.146	0.120	0.089
M_2 - soil : coir pith : FYM 1:1:1	0.078	0.081	0.095	0.140	0.162	0.132	0.095
M_3 - soil : coir pith : FYM 0.75:1.25:1	0.076	0.078	0.081	0.134	0.148	0.123	0.092
CD(p=0.05)	-	-	-	-	0.013	-	-
Available P							
M_1 - soil : sand : FYM 1:1:1	0.039	0.048	0.058	0.035	0.019	0.015	0.016
M_2 - soil : coir pith : FYM 1:1:1	0.052	0.071	0.076	0.041	0.024	0.023	0.021
M_3 - soil : coir pith : FYM 0.75:1.25:1	0.069	0.076	0.062	0.036	0.026	0.022	0.023
CD (p=0.05)	0.0104	0.0116	-	-	-	-	-
Available K							
M_1 - soil : sand : FYM 1:1:1	0.016	0.018	0.021	0.019	0.039	0.040	0.048
M_2 - soil : coir pith : FYM 1:1:1	0.018	0.020	0.026	0.026	0.057	0.070	0.062
M_3 - soil : coir pith : FYM 0.75:1.25:1	0.021	0.021	0.027	0.027	0.062	0.094	0.064
CD (p=0.05)	-	0.003	0.005	0.006	0.010	0.012	0.013

initial values. Initial increase and further lowering of available P status was observed by Sheeba (2004), Divya (2008) and Vipitha (2011) in their incubation studies. Though marked variation in available P status between growth media was observed during initial two months of incubation, available P content in M_1 was lower than in M_2 and M_3 at all stages. On decomposition over time, coir pith included in M_2 and M_3 might have released P in available form.

Initially, K content was slightly higher in the growth media M_2 and M_3 than M_1 (Table 4) and the same trend continued at 7 MAI. The final K status was enhanced by more than three times than the initial values in all the growth media. Divya (2008) also observed buildup of available K at the end of six months when rock dust was incubated with FYM. At all stages of incubation except 1 MAI, significant difference in K status was observed between growth media. Available K content was the highest in M3 throughout the period of incubation which might be due to higher content of coir pith in it and consequent higher release of K in available form.

CONCLUSION

The results of the incubation study with different growth media indicated that pH and EC of all the media were within permissible limits for crop production. Higher organic carbon and increased availability of N, P and K throughout the period of incubation were observed in the growth media M_2 and M_3 in which, sand in the conventional growth medium M_1 was substituted with coir pith. Thus it can be concluded that the

nutrient release pattern in M_2 (soil : coir pith : FYM 1:1:1) and M_3 (soil : coir pith : FYM 0.75:1.25:1) is favorable for crop production.

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Inducing Systemic Resistance in Tomato Plants against *Fusarium* Wilt Disease using Salicylic Acid

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Abstract: This study was conducted to evaluate systemic resistance in tomato plants against wilt disease caused by *Fusarium oxysporum* under laboratory, greenhouse and field conditions with salicylic acid. The salicylic acid was evaluated at 50,100 and 200 ppm on growth of *F. oxysporum* under laboratory condition showed significant variation in inhibition of the pathogen fungus, 200 ppm of salicylic acidca used significantly higher inhibition than 50 and 100 ppm. The different concentrations of salicylic acid caused significant reducing in the number of spores produced on culture media (PDA), the treatment 200 ppm of SA was significantly superior the other treatments. The SA 200 ppm was significantly superior to other treatments on tomato plant growth parameters (plant height, root length, no. of leaves and flowers/plant, fresh and dry weight/plant)when artificially infected by *F. oxysporum* under greenhouse and also significantly reduced the percentage of plant wilt. The results of field experiment pointed that treatment with salicylic acid (200 ppm) significantly improved the improved growth parameters and significantly reduced incidence of wilt and increased the yield.

Keywords: Fusarium wilt, Systemic resistance, Salicylic acid, Tomato

Tomato crop (*Solanumly copersion* L.) suffers from many fungal pathogens, and the most important pathogen is *Fusarium oxyspornm* f. sp. *lycopersici*, which affects the plants of the tomato, causing vascular fusarium wilt disease, which affects the roots during all stages of plant growth, causing large financial losses (Al-Azawi 2010). In order to avoid negative effect of fungicides need to identify varieties resistance/tolerant to this pathogen as some chemical stimulate self-resistance of the plant to this pathogens. The most important catalysts identified as salicylic acid (Breitenbach et al 2014) and is one of the most effective substances in acquired systemic resistance as it controls a number of physiological processes within the plant. This inhibits plant vitality and the growth of plant pathogens as well as stimulating resistance mechanisms. The treatment of plants externally with SA increases its concentration in plant by 180 times. This increase is linked to the increase of several proteins which promote disease resistance, the treatment with SA is safer and less harmful to non-target microorganisms and the environment (Schalau 2002). Some of studies have indicated the main role of salicylic acid in the transmission and distribution of systemic resistance signals to stimulate plant genes. The salicylic acid also interferes with iron-forming enzymes or transfers metal ions by binding to pathogenic proteins, resulting in the formation of phenols with free radicals resulting from the interaction of salicylic acid with catalase enzymes and ascorbic peroxidase enzymes, which stimulate systemic resistance in plants (Gaffney et al 1993, Durner and Klessing 1995). Javaheri et al (2102) observed that spraying tomato plants with different concentrations of salicylic acid has resulted in increased production and improved quality compared to untreated plants. The treatment of salicylic acid increased the number of fruits per plant and increased the content of lycopene and vitamin C, in addition, it increased the thickness of the pericarp. Jonston et al (2012) pointed out that salicylic acid regulates the plant resistance of different plant pathogens and significantly reduced the growth of fungi and conidial formation of fungus *Fusarium graminearum* in solid and liquid media, as well as it inhibits the mycotoxin deoxynivalenol production. Abdel-Monaim (2012) observed that the treatment of tomato seeds with salicylic acid has stimulated systemic resistance against *Fusarinm oxysporum* disease and provided the greatest protection for tomato plants against pathogenic fungi. For these reasons, this study aimed to determine the effective concentrations of salicylic acid in inhibiting the growth of pathogen *Fusarinm oxysporum*.

MATERIAL AND METHODS

Chemical inducer (salicylic acid): In this study, the chemical catalyst Salicylic Acid, hydroxy benzoic acid-2 and chemical formula $C_7H_6O_3$ (y BDH chemicals Ltd, England) with three concentrations (50, 100, 200 ppm) were used to

study their effect on *Fusarium oxysporum* under laboratory conditions.

Growth of pathogen *Fusarium oxysporum*: 250 mL glass flask were used containing 100 ml from the PDA media after sterilization of the medium and cooling to a temperature of 50-40°C, the chemical inducer was added in the three concentrations (50, 100, 200 ppm) to each flask, and then adding the media in petri dishes (9 cm diameter) with a rate of 20 ml / dish, three dishes were used for each concentration. In the control treatment, only sterile distilled water was used. After the hardening of the media, the center of each dish was infected with a single disk (0.5 cm diameter) from a pure culture with age of 7-day from *F. oxysporum* grown on the PDA media. The dishes were incubated at 25 ± 2°C, and the fungus growth rate was calculated for the different treatments and the results were compared to the control treatment.

Dry weight of *Fusarium oxysporum*: Take one tablet diameter 0.5 cm from a pure farm of *F. oxysporum* at the age of 7 days and add to a 250 mL glass flask containing 100 ml of sterile PDB. Then add the SA in three concentrations (50, 100, and 200 ppm). After 7 days of incubation at 25 ± 2°C., the filtration medium was filtered through Wattman no 1 filter paper. The biomass was dried at 80°C for 24 hours. The dry weight of the biomass of the pathogenic fungi was taken, and the results were compared to the control.

Effect of SA in spores' formation of *Fusarium oxysporum*: After calculating the growth rate of the fungus for different treatments in the solid media, one disc was taken from each stem medium (diameter 0.5 cm) of each treatment and added to a test tube containing 9 ml distilled water and after one hour the number of spores of the fungus *F. oxysporum* were calculated using the Haemocytometer slid.

Efficacy of SA under protected house conditions: Two experiments were carried out in the protected house of the Plant Control Department of Plant Diseases according to complete randomized design (CRD), where the plastic pots (2 kg) were filled with sterile mixed soil. There were eight treatments replicated three times (Table 2). Five days after treatment 100 ml of the fungus *F. oxysporum* filtrates containing 1 x 106 spore ml^{-1} was added. The pots were kept in protected greenhouse a suitable level of moisture was maintained by irrigating at frequent interval to ensure the vitality of the fungus pathogen. After 30 days of seed germination, plant growth parameters and disease incidence was calculated.

Efficacy of SA under protected house conditions: Seedlings of about 10 cm were taken from healthy tomato plants and were cut and the roots were soaked in concentrations (50, 100, 200 ppm) of salicylic acid for 6 hours and then replanted seedlings in field soil and distributed the treatments according to the design of the in complete random sectors (RBCD) with three replications. At the end of the experiment growth parameter were calculated (plant height, number of flowers, root length, number of leaves, soft and dry weight). The percentage of infection also calculated.

RESULTS AND DISCUSSION

The results of the effect of three concentrations of salicylic acid (50, 100 and 200 ppm) in the growth of *Fusarium oxysporum* under laboratory conditions showed that the different treatments varied in their ability to inhibit the growth of pathogenic fungi, but in 200 ppm of salicylic acid inhibition of growth was significantly higher (89.65%) while the ppm50 showed an inhibition ratio of 32.40 per cent (Table 1). The effect of salicylic acid on the dry weight of the pathogenic fungi biomass was maximum in 200 ppm followed by 100 and 50 ppm of salicylic acid. The results showed that the different concentrations of salicylic acid achieved a significant reduction of the number of produced spores by the fungus in the media (PDA) being significantly minimum in 200 ppm of the (4.73 × 106 spores cm^2).

The effect of salicylic acid on some parameters of the growth of cultivars contaminated with fungus *F. oxysporum* under greenhouse conditions showed all the treatments improved significantly the growth parameters (plant height, root length, number of leaves and number of flowers / plant, dry weight and dry weight of the plant) as well as a significant reduction in the percentage of plant decay (Table 2). The addition of salicylic acid (50, 100, 200 ppm) was the effective in increasing the plant growth parameters and decreasing the percentage of plant wilt. In improving most growth parameters and in curbing the percentage of wilt, the treatment (200 ppm) in the presence of the pathogen and in the absence of pathogens was the most significant on the rest of the treatments. In the absence of pathogens, the 200 ppm treatment was the best in improving growth parameters (plant height, root length, number of leaves, number of flowers / plant, soft weight and dry weight of the plant). In the presence of pathogens, seed treatment + seed treatments + pathogens) growth parameters improved significantly (Table 2).

The field experience indicated that salicylic acid treatment significantly improved of the growth parameters and were significant improved in (200 ppm) was than the rest of the growth parameters being /plant with 96.27 and 36.63 cm and root length, 2.60 branch, 12.87 fruit, 154.07 gm, 361.90 and 155.97 gm. The results showed that the treatment of conc.200 ppm was significantly better than (50 ppm) and (100 ppm) in increasing the growth parameters. The treatment of (200 ppm+ pathogen) significantly reduced

the percentage of wilted plant 36.33 per cent while the treatments (100 ppm + pathogens) and (50 ppm + pathogens) were 43.19 and 45.53 per cent, respectively (Table 3).

Khan et al (2000) observed that spore germination and growth of the fungus *F. oxysporum F spcumini* were significantly inhibited in the presence of high concentrations of SA. These results have supported the findings of this study. Band and Babu (2013) documented that salicylic acid works to activate the defense response of the plant through the genetic expression of genes related to pathogenesis, which increases the resistance of plant pathogens. The results of this study indicated the important role of salicylic acid in stimulating systemic resistance in the plant by stimulating the plant to manufacture compounds that lead to changes in the structure of the cellular wall and to strengthen it to make it more resistant to penetration by the pathogen. SA is a natural phenolic compound of molecular signaling compounds in the plant that controls the process of flowering and stress resistance and its extensive role in the defense responses of

Table 1. Effect of SA treatment on the growth of fungi in laboratory conditions

Treatment (concentration of SA in ppm)	Rate of growth (cm)	Inhibition (%)	Dry weight (gm)	Inhibition (%)	Number of spores (10^6 cm^2)
0.0	48.33	0.0	0.27	0.0	28.50
50	32.67	32.40	0.24	11.11	21.20
100	23.33	51.72	0.12	22.22	17.57
200	5.0	89.65	0.18	33.33	4.73
CD (p=0.05)	3.88	-	0.01	-	10.47

Table 2. Effect of SA treatment on some growth parameters of tomato that infection by *F. oxysporum* under green house

Treatment	Plant height (cm)	Root length $stem^{-1}$	Leaves number $plant^{-1}$	Flowers number $plant^{-1}$	Wet vegetative weight $plant^{-1}$ (g)	Dry weight $plant^{-1}$ (g)	Wilting (%)
Control without pathogen	43.50	15.80	16.0	13.73	62.53	23.07	1.33
Control with pathogen	17.53	7.03	5.50	2.37	19.30	6.30	79.83
Treatment 50 ppm SA	45.70	19.27	18.73	14.63	65.63	25.80	-
Treatment 100 ppm SA	51.23	23.33	21.03	17.50	81.77	31.13	-
Treatment 200 ppm SA	55.93	26.23	25.77	20.60	98.20	36.10	-
Treatment 50 ppm SA + pathogen	37.83	16.67	16.47	12.30	61.50	21.80	45.97
Treatment 100 ppm SA + pathogen	40.0	17.07	16.93	12.50	67.90	24.70	40.47
Treatment 200 ppm SA + pathogen	41.43	18.03	18.73	14.60	71.40	28.30	33.30
CD (p=0.05)	1.33	1.20	1.11	0.92	2.39	1.60	2.00

Table 3. Effect of SA treatment on some growth parameters of tomato that infection by *F. oxysporum* under field conditions

Treatment	Plant height (cm)	Root length (cm)	Branches number $plant^{-1}$	Fruits number $plant^{-1}$	Fruit weight (g)	Wet vegetative weight $plant^{-1}$ (g)	Dry weight $plant^{-1}$ (g)	Welting (%)
Control without pathogen	76.07	31.23	2.0	9.60	102.20	272.60	97.67	1.8
control with pathogen	23.17	14.83	0.0	0.0	0.0	94.90	35.50	78.27
Treatment 50 ppm SA	77.63	32.77	2.40	9.70	106.67	283.80	102.50	-
Treatment 100 ppm SA	89.10	36.63	2.50	11.87	112.57	294.5	114.07	-
Treatment 2000 ppm SA	96.27	36.63	2.60	12.87	154.07	361.9	155.97	-
Treatment 50 ppm SA+ pathogen	76.10	31.60	1.90	9.53	102.67	265.8	98.30	45.53
Treatment 100 ppm SA + pathogen	78.13	32.77	2.16	10.0	102.67	272.5	104.20	43.10
Treatment 200 ppm SA + pathogen	81.23	32.30	2.33	10.57	109.40	276.8	106.30	36.33
CD (p=0.05)	2.44	2.80	0.52	0.99	4.22	10.98	6.84	2.40

the plant against pathogens (Rivas-San Vicente and Plasenicia, 2011) and stimulates genes responsible for the production of proteins related to pathogenicity secondary primary compounds responsible for situational and systemic resistance acquired (Darrant and Dong 2004).

CONCLUSIONS

The salicylic acid reduced the rate of growth of the fungus and dry weight of the biomass as well as reduced the number of spores. The use of salicylic acid also increased the growth studied under green house and field conditions. Treatment salicylic acid externally led to increase its concentration to 180 times than the earlier studies. This increase is linked to the increase of several proteins related disease. So salicylic acid action is based on the acid binding of the enzyme and inhibits its work. This increases the concentration of H_2O_2, which stimulates the production of the proteins associated with the disease. The salicylic acid is a signaling vehicle in the plant and controls the disinfection process and carries stress and its role in defensive responses.

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Evaluation of the Spread of *Orobanche crenata* in Carrot (*Daucus carota* L.)

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Abstract: *Orobanche crenata* infestation in carrot fields has been reported to increase during recent years causing substantial yield losses in Morocco. The regions of Rharb, Souss and Tadla were not infested while the Chaouia and Doukkala regions were infested with *O. crenata* at differential degree of incidence severity. Higher infestation rate was observed at the Chaouia region. In fact, out of 42 fields studied in this region, 81% of the fields were infested and the number of plants of the *O. crenata* per $m^2$was more than 110 in several cases and the attack severity reached 5 plants of *O. crenata* per carrot root. Only 19 per cent of the fields were free from the parasitic plants.

Keywords: Carrot, *Orobanche crenata*, Rate of infestation, Severity of attack

Orobanche spp. is an holoparasitic plant that attacks several species of dicotyledonous plants worldwide (Punia 2014). The genus *Orobanche* contains more than 150 species (Musselman 1980), but five species are considered the most devastating for agriculture namely, *Orobanche crenata*, *O. cumana*, *O. aegyptiaca*, *O. ramosa* and *O. minor* (Perez-de-Luque et al 2004). These Orobanche species attack the families of *Cucurbitaceae*, *Apiaceae, Solanaceae, Fabaceae and Asteraceae*. The species reported in Morocco are *O. crenata*, *O. aegyptiaca*, *O. ramosa*. Some appearances of *O. foetida* (Zemrag 1999, Saffour 2003) and *O. cumana* (Naboulsi 2018) were also reported *O. crenata* remains the serious parasite of legumes (Bouhache et al 2007, El Yousfi 2016). The first infestation was reported in 1943 on faba bean in the Fez region (northeastern Morocco), afterwards it extended to all major areas of legumes: Zaer and Rharb regions (northwestern Morocco), Sais and Pre-Rif (northern central Morocco), Chaouia-Abda-Doukalas regions (western-north central Morocco), Tadla and Haouz regions (central Morocco) (Grenz et Sauerborn 2007). The percentage of infested fields increased from 12 in 1981 to 26 in 1994, 30 in 2001, 51 in 2013 and reached 90 in 2016 (FAO 2014, Fernández-Aparicio et al 2016). *O. crenata* subsequently became a dangerous parasite and a limiting factor for other legumes especially lentil and pea (Tanji 2003). It causes losses ranging from 5 to 100 per cent of yield according to the degree of infestation (Saffour et al 1999, Bouhache et Dahan 2008). It has pushed some growers to abandon legumes crops resulting in significant decrease of cultivated areas because the control methods are not well known.

In addition to legumes in Morocco, carrot (*Daucus carota* L.) are subject to attacks by *O. creanta* causing quantitative and qualitative damages. Two orobanche species have been reported to attack carrot worldwide: *O. crenata* and *O. aegyptiaca* (Parker 2012). Carrot is considered an important cash crop in Morocco. It is providing high incomes for farmers and creating an important number of jobs especially during the harvesting period. The acreage dedicated in Morocco to this crop is between 8000 to 9000 ha (Mojahid 2014). It is grown mainly in the following regions: Doukkla (western-central), Chaouia (north-central), Rharb (northwestern), Taldla (central) and Souss (western south). *O. crenata* infestation in carrot fields has been reported to increase during recent years in Morocco. The extent of damages and losses caused and severity of attacks by this parasite is not yet assessed. Thus, in the absence of such information, this study aimed to know the prevalence of the infestation of carrot fields and the degree of severity of attack of *O. crenata* in Morocco?

MATERIAL AND METHODS

Infestation assessment methods description: Fifteen fields from different regions of Morocco (Rharb, Souss, Doukkala, Chaouia and Tadla) (Fig. 1a) were surveyed during March to May of the 2018 season which correspond to the flowering stage of *O. crenata*. The sowing was done during October, November and December. The evaluation of the infestation was based on the absence or presence of *O. crenata* plants in the surveyed fields. To study the prevalence and the severity of *O. crenata* infestation in the most infested

region of Morocco, which is the Chaouia (50% of the carrot area) located in the center of Morocco, 42 carrot fields were investigated (Fig. 1b). The following scoring scale was used: Clean: 0 *O. crenata* plants ha^{-1} (not infested); Low: <20 *O. crenata* plants ha^{-1}; Medium: 20 to 50 *O. crenata* plants/ha: High: 50 to 100 *O. crenata* plants ha^{-1}; Very high: >100 *O. crenata* plants ha^{-1}. The severity of *O. crenata* infestation was carried out by counting the number of carrot plants infected per m² and the number of *O. crenata* shoots per plant and by measuring the distance between the attachment points and stem (cm) in three field on elementary plots of 1 m^2 with 3 repetitions.

Experiment details: The study related to severity of attack was carried out in 3 clay soil carrot fields (latitude 33°17'13.3"N, longitude 7°24'19.5"W ;latitude 33°14'55.5"N ,longitude 7°28'49.0"W; latitude 33°19'29.8"N, longitude 7°19'36.6"W) in Berrechid (Fig. 1a), (region Casablanca-Settat), latitude 33°15'35"N, longitude 7°34'48"W and altitude 221 m. Each plot was 1 m² with a density of 170 plants/m². The two hybrid varieties, which are the most grown carrot varieties in Morocco, were used in this study. The previous cultivated crops in the three fields were, faba bean for the field 2 and wheat for the fields 1 and 3. The sowing was 1 November 2017 (winter carrot). Regular crop management practices were followed during the experiment. Control plots were chosen in field parts known for the absence of *O. crenata* infestation based on farmers experience regarding plots history. We considered plots free form infestation when no *O. crenata* plants emerged all along the experiment period. While infested plots were chosen in *O. crenata* hot-spot in the same field based on farmers observations during the last five years.

RESULTS AND DISCUSSION

The survey indicated that out of the 75 fields only 12 that are infested (16%). No *O. crenata* infestation was observed in Rharb, Tadla and Souss. The highest infestation was observed in Chaouia region (11 fields) and low in Doukkala region (1field). Among the investigated carrot fields in Berrechid region, central Morocco where more than 90 per cent of carrot produced in Chaouia (Fig. 1b) is being grown, *O. crenata* was observed in 81 per cent of the fields (Fig. 1c, Fig. 2). The infestation was high in 40 % of the studied fields, in which 33 per cent were very highly infested. The prevalence of the parasitic plant was medium in 17 % of the fields. Only 19 per cent of the investigated fields were clean without any *O. crenata* plants.

The number of carrot plants infested by *O. crenata*

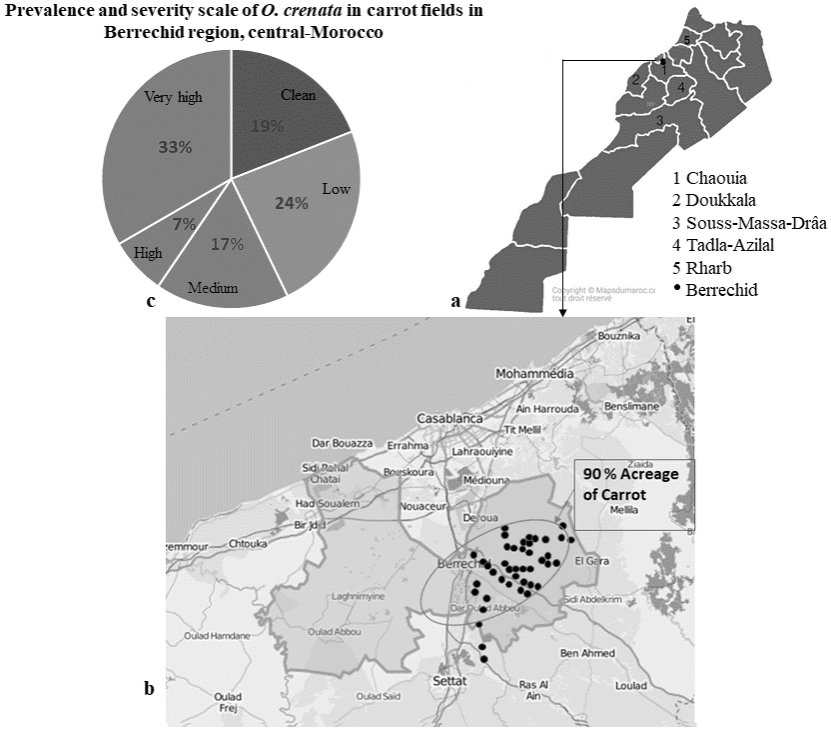

Fig. 1. Map position of the regions of the study (a),map position of surveyed carrot fields (b), prevalence and severity scale of *O. crenata* in carrot fields in Berrechid region, central-Morocco(c)

among the three studied fields ranged from 8 to 34 with an average of around 18.7 plants m^{-2}. Each infested plant was carrying 1 to 5 parasitic plants at different development stages. The distance between the attachment point to stem varied from 0.9 to 8 cm with an average of 4.85 cm (Table 1). The root of the carrot can be infested by one or more than plant of *O. crenata* at the same time at different depth and *O. crenata* doesn't have a favorite site in the root of carrot but its attachment point depends only on the position of its seeds in the soil layers

The highest infestation was observed in Chaouia region, with a severity of attack that can go up to 110 plants of *O. crenata* m^{-2} in some cases, that has a rich history of food legume cultivation (faba bean, lentil, pea and chickpea), the main host plants for the parasitic plants that may have contributed to increase soil *O. crenata* seed stock in these regions. Low infestation was observed in Doukkala region where the only infested field is located in the south of this area which contains only 1 per cent of the cultivated carrot area and it is considered a new crop for this part of Doukkala. The main crops are cereals and legumes, which explain the occurrence of an infested field that probably had as a precedent cropping legume attacked by *O. crenata*. The 14 cleans fields are located in the center and north of Doukkala, which are vegetables areas and therefore the previous carrot crops are not a host plants of *O. crenata*, which may explain its absence. Furthermore, carrot growers initially based in Chaouia region started carrot cultivation in south of Doukkala region recently. They may have contributed to spread the parasitic seeds through their farming and other logistic material. This may explain the increasing infestation observed during recent years. While the Rharb, Tadla and Souss regions are rather known for vegetables cultivation. We observed that farmers from the infested regions use mainly hybrid varieties. Whereas, standard varieties are mainly grown in other regions. Based on these results related to infestation rate and severity attacks, our prevalence and severity study was carried in Chaouia region (Berrechid).

The Chaouia and southern Doukkala regions show a high risk of spreading *O. crenata* to other regions in the future because a plant of *O. crenata* can produce up to 1,200,000 seeds and the longevity of seed in the soil can be up to 10 years. This expected scenario was observed for grain legumes percent infested fields has increased from 12 per cent in 1981 to 90 in 2016 (FAO 2014, Fernández-Aparicio et al 2016). In the absence of efficient control in Morocco, the *O. crenata* can become a limiting factor in carrot production in the areas of Chaouia and South Doukkala which has been confirmed by some cases in Chaouia where some growers have abandoned the carrot crop in their fields with very high infestations.

Table 1. *O. crenata* observed characteristics in the three investigated carrot fields

Parameters	Average	Minimum	Maximum
Number of carrot plant infested/m²	18.69±9.6	8	34
Number of *O. crenata* shouts per plant	3.5±1.58	1	5
Attachment point to stem (cm)	4.84±3.23	0.9	8

Fig. 2. *O. crenata*-infested carrot field in Berrechid region (central-Morocco) on 28th May 2018

CONCLUSION

High infestation rate and severity attacks were observed in regions known for their historic cultivation of food legumes in Morocco, the increasing infestation rate by *O. crenata* of carrot fields could reduce farmers' incomes and jobs. Thus, developing control strategies is of utmost importance.

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Effect of *Ascophyllum* Extract and Water Stress on Soil Biological Properties and Growth of Onion (*Allium Cepa* L.)

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Abstract: A study was conducted to investigate the effect of *Ascophyllum* extract with different irrigations levels (A100%, A75%, A50% and A200%) of the field capacity on soil microbial activity, roots biomass, water use efficiency (WUE), aggregate stability, fresh weight of onion (*Allium cepa* L.) in different soils textures. The highest significant increase in microbial activity was in A100 (4.81 CO_2–C mg g^{-1}).In sandy texture, microbial activity in A100 was similar to A50 and A75. Moreover, a pronounced increase in aggregate stability was (13.77%)inA100. Additionally, there was a clear rise in WUE (0.189 g l^{-1}) in A100. Similarly, significant increases in fresh weights of onion were observed (10.07 g) in A100 treatment. Root biomass was higher (8.66 g) in A200 but this treatment did not significantly differ from the A100 treatment. In the silty clay texture, microbial activities, WUE and aggregate stability had extensively increased, while the opposite was true for the roots biomass which was intensified in sandy soil. In conclusion, the combination of *Ascophyllum* extract had reduced the adverse effects of water stress in both soils confirming the beneficial use of algal materials in overcoming the water stress and increase microbial activity, roots biomass and the onion yield.

Keywords: *Ascophyllum,* Microbial activity, Roots biomass, Onion yield, Water use efficiency WUE, Soil structure

The productivity of onion (*Allium cepa* L.) in Iraqis 3.5tonnes per hectare and considered very low as compared to the global average productivity of 17.10 tonnes per hectare (Currah 2002, Soppe and Saleh 2012). The lower productivity of onion is caused by inappropriate irrigation programmes, lack supply of nutrients, soil salinity and poor use of biofertilizer (Wakchaure et al 2018). There is therefore, a need to consider possible ways to improve the crop, including bio-fertilizer and organic fertilizers, which are an important step to reduce soil contamination and increase productivity. One of these ways is the application of algae which might play a vital role in soil fertility, because of their advantages in supplying of the organic matter and soil nutrients (Khan et al 2009, AL-Maliki and AL-Masuadi 2018, AL-Zabee and AL-Maliki 2019) such as nitrogen, phosphorus, iron and other micro-elements (Co, B, Mo, Zn, Cu) as well as providing plant growth regulators (Auxins, Gibberellins and Cytokinin) that increase the effectiveness of the plant (Jensen 2004). For instance, Babilie et al (2015) observed that the application of seaweed extract (10 g l^{-1}) on onion plant increased plant biomass, leaf area, dry matter content and water use efficiency. Gougoulias et al (2018) observed that algal dried biomass hasten the organic matter decomposition and results in more available nutrients in the soil. The influence of algae on soil nutrients and aggregate stability was various based on the algal organic composition, initial nutrients concentrations in biomass (Flavel and Murphy 2006) and soil types (AL-Maliki and AL-Masuady 2018). Alobwede et al (2019) documented that algae did not enhance soil aggregate stability in greenhouse and field. It is likely possible that there are additional factors such as drought condition, soil types and quality of algal materials might affect soil properties. *Ascophyllum nodosum* enhance growth and drought stress tolerance in citrus trees (Spann and Little2011). *Ascophyllum nodosum* also can improve seed germination and yield, as well as supplying a tolerance to biotic and abiotic stress (Khan et al 2009). Brown seaweeds consist of decent amounts of polyuronides (alginates and fucoidans), which interact with metallic ions in the soil. They have a capacity to form high-molecular-weight complexes that absorb and retain moisture leading to ameliorated soil microbial activity (Khan et al 2009). The proposed hypothesis is that the application of algae can benefit soils with a lower level of irrigation and the benefit could be to a larger extent with the silty clay texture. Therefore, to exploit the benefit of algae, this study was initiated to examine the interaction between algae and different irrigation levels and its effects on onion production in different types of soils as an attempt to reduce the amount of water used.

MATERIAL AND METHODS

Experimental site: A greenhouse experiment was set up at the AL-Qasim Green University, Iraq (32_23'34.3"N,

44_24'07.8"E). The area is considered as an arid–desert–hot region (BWh). Two types of soils were used in this experiment sandy loam (sand 70%, clay 10% and silt 20%) and silty clay (sand 15%, clay 45% and silt 40%). pH for the sandy loam and silty clay was 7.10 and 7.40, respectively. The electrical conductivity for the sandy loam and silty clay was 3.40 dS m^{-1} and 3.90 dS m^{-1}. Soil samples were obtained from two fields at the depth of a 30 g and then placed in 5 kg mesocosms. Five kg pots with a 30 g height and a 15 g diameter were laid in the greenhouse. Four levels of irrigation (100% as a control, 200%, 75% and 50% of the field capacity) were used in this experiment. Four combined treatments were used in each soil (algae+ 50% field capacity, algae+ 75% field capacity, algae+ 100% field capacity and algae+ 200% field capacity). The four treatments were replicated three times in each soil to obtain 24 pots. All pots were randomly placed in the greenhouse utilizing the RCD Design. Soil water content was weighted gravimetrically. The field capacity for the sandy loam soil was 20 while it was 35 per cent for the silty clay soil. 1000 and 1750 mm were added to each pot for the sandy loam and silty clay as equal as field capacity, while the rest of field capacity percentages were calculated mathematically based on the percent proportions.

Ascophyllum nodosum: *A. nodosum* is one of the algal species selected as a biofertilizer in this study. The extract was added at a rate of 5 g for each pot after dissolving in a litre of water and at three occasions. The first application was when seedlings were planted while the second stage and third stage were applied 20 and 40 days following seedlings. The composition of algal extract contains 45 NPK, 4 moisture, 4 amino acid and 20 per cent organic matter.

Planting experiment: Four local onion seedlings were planted in pots and thinned to 3 at two weeks. Urea was added at 260 kg ha^{-1} (46% N) as a source of nitrogen. Triple superphosphate was applied at 597 kg ha^{-1} (46% P_2O_5) as a source of phosphorus while potassium sulphur was added at 288 kg ha^{-1} (41% K_2O_5) as a source of potassium. After 70 days of planting, measurements were taken including plant height (g), roots biomass (g), fresh weight (g) and dry weight (g).

Measurements: Soil respiration was briefly estimated by the Alkali trap method (Anderson 1982, ALMaliki et al 2018). A quantity of moist soil (25 g) was kept inside a flask sealed properly and consisted of a 10 ml beaker. The beaker contained a 5 ml solution of 1M NaOH. The benefit of using a sodium hydroxide solution is to absorb soil carbon dioxide. Three drops of the phenolphthalein indicator were placed into the sodium hydroxide solution made a pink color. 1M of HCl was prepared to neutralize a 5 ml of NaOH. The titration was ended when the pale colour was visible. In addition, a solution of $BaCl_2$ (2.0 ml) of a 30% (w/v) was mixed with the samples before titration to precipitate the CO_3 as $BaCO_3$.The following equations were used to estimate the ultimate amounts of CO_2.

$$\text{Meq } CO_2 = \text{Meq NaOH} - \text{Meq HCl} \quad (1)$$

$$CO_2 \text{ mg} = \text{Meq } CO_2 \times \text{Equivalent weight } CO_2 \quad (2)$$

Where the equivalent weight of CO_2 is 22

Meq= volume (ml)* Molarity (M)

Roots were properly taken from the bulk soil samples and passed through 2 and 1 mm sieves and then water-filled to remove soil particles attached. Roots samples were then oven-dried at 65°C for 72 hours (Yang et al 2004). The determination of root biomass weight then was recorded (g). Water use efficiency (WUE) calculated by dividing the productivity of onion to water used and according to the below equation according to Zhengbin et al (2011)

$$WUEf = Y/WA \quad (3)$$

Where WUEf is water use efficiency (g l^{-1}) Y is the productivity of onion (g), WA is the quantity of water irrigation added for plants for the whole season (L).

Aggregate stability was estimated by wet sieving (Hazelton and Murphy 2016). The soil was sieved to 2 mm, and then resettled to sieves with 0.25 mm apertures on a shaking machine. Stable aggregates were dried at 110 C°, and corrected for sand content (AL-Maliki and Scullion 2013).

Statistical analysis: Minitab version 14 was chosen to analyze the current findings. The two soils were compared statistically. Means were examined where significant treatment effects were noted using Tukey's honest significance difference (HSD) test with a significance level of $p<0.05$.

RESULTS AND DISCUSSION

Algal biomass, water level and microbial activity: The application of algae to soils at different water levels affected microbial activity and significantly increased microbial activity in A100 (4.81 CO_2–C mg g^{-1}) as compared to A200 (4.24 CO_2–C mg g^{-1}), A75 and A50. Increases in microbial activity at A100 could be due to adequate levels of soil moisture for microbes to maintain healthy soils encourage the plant growth (Table 1). The aggregate stability was improved to a larger extent when A100 was applied. Enhancements in aggregate stability could be an indication that soil structure and soil pores had retained organic carbon and moisture leading to an optimum soil microbial activity (ALMaliki et al 2017). Lower releases of CO_2 at A50 might result from the severe drought conditions of soils that could impede the movements of water and air causing anoxic conditions inhibiting the CO_2 releases from soils. Gougoulias et al (2018) found that the algal biomass improved microbial

activity as a result of increases in soil organic matter and nutrients. Time is also another factor modifying the microbial activity in soil. The microbial activity was lower significantly at day 2 but showed a more pronounced increase at day 5 and 14 and then a considerable decrease at day 21 as compared to day 14. The slow decomposition of algal materials at the starting time might confirm that these substances were not easily degraded at day 2 but revealed further decomposition thereafter at day 5 and 14 due to more available materials in soil supporting soil microbes. However, at day 21, a steadily decline in microbial activity was proved and it is probable that most of the algal materials in soil were run out and incapable of reviving of the soil microbes over time. When the two soils were compared statistically, microbial activity was more dominated in the silty clay texture than that of the sandy loam and the reason could be that the silty clay soil is more fertile aiding soil microbes for a longer time. It was suggested that clay soil has enormous small pores in which more water is kept and might have promoted microbial activity in the clay soils.

The microbial activity recorded more notable raise in silty clay texture at A100. A similar scenario had occurred at A75. There were no significant differences in microbial activity at A50 and A200 in both soils. Algae were capable of reducing the negative roles of sandy soil in which a very low microbial activity is appeared and render it as similar as clay soil under the stress and saturated status. The algae did not allow to microbial activity to show a decline under 50% water irrigation levels for the sandy soil. Furthermore, the algal biomass is rich in amino acid and carbon which is in favour of microbes (Devi and Rout 2018). It is suggested that algae have an important role in overcoming the negative impact of low water level irrigation in sandy soil. One possibility is that algal biomass in soil could increase organic matter in soil and it's influenced on developments of soil structure, soil porosity and soil water holding capacity. Riley (2002) observed that the algal fibre waste had improved water held capacity at low and high soil moisture tension. This can confirm the benefits of moisture in enhancing the microbial community.

Algal biomass, water level and roots biomass: There were differences in roots biomass between samples. The highest root biomass was 8.66 g when algal materials integrated with 200 per cent of the field capacity compared to A50 and A75. However, the biomass of roots in this treatment did not significantly differ from the A100. Additionally, A100 was further different from A50 and A75. The optimum supply of water to soils is very necessary to overcome drought conditions in which roots penetration are restricted. Thus, the meaningless inferences are to provide water as much as the field capacity or twice the field capacity to ensure greater roots biomass. Unexpectedly, the biomass of the roots in the sandy soil was higher (7.80 g) than the clay soils (5.70 g). Despite the concept that clay soils have good fertility than sandy soils as clay shows a higher cations exchange capacity (Caravaca et al 1999). There are other soil stresses influenced roots growths and one of them is the large space between the soil particles to which roots are likely to extend smoothly through macropores. Besides, the soil aeration which likely might have risen in the sandy soils than the clay soils leading to more roots growth. By contrast, clay soils have an important aspect which is shrinkage at drying but swelling at rewetting. Consequently, clay soil could impede mechanically the roots growth due to a space reduction. Gregory et al (2009) observed that clay soil weakened roots to penetrate and its effect on plant growth. These observation are in accordance with Hoad et al (2001) who reported that roots biomass were greater in the sandy soil than clay soils supporting the comprehensive concept that root extension in large pores is easier than those of the small sizes. The sandy soils required much water up to 100 and 200 per cent of the field capacity to ameliorate the biomass of the roots. Whereas, in the clay soils, the improvements of roots biomass was quite distinguishable in A200 and appeared to be diminished when algal materials integrated with 50, 75 and 100 per cent of the field capacity. This indicate that sandy soils needed much water such as 100 and 200 per cent of the field capacity to develop roots biomass as these soils have large spaces between particles

Table 1. Effect of *Ascophyllum* extract and soil texture on respiration and root biomass in soil

Treatments	Microbial activity mg g^{-1}			Root biomass (g)		
	Sandy loam	Silty clay	Mean	Sandy loam	Silty clay	Mean
A 100	4.43^{a}	5.18^{a}	4.81^{a}	10.00^{a}	5.66^{a}	7.83^{ab}
A 75	4.16^{a}	4.60^{b}	4.38^{b}	6.33^{a}	4.33^{b}	5.33^{b}
A 50	4.05^{a}	4.12^{b}	4.08^{c}	7.00^{a}	3.66^{b}	5.33^{b}
A 200	4.21^{a}	4.26^{b}	4.24^{bc}	8.00^{a}	9.33^{a}	8.66^{a}
Mean	4.21^{a}	4.54^{b}		7.83^{a}	5.75^{b}	

Means with different superscript letters in column represent the statistically significant differences (Tukey, HSD, $p<0.05$)

able to drain water rapidly, therefore a large quantity of water is required to meet the plant requirements. In contrast, the exact water quantity used to improve roots biomass in the clay soil was up to 200 per cent of the field capacity and the probable cause is that clay soils when it's dried, a penetration of roots is impeded, and nonetheless, a suitable amount of water could reduce the shrinkage level resulting in more roots growth.

Algal biomass, water level and water use efficiency: The significant rise in water use efficiency (WUE) was in A100 (0.189 g l^{-1}) as compared with A200 (0.05 g l^{-1}). A100 successfully improved WUE and this could be resulted from the enhancement of soil structure which might reverse an increase in soil pores and soil water retention. The inadequate water level in soil could deteriorate soil microbes and soil aggregations causing limited WUE. However, no significant differences were detected between A100, A75 and A50. Regarding to the soil texture, the silty clay soil had markedly and significantly the highest WUE as compared to the sandy loam soil. Clay soils have indeed more stored pores and well-aggregated soil leading to a restriction of the water loss and a maximization of the water retention. Application of algae to clay soils improved microbial activity to a greater extent than those of the sandy soils. As such, this status could reflect improvements of the physical and biological properties of the soil leading in turn to higher water holding capacity and WUE. Ismail and Ozawa (2007) also observed that the high clay content in soil increased WUE.

The silty clay soil corresponded efficiently to the lowest amount of irrigation (A50), while the sandy soil had a different profound scenario, where it was required much more amounts of water (A100). These important findings determined that sandy soil consumed much water to overcome the drought conditions due to a rapid drain of water, while clay soil seemed to be less consummative of water since its water holding capacity is double than those of the sandy soils. More importantly, these data assured that the clay soil saved about 50 per cent of the irrigation water. Furthermore, it is revealed that the response of clay soils to algal addition particularly at the 50 per cent water level is more effective than those in the sandy soils. The exact reason is probable that clay soils as such provided a suitable habitat for the decomposition of algal materials by soil microbes resulting to substantial products and mucilage of microbes which led to a definite promotion of soil structure and water retention.

Algal biomass, water level and aggregate stability: The maximum increase in aggregate stability was 13.77 per cent at A100 but not significantly higher from A200 (13.38%) (Table 1). The availability of the equal amounts of water and oxygen in soil is a great priority for improving soil microbes and their outputs which are simultaneously eligible to bring soil particles side by side leading to more stable aggregates. Moreover, microbes in this study at these levels showed an ultimate raise due to tangible decomposition of algal biomass in which a certain release of organic binding by-products are recorded (Abiven et al 2009).These by-products have a crucial function in aggregate stability, especially where an ideal moisture level is distinctly present. However, At A50, A75, reductions in aggregate stability (9.86 and 8.85%) were marked in a comparison with A100 and A200. There is no doubt that the low level of water has unfavourable impacts on microbial products causing destructive soil aggregates. The previous study of Bronick and Lal (2005) observed that insufficient soil moisture can result in decreasing the development of aggregates as well as increased erosion. However, aggregate stability at A50 was higher significantly than A75. The drought conditions for soils can cause shrinking and then the soil particles become closer to each other due to losing water. The shrinking and drying might bring the clay particles to organic matter. This undoubtedly led to closer contact between components, which probably contributed to higher stability. The soil texture has a decisive capacity in changing aggregate stability values. The silty clay soil demonstrated more stable aggregates (14.86%) than sandy loam (8.81%). The probable explanation is that based on our data that clay textured soils promoted more microbial activity than coarse textured soils. The decent microbial activity in clay soil might be related to soil moisture and nutrient contents which provoke more stable aggregates. The presence of fair amounts of clay in soil could form clay-polyvalent cation-organic matter bonds which considered very important in the stabilisation of aggregates. The more active microbes the more mucilage are produced. Pronounced stable aggregates can result from the presence of hydrophobic organic materials, such as fats and waxes which prevent water entry to aggregates. Moreover, sandy soil is structure less due to low quantities of clay and organic matter which supposed to be unsuspicious factors improved aggregates stability.

At A100, marked improvements in aggregate stability were listed in silty clay soil while the opposite was true in sandy loam soil in which more stable aggregates were obvious at A200and confirmed that microbial activity was high at A100 and perhaps because of produced mucilages which are essential for structural stability. Conversely, in sandy loam soil, a marked increase in aggregate stability at A200 was displayed which implies that the sandy soil was required a higher level of irrigation to have algal biomass being decomposed and to form more resistant stable

aggregates against disruptive forces. Sandy soils have large pores which are incapable of retaining water and organic matter. Hamarashid et al (2010) pointed out that sandy soils did not retain water and drain rapidly. In contrast, clay loam holds water and nutrients. However, it's proved that the addition of water as twice as the field capacity is a very important step to improve aggregate stability in sandy soil.

Algal biomass, water level and plant height: There were apparent changes in plant height between treatments (Table 2). The A100 treatment had demonstrated a significant increase (61.50 g) in plant height as compared to A50. However, plant height at A100 was not significantly different from A75 and A200. There are undeniable developments in soil microbial activity and physical properties when algal materials mixed in soil at the constant field capacity (100%) and this allowed to roots to move into soil freely, therefore, they might absorb loads of nutrients promoting plant to grow properly. The less amount of water at A500 had reduced plant height due to drying circumstances that restricted plant develops. The plant height was significantly higher in the sandy texture (61.08 g) than clay soil. It is likely that soil aeration is a prerequisite for the growth of the onion plant. Moreover, roots expansion was quite tangible in the sandy soil in which more exploitation to soil nutrients is available resulting in a healthy plant. Likewise, sandy soil might not restrict root expansion, and consequently, the ability to exploit nutrients could be quite observable in this soil. A significant interaction was observed between treatments and soil texture. It elucidated that most variations in plant height were in clay soil under a different water regime, while almost a constant change in plant height was in the sandy soil. The interaction approached that the application of algal materials successfully secured the height of plant under the severe conditions of drought (A50, A75) in the sandy soil and rendered the plant height as comparable as those of the normal condition (A100). Algae play an important role in overcoming the adverse effects of low water level, and this may be due to the role of gibberellins in increasing cell division and elongation process (Haroun and Hussein 2003). The seaweed extract was enriched with some important plant hormones such as Auxin Gerbillin and Cytokine (Kasim et al 2015) contributing to the alleviation of water stress which is negatively reflected in the inhibition of the rate of division and elongation of cells causing a lack of plant height (Soleimanzadeh et al 2010). Apart of the benefits of algal materials, they did not protect the plant height in clay soil from the severe conditions of drought (A50) and this could be evidence that clay soil turned into a very cohesive soil and more likely did not give a chance to plant to grow

Algal biomass, water level and fresh weight of onion plant: Marked variations in fresh weights of onion plant were displayed between treatments (Table 3). The significant increase in fresh weights was 10.07 g in A100 treatment. However, A75, A50, A200 treatments were not significantly different from each other. The pronounced progress in fresh weight of plant at A100 could be attributed to the developments of the WUE, roots biomass and aggregate stability which all together might have encouraged the growth of the plant. In addition, improved soil physical properties at A100 might have raised the water use efficiency and soil moisture content in the rhizosphere area leading to higher production. The soil texture affected the fresh weight of plant. Sandy loam soil had higher fresh weight (8.73 g) than the silty clay soil (5.72 g). Importance of sandy soil is likely to be in maintaining large pores which allowed to easily roots movements in which more nutrients and water could be absorbed causing more production in onion plant. Interaction produced considerable variances between treatments and demonstrated that there were slight changes in fresh weight amongst the water regimes provided where plant was cultivated in sandy soil, and it seems that algal materials reduced the negative effects of the water stress, therefore, plant growth at A50 was similar to A100. In contrast, in clay soil, the opposite was true, the reduction in the water supply led to a very obvious decrease in fresh weight especially at the A50 treatment. Limited water supply even in the

Table 2. Effect of *Ascophyllum* extractand soil texture on water use efficiency and aggregate stability

Treatments	Sandy loam	Silty clay	Mean	Sandy loam	Silty clay	Mean
A100	0.21^{a}	0.16^{c}	0.18 ^{a}	6.50^{b}	20.26^{a}	13.38^{a}
A75	0.14^{ab}	0.18^{c}	0.16 ^{a}	7.37^{b}	10.26^{b}	8.81^{b}
A50	0.09^{b}	0.24^{a}	0.17^{a}	5.52^{c}	14.20^{c}	9.86^{b}
A200	0.05^{b}	0.06^{b}	0.05^{b}	13.02^{a}	14.53^{c}	13.77 ^{a}
Mean	0.12^{b}	0.16^{a}		8.10^{b}	14.81^{a}	

Means with different superscript letters in column represent the statistically significant differences (Tukey, HSD, $p<0.05$)

Table 3. Effect of treatments and soil texture (sandy loam, silty clay) on plant height (cm) and fresh weight (g)

Treatments	Plant height (cm)			Fresh weight (g)		
	Sandy loam	Silty clay	Mean	Sandy loam	Silty clay	Mean
A100	59.67^{a}	63.33^{a}	61.50^{a}	9.82^{a}	10.33^{a}	10.07^{a}
A75	60.67^{a}	50.67^{a}	55.67^{a}	8.66^{a}	5.32^{b}	6.99^{b}
A50	62.00^{a}	29.33^{c}	45.66^{b}	8.99^{a}	2.23 ^{b}	5.61^{b}
A200	62.00^{a}	47.00^{b}	54.50^{a}	7.46^{a}	5.00^{b}	6.23^{b}
Mean	61.08 ^{a}	47.58^{b}		8.73^{a}	5.72^{b}	

Means with different superscript letters in column represent the statistically significant differences (Tukey, HSD, $p<0.05$)

attendance of algal materials has adverse effects on soil strength and plant growth since the shrinkage of clay particles while stress conditions targeted soil leading to a prevention of the roots growth and microbial activity. In turn, an automatic restriction of oxygen stress and plant growth had happened.

CONCLUSION

The addition of algae to soils at 100 per cent of the field capacity developed soil microbial activity, soil aggregate stability, roots biomass, water use efficiency and onion yield. Clay soils had well-developed of the soil microbial activity, soil aggregate stability, water use efficiency as compared to the sandy. Whereas, sandy soil had developed extensively the root biomass and the onion yield. The reduction in water supply for the clay soil had negative effects on onion yield even when the algal materials were available, while to less effect on the sandy soil. The incorporation of *Ascophyllum* extract had limited the negative effects of water stress in sandy soils confirming the advantageous addition of algal materials to control the water stress and increase the onion yield.

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Marker-assisted Selection for Incorporating Bacterial Blight Resistance Genes in the Segregating Generation of Rice Variety CO 43

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Abstract: A popular rice variety of South India, CO 43 is tolerant to high salinity and alkalinity stress but is susceptible to bacterial blight. In the present study, gene-based molecular markers were used for the foreground selection of bacterial blight disease resistance genes *Xa21* and *xa13* in an inter cross F_3 generation of CO 43. B95-1 X Tetep and B95-1 X Abhaya were used as the donors for *Xa21* and *xa13* genes. Two-hundred and ten plants of the inter cross F_3 generation were genotyped for the two genes. Eleven plants having both the genes in homozygous condition were selected and advanced to F_4 generation for disease screening and agronomic evaluation. All the selected lines recorded a high level of resistance against bacterial blight. Agro-morphological evaluation of the inter cross F_4 lines led to the identification of two lines 59-44 and 59-62 which were superior to CO 43 with respect to both agronomic performance and disease resistance. The selected inter cross F_4 lines will be screened for disease resistance under field conditions and subsequently advanced for yield trials.

Keywords: Bacterial blight, CO 43, Disease resistance, Molecular markers, Rice

Rice is a chief cereal crop of the developing world and serves as the staple diet for the Asian population. World rice production stands at 728 million tonnes with acreage of 161 million ha (Ricestat 2018). In India, rice occupies an area of 43 million hectares with a production of 163 million tonnes (Ricestat 2018). Rice production needs to be doubled by 2030 to meet the demands posed by the ever-increasing population and improved standards of living (Foley et al 2011). The global average yield of irrigated rice is 5 tonnes ha^{-1} as against the estimated yield potential of 10 tonnes ha^{-1} (Khush and Jena 2009). Various biotic and abiotic stresses are responsible for this yield gap. Bacterial blight, a serious disease of rice is caused by the bacterium *Xanthomonas oryzae* pv. *oryzae* (Xoo) (Ishiyama 1922) and can cause up to 80 percent yield losses depending on crop growth stage, level of susceptibility and environmental factors (Shin et al 1992, Mew et al 1993, Noh et al 2007). In India, the yield losses vary from 15 to 40 per cent (Upadhyay et al 1985). Plant diseases can be managed through chemicals, good agronomic practices, and deployment of disease resistant varieties. Breeding and deployment of resistant cultivars having durable resistance is the most eco-friendly and sustainable approach for managing plant diseases (Jena and Mackil 2008, Sharma et al 2012). Until the late twentieth-century, disease resistant cultivars were developed by backcross breeding strategy involving repeated backcrosses and phenotypic selections which took at least 8 to 10 years to develop/improve a variety. With the advent of molecular marker technology in the early twenty-first century, there was a paradigm shift in plant breeding leading to the birth of molecular plant breeding. Till date, more than 42 resistance (R) genes for bacterial blight have been catalogued from diverse germplasm resources (Busungu et al 2016).

Genes identified in multiple parents can be accumulated into a single genotype using the gene pyramiding approach. It can facilitate the introgression of genes encoding resistance to different races of a pathogen into a particular genotype providing robust resistance against the disease (Jiang et al 2004). Molecular markers had been used to precisely tag disease resistance genes in rice, and marker-assisted selection can be utilized for pyramiding these genes into susceptible cultivars (Jena and Mackill 2008). Khush et al (1990) transferred the dominant bacterial blight resistance gene *Xa21* into *Oryza sativa* from the wild rice species *O. longistaminata.* It is a broad spectrum resistance gene and is found to be effective in conferring resistance to diverse Xoo races. Ronald et al (1992) localized the gene to rice chromosome 11. The recessive gene *xa13* is known to confer resistance to Philippine race 6, one of the highly virulent races of the bacterial blight pathogen. This gene was

identified in the rice variety BJ1 by Ogawa et al (1987) and was located on the long arm of chromosome 8 (Sanchez et al 1999). CO 43 is a popular rice variety released by Tamil Nadu Agricultural University, Coimbatore for general cultivation in the Tamil Nadu state. It is a medium duration, fine grain variety with an average yield of 5.3 tonnes ha^{-1} having tolerance to salinity and alkalinity. The variety is susceptible to bacterial blight disease. Therefore the current study was taken up to incorporate bacterial blight resistance genes *Xa21* and *xa13* into CO 43 rice variety through marker-assisted selection using gene-based molecular markers (Fig. 2).

MATERIAL AND METHODS

Plant material and location of study: CO 43 was crossed with the donors of *Xa21* (B95-1 X Tetep) and *xa13* (B95-1 X Abhaya) genes individually and the crosses were advanced to BC_3F_3 generation practising foreground selection in BC_1, BC_2 and BC_3 generations. Background selections were carried out in BC_2F_1 and BC_3F_1 generations using 53 and 46 polymorphic SSR markers spanning all the 12 chromosomes for B95-1 X Tetep and B95-1 X Abhaya crosses respectively. Single BC_3F_3 plant was selected from both the crosses having the resistance gene in homozygous condition along with maximum recurrent parent genome recovery (above 85%). The two selected plants were inter crossed among each other to generate the inter cross F_1 generation and further selfed to obtain inter cross F_3 generation. Foreground selections were carried out in F_2 and F_3 inter cross generations to select only those plants positive for both the genes. A single F_3 plant derived population labelled as Line 59 was selected as the starting material. This line had a total of 210 plants derived from F_3 generation of the inter cross {F_3[CO 43/4*(B95-1XAbhaya)] / F_3[CO 43/4*(B95-1XTetep)]} (Fig 1.). The plant materials were generated at Wetland Field, Tamil Nadu Agricultural University (TNAU), Coimbatore during the *Kharif* season (June-October, 2014). The donor lines were provided by Indian Institute of Rice Research, Hyderabad.

Foreground selection: Gene-based markers were used for the selection of intercross F_3 lines having the disease resistance genes (*Xa21* and *xa13*) in combination. STS primers pTA248 and xa13-prom were used for the foreground selection of *Xa21* and *xa13* genes respectively (Ronald et al 1992, Chu et al 2006). Details regarding the primers used for foreground selection are presented in Table 1. Fresh young emerging green leaves were collected from the field grown inter cross F_3 plants and DNA was isolated using the modified CTAB protocol (Sambrook et al 1989). The DNA was quantified using Nanodrop spectrophotometer (Thermo Scientific, USA) and stored at -20°C for further use. The final DNA concentration of all the samples was adjusted to 40 ng μl^{-1}. The diluted DNA was consequently used for PCR amplification.PCR amplification of genomic DNA was carried out using forward and reverse primers, dNTPs, assay buffer, DMSO, and *Taq* DNA polymerase. Template DNA was initially denatured at 95°C for 5 min followed by 35 cycles of PCR amplification with the following parameters: 45 sec of denaturation at 94°C, 1 min of primer annealing at 65°C and 90 sec of extension at 72°C for the marker pTA248; 30 sec of denaturation at 94°C, 90 sec of primer annealing at 59°C and 1 min of extension at 72°C for the marker xa13-prom. Finally, the reaction mixture was maintained at 72°C for 5 min before completion. The PCR amplified products were mixed with 4 µl of 6X loading dye and resolved in 3 per cent agarose gel.

Greenhouse screening for bacterial blight resistance: The two gene pyramids of intercross F_4 generation homozygous for both the genes were screened for bacterial blight resistance during December 2014-March 2015. The seeds of the selected intercross F_4 lines along with parents namely, CO 43, B95-1X Abhaya, B95-1X Tetep and the susceptible check, ADT38 were sown in pots. For each line, 15-20 seeds were sown on pots of 15 cm diameter and 20 cm height following completely randomized design with three replications. At 15 days after sowing (DAS), 5 seedlings from each line were transplanted to a newly prepared pot containing puddled soil and placed in a circular tank to provide a constant stagnation of water (3-5 cm above the soil surface).

Leaf clip method as suggested by Kauffman et al (1973) was used for the inoculation of the rice plants with Xoo liquid culture. Xoo was isolated from bacterial blight infected rice fields in the Coimbatore region of Tamil Nadu. The bacterial culture was maintained in Nutrient Agar (NA) slants. A loopful of bacterial culture from the NA slant was inoculated into NA

Table 1. List of primers for foreground selection

Gene	Primer	Chromosome	Linkage distance	Forward primer sequence	Reverse primer sequence	Marker type	Reference
Xa21	pTA248	11	Gene-based	AGACGCGGAAGGGTGG TTCCCGGA	AGACGCGGTAATCGAAGA TGAAA	Co-dominant	Ronald et al (1992)
xa13	xa13-prom	8	Gene-based	GGCCATGGCTCAGTGTT TAT	GAGCTCCAGCTCTCCAAA TG	Co-dominant	Chu et al (2006)

broth and incubated at 28°C in an incubator cum orbital shaker for one and a half days until an optical density (OD) of 0.5 (approximately $3x10^9$ CFU/ml) at the wavelength of 600 nm was obtained. This broth culture was used for inoculating the plants. Inoculation was done at active vegetative phase. Leaves of all the tillers in a single plant were grasped in one hand and the top 1-2 inches of 5 leaves were clipped off and the same procedure was repeated for all the plants of a line. For disease scoring, the length of the longest lesions of five undamaged leaves of each individual line was measured at 21 days after inoculation. A line was classified as resistant, moderately resistant, moderately susceptible or susceptible based on the scoring protocol described by Chen et al (2000). The mean lesion length values of all the lines were compared and ranked using Duncan's Multiple Range Test (DMRT) at 5 per cent significance level.

Agronomic evaluation of intercross F_4 lines: The selected gene pyramided lines of intercross F_4 generation along with the recurrent parent were sown in 3.0 m X 0.8 m plots (4 rows per plot) at the wetland field, TNAU, Coimbatore during January 2015. The experiment was conducted in a randomized block design with three replications for each line. The selected lines were evaluated for yield and yield attributing parameters namely, days to fifty per cent flowering, plant height, number of productive tillers, panicle length, number of filled grains per panicle, thousand-grain weight, and single plant yield. For estimating the above parameters except for days to fifty percent flowering, five plants were selected from each replicate and the mean values were calculated. The days to fifty percent flowering was calculated as the number of days required for approximately half of the plants in a plot to initiate flowering. The overall mean of the three replicates was taken as the final value for all the parameters. The mean values of the gene pyramided lines were compared with that of the control (CO 43) using Dunnett's test at 5 per cent significance level.

Statistical analysis: The statistical analysis was performed in the statistical software SAS® release 9.4 (SAS Institute Inc. 2002-2012).

RESULTS AND DISCUSSION

Foreground analysis of intercross F_3 segregating generation: Out of the 210 plants genotyped, 11 plants were identified possessing the disease resistance genes in homozygous dominant (*Xa21Xa21)* and recessive (*xa13xa13*) condition. Primer pTA248 resolved 1 kb and 650 bp size bands in the resistant parent (B95-1X Tetep) and recurrent parent (CO 43) respectively (Fig. 4a). The marker xa13-prom resolved a 500 bp band in the resistant parent B95-1X Abhaya and a 280 bp band in CO 43 (Fig. 4b). Similar

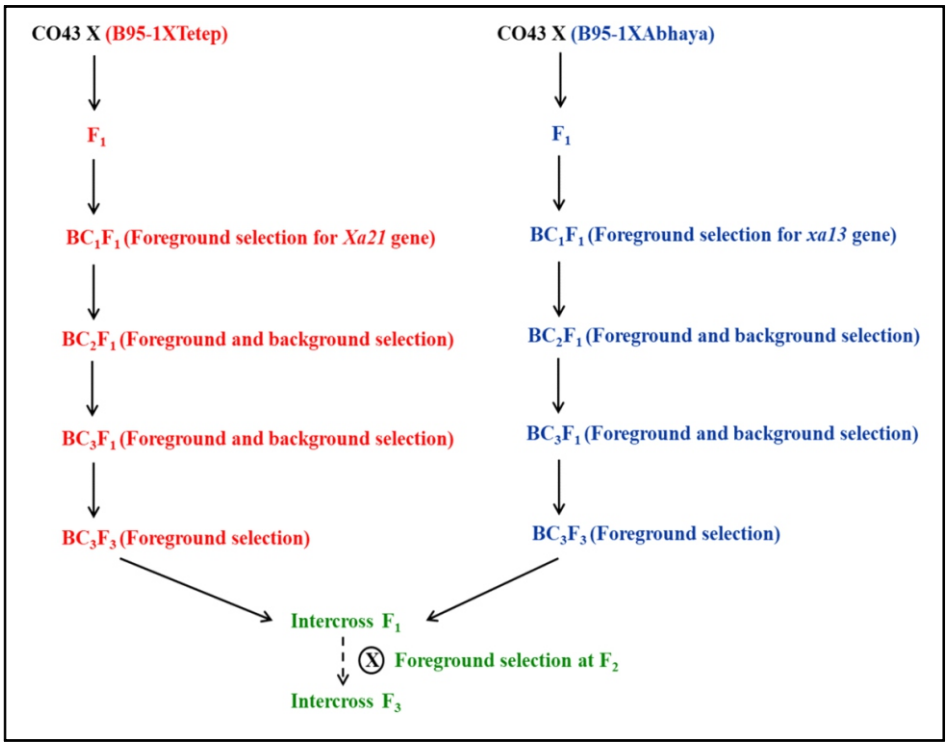

Fig. 1. Schematic outline of development of intercross F_3 lines combining two disease resistance genes in the background of CO 43

interventions were reported by earlier workers (Dash et al 2016, Deshmukh et al 2017, Baliyan et al 2018, Nguyen et al 2018). The selected plants were advanced to F_4 generation for disease screening and agronomic evaluation.

Two or more major disease resistance genes having distinct resistance spectra can be pyramided into elite cultivars for incorporating durable resistance to one or more diseases. The dominant R gene *Xa21* belongs to a multigene family containing at least eight members. *Xa21* is unique in itself as it encodes three structural features: involving a combination of an extracellular domain with leucine-rich repeats (LRR), a transmembrane domain and a cytoplasmic serine/threonine kinase domain which were not present in the gene product of other reported R genes (Century et al 1999). The recessive gene *xa13* triggers disease resistance by mediating nucleotide-binding site/leucine-rich repeat (NBS-LRR) and LRR receptor kinase proteins (Chu et al 2004). Other R genes such as *xa5, Xa4,* and *Xa21* were found to interact strongly with *xa13* (Li et al 2001). A number of genes involved in *xa13* mediated defense responses had been identified through gene expression studies and pathogen-induced subtractive cDNA library analysis. These studies point that the genes involved in the *xa13* mediated resistance are not involved in the pathways mediated by dominant R genes (Zhou et al 2002, Wen et al 2003, Chu et al 2004). This suggests that *xa13* functions distinctly from other R genes in facilitating disease resistance. Thus the two R genes having different resistance mechanisms were selected in the present study to incorporate broad-spectrum bacterial blight resistance. The pyramided lines with multiple disease resistance genes (*Xa21* and *xa13*) exhibited higher levels of resistance to bacterial blight than those carrying only one resistance gene, demonstrating the effectiveness of gene pyramiding strategy. The results are supported by the findings of Dokku et al (2013), Pradhan et al (2015), Arunakumari et al (2016) and Rao et al (2017).

Greenhouse screening for bacterial blight resistance: Eleven intercross F_4 lines along with parents CO 43, B95-1X Tetep, B95-1X Abhaya and ADT38 (susceptible check) were screened under greenhouse conditions for bacterial blight (BB) resistance (Table 2, Fig. 3). The mean bacterial blight lesion lengths recorded on ADT38, CO 43, B95-1X Abhaya and B95-1X Tetep were 14.47 cm, 9.23 cm, 1.17cm and

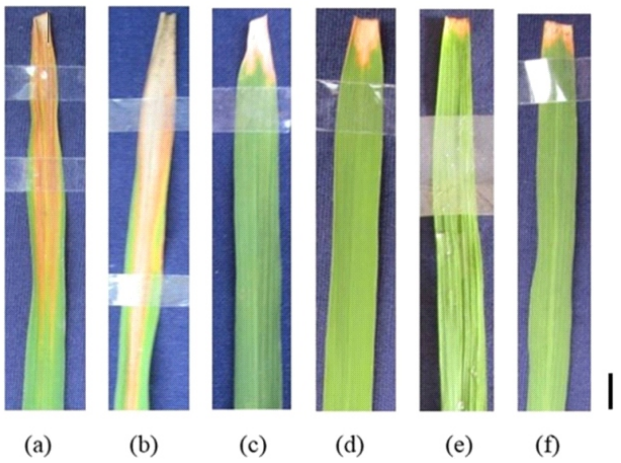

Fig. 3. Disease reactions of parents and gene pyramided lines inoculated with bacterial blight pathogen culture. (a) CO 43; (b) ADT38; (c) B95-1 X Tetep; (d) B95-1 X Abhaya; (e) Line 59-53; (f) Line 59-62. (1 scale bar = 1cm)

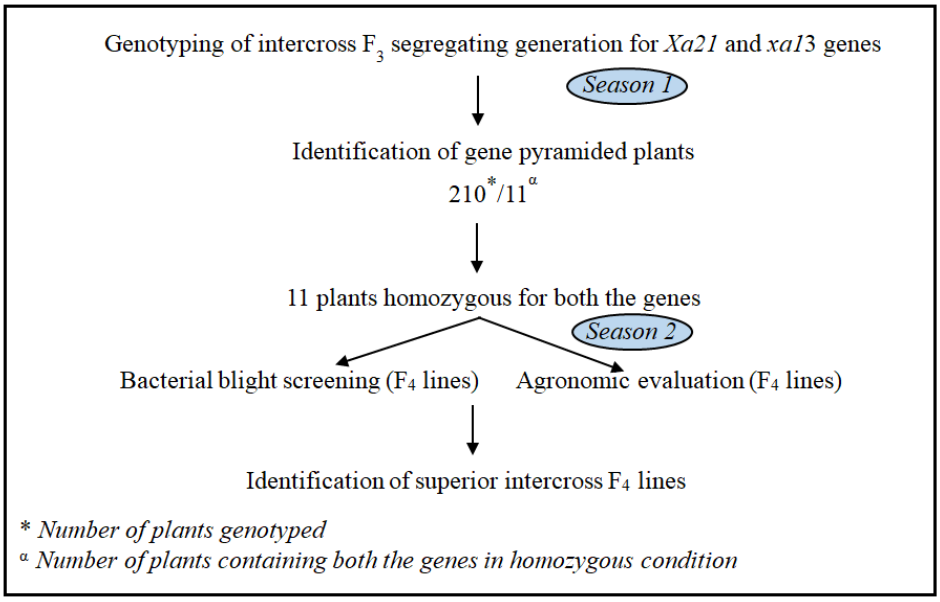

Fig. 2. Schematic outline of marker-assisted selection programme

Table 2. Bacterial blight reaction and mean agronomic performance of gene pyramided inter cross F_4 lines

Line	Gene combination	BB lesion length (cm)	BB reaction	DFF (days)	PH (cm)	NPT	PL (cm)	NFG	TGW (g)	SPY (g)
CO 43	No gene	9.23[b]	S	104.7	104.5	16.2	23.8	168.1	17.2	29.5
B95-1X Tetep	*Xa21Xa21*	1.57[cd]	R	93.7*	80.6*	16.3	17.9*	153.9*	15.1*	20.8*
B95-1X Abhaya	*xa13xa13*	1.17[cd]	R	99.7*	102.7	17.2	25.2	146.1*	15.7*	23.5*
ADT38	No gene	14.47[a]	S	-	-	-	-	-	-	-
86-2	*Xa21Xa21 + xa13xa13*	0.87[d]	R	102.7	98.0*	16.2	23.3	155.1*	19.2*	25.4
59-23	*Xa21Xa21 + xa13xa13*	0.70[d]	R	103.3	104.5	15.7	22.6	166.4	16.8	21.8*
59-30	*Xa21Xa21 + xa13xa13*	1.30[cd]	R	105.7	102.5	17.7	21.1	162.5	16.2*	30.1
59-40	*Xa21Xa21 + xa13xa13*	1.40[cd]	R	105.3	103.2	15.2	23.0	171.3	16.9	28.7
59-43	*Xa21Xa21 + xa13xa13*	0.80[d]	R	103.7	104.8	14.6	24.1	163.3	16.0*	23.2*
59-44	*Xa21Xa21 + xa13xa13*	0.90[d]	R	105.0	104.7	18.5*	21.8	175.3	18.0	34.4*
59-45	*Xa21Xa21 + xa13xa13*	0.50[d]	R	103.0	107.8	12.6*	23.1	158.3*	17.1	20.3*
59-53	*Xa21Xa21 + xa13xa13*	0.70[d]	R	104.7	102.3	13.1*	20.9	151.7*	18.9*	23.1*
59-62	*Xa21Xa21 + xa13xa13*	1.20[cd]	R	106.0	102.0	18.1*	24.1	177.1	18.4*	35.6*
59-65	*Xa21Xa21 + xa13xa13*	2.07[c]	R	102.3	102.1	15.4	20.9	154.5*	17.5	26.1
59-68	*Xa21Xa21 + xa13xa13*	2.23[c]	R	103.3	104.1	17.7	23.7	166.3	18.4*	32.1

DFF- Days to fifty percent flowering, NPT- Number of productive tillers, PL-Panicle length, PH-Plant height, NFG- Number of filled grains/panicle
TGW- Thousand-grain weight, SPY- Single plant yield.
*The values are significantly different from the control (CO 43) at p<0.05
Lesion length refers to mean of three replicates. A mean in a column followed by a common letter are not significantly different at p<0.05
BB Scoring Scale: <3 cm = Resistant; 3-6 cm = Moderately resistant; 6-9 cm = Moderately susceptible; >9 cm = Susceptible

1.57cm, respectively. They showed susceptible (ADT38 and CO 43) and resistant reactions (B95-1X Abhaya and B95-1X Tetep). All the 11 intercross F_4 lines exhibited resistant reaction with mean lesion length varying from 0.50 cm (59-45) to 2.23 cm (59-68).

Agronomic evaluation of gene pyramided intercross F_4 lines: Eleven intercross F_4 lines were evaluated for agronomic performance along with the recurrent parent CO 43 (Table 2). The days to fifty percent flowering ranged from 102.3 to 106 days. In case of plant height, the line 86-2 recorded the lowest plant height (98.0 cm) which differed significantly from CO 43. The line 59-45 recorded the highest plant height of 107.8 cm. The number of productive tillers varied from 12.6 (line 59-45) to 18.5 (line 59-44). The lines 59-44 and 59-62 recorded a significantly higher number of productive tillers in comparison to CO 43. With respect to panicle length, the lines 59-53 and 59-65 recorded the lowest panicle length (20.9cm), whereas, the line 59-62 recorded the highest panicle length (24.2cm). The mean values of the number of filled grains per panicle ranged from 151.7 (line 59-53) to 177.1 (line 59-62). In the case of thousand-grain weight, the line 59-43 recorded the lowest (16.0 g) and the line 86-2 recorded the highest (19.2 g) thousand-grain weight respectively. The thousand-grain weights of the lines 86-2, 59-53, 59-62 and 59-68 were significantly higher than CO 43. The mean values of single plant yield ranged from 21.8 g (line 59-23) to 35.6 g (line 59-62). The lines 59-44 and 59-62 yielded significantly higher than CO 43. The agronomic evaluation of gene pyramided lines led to the identification of

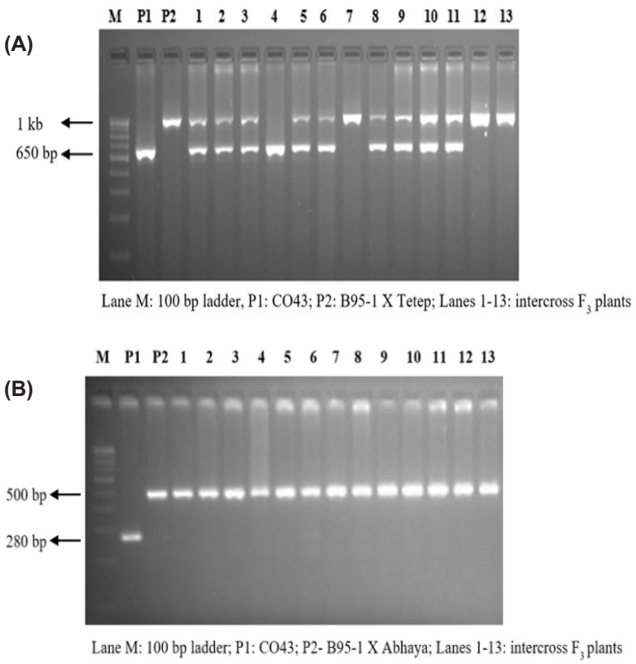

Fig. 4. Foreground selection in intercross F_3 segregating generation for (A) *Xa21* gene (pTA248 marker) and (B) *xa13* gene (xa13-prom marker)

two lines 59-44 and 59-62 which were superior to CO 43 as they had higher single plant yield and were simultaneously resistant to bacterial blight disease. The reduction in the yield of CO 43 can be ascribed to the moderate incidence of bacterial blight in CO 43 line during the agronomic evaluation. The higher single plant yield in the gene-pyramided lines was possible due to the higher number of productive tillers and thousand-grain weight as a result of protection conferred by the R genes against the bacterial blight disease. This could also be due to the presence of transgressive segregation in these lines which can be attributed to the stringent phenotypic selection of lines which were better than CO 43 in the early backcross generations.

CONCLUSION

Further testing of the improved lines against diverse bacterial blight pathogen isolates is necessary to confirm the durability and effectiveness of the selected genes. Large-scale multi-environment trials are required to evaluate the stability of the selected lines. Evaluating grain quality parameters will help in identifying the improved lines which retain the grain quality traits of the recurrent parent. The above-stated tests are to be carried out on the improved lines to qualify them to be released as an improved variety. Thus, the present study demonstrates that application of marker-assisted selection integrated with stringent phenotypic selection will pave way for the development of disease-resistant rice varieties that can sustain our agriculture and yield better profits to the farming community.

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Combining Ability of Early Segregating Generation RGR F_4 Lines of Heteroticbox in Cotton

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Abstract: Present study was designed for evaluation of combining ability of different quantitative characters in early segregating generation *i.e.* F_4 lines derived from exploitation of heterotic box in cotton. Ten F_4 lines were selected and crossed with four testers resulting in forty derived hybrids. All the forty derived hybrids, their parents and checks were evaluated in randomized block design. Parents were found to be significantly different for most of the characters studied except number of monopodia plant^{-1}, boll weight, ginning outturn and lint index in the analysis of variance. Analysis of variance for combining ability showed that MSS due to lines and testers were significant for seed cotton yield and lint yield. SCA variance was greater than GCA variance for all characters studied except for seed cotton yield and lint yield. RGR F_4 5 line recorded significant positive *gca* effect for important yield attributing characters studied except for number of bolls/plant, boll weight, sympodial length at 50 per cent height, ginning outturn, seed index and lint index. Hybrid RGR F_4 1 × DR 8 had positively significant *sca* effect for sympodial length at 50 per cent height, seed cotton yield, lint yield and seed index.

***Keywords*:** Cotton, Combining ability, *GCA* effect and *SCA* effect

Besides being important crop cotton (*Gossypium hirstum* L.) is also an important commodity by giving livelihood to 60 million individuals of which 4.5 million are Indian farmers thus contributing in Indian economy through production and processing. Hence it becomes crucial to increase the yield per unit area for better livelihood of cotton growing farmers. Combining ability is extensively used biometrical genetic method in plant breeding, which has been proved one of the potential options for breaking yield plateau in cotton, for increasing its production and productivity. Potential hybrid requires selection of good parents which possesses sufficient genetic diversity in addition to their ability to combine well with each other. Therefore, combining ability studies assistances in selecting the parents with better combining abilities. Selected parents with good combining ability on crossing would produce more desirable hybrids as well as segregants in F_2 generation. Plant breeders are continuously searching desirable genes and their complex in different genotypes of segregating population for incorporating into a genotype for better performance under diverse conditions. These studies also reveal the nature and magnitude of gene action in the inheritance of yield and its components, which help in deciding the future breeding programme. The population having predominant additive gene action varietal development will be potent option whereas population with non-additive (dominant) gene action hybrid development will be objective.

MATERIAL AND METHODS

Genetic material was developed by crossing the elite lines in this manner (DSMR 10 × DSG 3-5) × (DRGR 32-100 × DRGR 24-178), which lead to the development of two highly diverse base populations. The two F_1s of (DSMR 10 × DSG 3-5) and (DRGR 32-100 × DRGR 24-178) were advanced to F_4 generation to develop two populations, population I RSG F_4 lines and population II RGR F_4 lines, respectively. Ten randomly selected lines of population II RGR F_4 lines were used in the present investigation. F_4 lines were crossed with DSMR 10 (T_1) and DSG 3-5 (T_2) (opposite testers) along with one additional tester DH 7225 (T_3) and one diverse tester DR 8 (T_4) which generated forty derived hybrids. Selfed seeds of F_4 parent lines *i. e*. F_5 lines, four testers and forty F_4 derived hybrids were sown at the Agricultural Research Station, Dharwad Farm on black soil during *Kharif,* 2014-15 in randomized block design with two replications. All the recommended cultural practices for cotton were carried out at regular interval. Observations were recorded on four randomly selected plants for different traits (Table 1).

Line x Tester analysis of combining ability was performed as suggested by Kempthorne (1957) and the variation among the hybrids was divided into genetic components attributable to general combining ability (*gca*) and specific combining ability (*sca*).

RESULTS AND DISCUSSION

Analysis of variance: Analysis of variance for population II RGR F_4 lines for fourteen characters showed significant differences between the parents for all characters except

Table 1. Different traits

Sl. No.	Traits
1.	Plant height (cm)
2.	Number of monopodia plant^{-1}
3.	Number of sympodia plant^{-1}
4.	Number of bolls plant^{-1}
5.	Boll weight (gm)
6.	Sympodial length at 50 per cent height (cm)
7.	Reproductive points on sympodia
8.	Interboll distance (cm)
9.	Interbranch distance (cm)
10.	Seed cotton yield (kg ha^{-1})
11.	Lint yield (kg ha^{-1})
12.	Ginning outturn
13.	Seed index (gm)
14.	Lint index

number of monopodia plant^{-1}, boll weight, ginning outturn and lint index (Table 2). Lines used were significantly different for most of the characters except number of monopodia plant^{-1}, ginning outturn and lint index while testers were significant for seven characters except plant height, number of monopodia plant^{-1}, number of sympodia plant^{-1}, boll weight, reproductive points on sympodia, ginning outturn and lint index. Line and tester interaction was significant for several characters while for other characters like number of monopodia/ plant, number of sympodia plant^{-1}, boll weight, reproductive points on sympodia, seed cotton yield, lint yield, ginning outturn and lint index it was found to be non-significant. The mean sum of squares of hybrids was significant for all the characters. Variance for interaction concerning hybrids and parents was significant for most of the characters except number of monopodia plant^{-1}, number of sympodia plant^{-1} and ginning outturn.

Analysis of variance for combining ability: for the combining ability of population II RGR F_4 lines revealed that mean sum of squares (MSS) due to lines were significant for plant height, number of sympodia plant^{-1}, seed cotton yield and lint yield while MSS of tester were significant for number of bolls plant^{-1}, seed cotton yield and lint yield (Table 3). Line x tester interaction was significant for all the characters except lint index. This suggests that the variation for traits showing significance were present. GCA to SCA variance ratio was less than half in most of the traits except seed cotton yield and lint yield.

***Per se* performance of parents:** Number of bolls plant^{-1} among the F_5 lines ranged from 12.50 (RGR F_5 1) to 23.75 (RGR F_5 3) while for testers ranged from 15.25 DH 7225 (T_3) to 20 DSG 3-5 (T_2) (Table 4). Boll weight fluctuated from 3.50 (RGR F_5 1) to 5.45 (RGR F_5 6), whereas for testers value

Table 2. Analysis of variance for different quantitative characters for evaluation of combining ability in segregating generations from heterotic box (Population II RGR F_4 lines)

Source of variation	df	Plant height (cm)	No. of Monopodia plant^{-1}	No. of Sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight (g)	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index (g)	Lint index (g)
Replicates	1	211.68	1.49	22.60	7.52	0.70	0.19	0.00	0.02	0.95	52665.2	2863.09	3.10*	0.56	2.96
Treatments	53	500.88**	1.06**	11.42**	21.14**	1.14**	116.13**	1.60**	8.16**	29.40**	246945.10**	37022.34**	2.24**	2.81**	1.34*
Parents	13	911.39**	0.31	12.56*	24.05**	0.55	166.28**	0.81**	14.28**	57.75**	304608.20**	46468.89**	0.81	2.28**	1.08
Parents (Line)	9	1254.90**	0.37	16.35**	29.60**	0.63*	180.45**	1.12**	17.06**	67.85**	350087.90**	55135.88**	0.81	2.12**	1.08
Parents (Testers)	3	44.70	0.24	1.36	10.05*	0.47	160.32**	0.15	9.63**	39.80**	260236.30**	34985.80**	1.02	2.563*	0.95
Parents (L vs T)	1	419.93*	0.01	12.06	16.03*	0.003	56.70*	0.09	3.17*	20.68**	28406.45	2915.27	0.17	2.92*	1.48
Parent vs Crosses	1	595.16*	0.08	5.45	70.54**	20.13**	1652.12**	7.72**	24.37**	444.10**	2264759**	332335.20**	0.001	6.45**	4.07*
Crosses	39	361.62**	1.33**	11.20*	18.91**	0.84**	60.03**	1.71**	5.71**	9.32**	175985.30**	26301.36**	2.78**	2.90**	1.36*
Error	53	88.17	0.38	5.82	3.014	0.30	10.48	0.12	0.69	0.76	13520.5	2414.18	0.61	0.64	0.78

varied from 3.70 DSMR 10 (T_1) to 5.05 DSG 3-5 (T_2). The variability for seed cotton yield were minimum 804.74 kg ha^{-1} (RGR F_5 1) and maximum 2094.94 kg ha^{-1} (RGR F_5 9). RGR F_5 9, RGR F_5 5 and RGR F_5 7 were the three hybrids with highest seed cotton yield. Among testers mean varied from 1267.05 kg ha^{-1} for DH7225 (T_3) to 2115.77 kg ha^{-1} DR 8 (T_4). Lint yield in the F_5 lines, fluctuated from 298.63 kg ha^{-1} (RGR F_5 1) to 806.95 kg ha^{-1} (RGR F_5 10). Lint index mean value ranged from 5.40 gm (RGR F_5 1) to 8.10 gm (RGR F_5 10).

***Per se* performance of hybrids:** Mean for number of bolls plant^{-1} among the F_4 derived hybrids differed from 12.50 (RGR F_4 10 × DSMR 10) to 27.75 (RGR F_4 9 × DR 8) (Table 5). Boll weight among the F_4 derived hybrids ranged from 3.6 (RGR F_4 9 × DH 7225) to 6.55 (RGR F_4 8 × DSMR 10). Seed cotton yield among the F_4 derived hybrids were minimum 1217.82 ha^{-1} (RGR F_4 4 × DSMR 10) and maximum 2724.07 ha^{-1} (RGR F_4 1 × DR 8). Hybrids showing highest mean seed cotton yield were RGR F_4 1 × DR 8, RGR F_4 5 × DR 8 and RGR F_4 5 × DH 7225. The lint yield fluctuated from 475.07 ha^{-1} (RGR F_4 4 × DSMR 10) to 1003.19 ha^{-1} (RGR F_4 1 × DR 8). The range of lint index for the F_4 derived hybrids were from 5.45 (RGR F_4 10 × DSG 3-5) to 9.05 (RGR F_4 9 × DR 8).

Combining ability effects: RGR F_4 7 line (1.30) and RGR F_4 8 line (1.95) showed positively significant *gca* effect while tester DR 8 (2.48) showed significantly positive *gca* effect for number of bolls plant^{-1} (Table 6). Among forty hybrids, thirteen hybrids showed significant *sca* effect out of which six were positively significant for number of bolls/plant (Table 7). Three hybrids exhibiting maximum *sca* effect were RGR F_4 9 × DR 8, RGR F_4 2 × DSMR 10 and RGR F_4 6 × DH 7225. The *sca* effect of three hybrid were positively significant for boll weight and among them RGR F_4 8 × DSMR 10 showed highest significant *sca* effect. For seed cotton yield three lines RGR F_4 5, RGR F_4 6 and RGR F_4 1 revealed positively significant *gca* effects. In testers, DR 8 was the best general combiner followed by DH 7225 for seed cotton yield. The *sca* effect for seed cotton yield was positively significant for two hybrids RGR F_4 1 × DR 8 and RGR F_4 4 × DSG 3-5. Three lines RGR F_4 6, RGR F_4 5 and RGR F_4 1 whereas two testers DR8 and DH 7225 exhibited positively significant *gca* effect for lint yield. Hybrid RGR F_4 1 × DR 8 showed positively significant *sca* effect for lint yield. RGR F_4 9 line exhibited positively significant *gca* effect and RGR F_4 6 × DSG 3-5 and RGR F_4 10 × DH 7225 (1.58) hybrids exhibited positively significant *sca* effect for lint index. Lines which were significantly superior for any traits can be used in future breeding program for transferring respective traits. Hybrids found significantly superior for seed cotton yield and lint yield should be tested for stability over the locations which can be released in future if found potential high yielding.

Table 3. Analysis of variance for combining ability involving population II RGR F_4 lines and its derived hybrids for different characters in evaluation of combining ability in segregating generations from heterotic box

Source of variation	Df	Plant height (cm)	No. of Mono podia plant^{-1}	No. of Sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight (g)	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index (g)	Lint index (g)
Replicates	1	0.72	0.28	17.67*	5.91	1.06	8.07	0.12	1.13	0.003	29328.21	774.2	3.69*	0.50	3.44
Line Effect	9	723.34*	0.89	22.80*	11.17	0.81	43.12	2.39	6.89	10.67	201897**	32579**	1.65	2.76	1.65
Tester effect	3	235.64	3.53	6.38	76.35**	0.08	14.79	0.92	3.27	1.81	1270281**	193364.30**	1.59	3.45	1.02
Line * Tester Eff.	27	255.05**	1.24**	7.87**	15.10**	0.94**	70.71**	1.58**	5.59**	9.71**	45759.70**	5646.26*	3.20**	2.88**	1.29
Error	39	55.36	0.21	3.49	2.285	0.38	7.42	0.13	0.53	0.18	15063.31	2652.08	0.56	0.77	0.97
s^2gca		30.30	0.14	0.79	2.05*	-0.04	1.54	0.11	0.32	0.43	49309.22**	7666.09**	-0.12	0.17	0.003
s^2sca		99.85	0.51	2.19	6.41**	0.27**	31.64	0.72	2.53	4.76	15348.19**	1497.088*	1.36**	1.06	0.16
s^2gca/s^2sca		0.30	0.28	0.36	0.78	-0.15	0.05	0.15	0.13	0.09	3.21	5.12	-0.09	0.16	0.02

The estimates of GCA variances were observed to be less than the corresponding SCA variances for plant height, number of monopodia plant^{-1}, number of sympodia plant^{-1}, sympodial length at 50 per cent height, reproductive points on sympodia, number of bolls/plant, boll weight, inter boll distance, inter branch distance, ginning outturn, seed index and lint index suggesting the preponderance of non-additive gene action in the inheritance of these traits. Ahuja and Dhayal (2007), Mohammad et al (2010) and Patilet al (2015) also observed non-additive gene action for number of bolls/plant and boll weight. The GCA variances were observed more than the corresponding SCA variances for seed cotton yield and lint yield suggesting that additive gene action is predominant along with dominant gene action. Many earlier worker reported additive gene action for the seed cotton yield (Naqib et al 2009, Patel et al 2009, Mohammad et al 2010 and Tantuway and Patil 2017). Some workers revealed additive and non-additive gene action for the seed cotton yield (Laxman and Ganesh 2003, Sivaprasad et al 2004, Panhwar et al 2008). Studies of Karunakar Raju (2005) and Kalpande et al (2008) reported additive gene action whereas Yanal et al (2013) and Tantuway and Patil (2017) observed additive and non-additive gene action for lint yield.

Study suggests that improved variety with higher seed cotton yield and lint yield may be developed but other traits are suitable for hybrid breeding. RGR F_4 5 line having significant positive *gca* effect for plant height, number of monopodia plant^{-1}, reproductive points on sympodia, inter branch distance, seed cotton yield and lint yield along with the high mean seed cotton yield and lint yield. Lines RGR F_4 7 and RGR F_4 8 for number of bolls plant^{-1}, lines RGR F_4 4, RGR F_4 6 and RGR F_4 10 for inter boll distance, RGR F_4 6 and RGR F_4 9 for ginning outturn were showing significant positive *gca* effect. Lines with significant positive *gca* effect may be used in breeding for specific traits. Hybrid RGR F_4 1 x DR 8 has showed significant positive *sca* effect for sympodial length at 50 per cent height, seed cotton yield, lint yield and seed index along with the highest mean seed cotton yield suggesting that it may be tested for releasing. Hybrids RGR F_4 3 × DH 7225, RGR $F_4$4 × DR 8, RGR $F_4$5 × DH 7225 and RGR $F_4$6 × DSG 3-5 were showing significant negative *sca* effect for plant height which may be used for developing dwarf hybrids.

Table 4. *Per se* performance of F_5 lines of (Population II RGR F_4 lines) for yield in evaluation of combining ability in segregating generations from heterotic box

F_5 Line	Plant height (cm)	No. of Mono podia plant^{-1}	No. of Sympodia plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index (g)	Lint index (g)
RGR F_5 1	103.50	1.75	19.63	12.50	3.50	36.75	6.10	6.02	9.19	804.74	298.63	37.11	9.15	5.40
RGR F_5 2	111.75	1.88	13.75	14.63	4.20	23.63	4.38	5.45	11.63	1008.10	388.02	38.43	10.37	6.47
RGR F_5 3	112.50	1.75	22.00	23.75	5.15	41.61	3.25	12.80	17.94	1458.35	566.50	38.94	11.38	7.28
RGR F_5 4	109.88	1.25	17.25	16.38	4.30	25.13	4.63	5.43	12.69	1690.70	650.36	38.46	11.35	7.10
RGR F_5 5	87.75	1.75	19.13	22.25	5.00	25.00	4.75	5.23	21.50	1936.06	758.19	39.14	10.32	6.64
RGR F_5 6	94.50	1.25	17.50	19.13	5.45	41.88	4.10	10.22	8.44	1575.23	616.58	39.13	9.86	6.33
RGR F_5 7	75.50	1.88	14.50	19.38	4.65	22.00	3.65	6.02	7.19	1896.99	747.01	39.38	10.93	7.10
RGR F_5 8	149.38	2.13	14.50	20.38	3.80	18.25	4.75	3.82	20.75	1880.95	727.11	38.65	11.23	7.07
RGR F_5 9	151.00	2.50	15.13	21.50	5.10	24.25	4.50	5.46	8.71	2094.94	806.95	38.52	11.79	7.38
RGR F_5 10	88.38	2.50	13.63	13.75	5.05	14.50	4.38	3.31	21.19	1385.85	538.68	38.86	12.73	8.10
Mean	108.41	1.86	16.70	18.36	4.62	27.30	4.45	6.38	13.92	1573.19	609.80	38.66	10.91	6.89
Minimum	75.50	1.25	13.63	12.50	3.50	14.50	3.25	3.31	7.19	804.74	298.63	37.11	9.15	5.40
Maximum	151.00	2.50	22.00	23.75	5.45	41.88	6.10	12.80	21.50	2094.94	806.95	39.38	12.73	8.10
DSMR (T_1)	97.63	1.50	15.38	16.13	3.70	15.63	4.25	3.68	15.70	1698.68	669.67	37.65	10.21	6.17
DSG 3-5 (T_2)	106.88	2.13	15.13	20.00	5.05	31.38	4.63	6.88	13.94	1493.30	574.88	39.42	9.31	6.06
DH 7225 (T_3)	98.13	1.75	14.25	15.25	4.35	17.25	4.38	3.94	22.00	1267.05	488.27	38.48	9.46	5.91
DR 8 (T_4)	96.75	2.25	16.25	15.38	4.95	32.38	4.00	8.09	11.63	2115.77	796.74	38.51	11.80	7.40
Mean	99.84	1.91	15.25	16.69	4.51	24.16	4.31	5.65	15.81	1643.70	632.39	38.52	10.19	6.38
Minimum	96.75	1.50	14.25	15.25	3.70	15.63	4.00	3.68	11.63	1267.05	488.27	37.65	9.31	5.91
Maximum	106.88	2.25	16.25	20.00	5.05	32.38	4.63	8.09	22.00	2115.77	796.74	39.42	11.80	7.40

Table 5. *Per se* performance of derived hybrids for fourteen traits of population II RGR F_4 lines in evaluation of combining ability in segregating generations from heterotic box

(Derived F_1) (F_4 line x tester)	Plant height (cm)	No. of Mono podia plant^{-1}	No. of Sympodia plant^{-1}	Sympodial length at 50% height (cm)	Number of bolls per plant	Boll weight (g)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning out turn (%)	Seed index (g)	Lint index (g)
RGR F_4 1 x T_1	108.40	1.50	16.65	34.15	16.38	4.85	4.40	7.80	9.10	1486.11	588.27	39.60	11.65	6.40
RGR F_4 1 x T_2	116.30	2.38	16.80	39.90	20.88	5.35	5.85	6.85	9.25	2079.16	793.14	38.10	12.20	7.35
RGR F_4 1 x T_3	105.65	1.13	16.15	28.15	18.00	4.90	5.00	5.65	8.40	1938.65	742.80	38.30	9.70	7.25
RGR F_4 1 x T_4	118.90	2.25	17.30	41.90	24.50	4.55	5.00	8.50	9.75	2724.07	1003.19	36.85	13.45	7.65
RGR F_4 2 x T_1	110.25	1.00	15.90	31.75	20.25	5.30	4.75	6.70	9.45	1844.91	693.90	37.60	11.85	6.90
RGR F_4 2 x T_2	118.65	1.63	16.90	41.15	17.75	4.75	6.15	6.70	9.80	1798.61	722.68	40.20	12.15	7.75
RGR F_4 2 x T_3	105.80	1.50	16.40	37.30	15.38	6.15	5.25	7.15	8.50	1999.24	753.70	37.70	9.80	7.70
RGR F_4 2 x T_4	119.25	2.00	16.55	36.75	18.63	5.00	5.40	6.85	17.75	2117.13	835.44	39.45	10.55	8.25
RGR F_4 3 x T_1	98.90	1.28	14.15	38.65	16.38	4.85	6.25	6.20	9.65	1521.98	581.77	38.25	11.35	7.00
RGR F_4 3 x T_2	103.80	2.75	14.55	30.65	18.13	6.40	5.50	5.55	9.30	1723.38	660.24	38.30	11.60	7.10
RGR F_4 3 x T_3	78.15	1.25	16.25	34.75	18.88	5.35	4.90	7.15	7.45	1908.56	722.79	37.90	9.80	5.95
RGR F_4 3 x T_4	120.65	1.88	18.05	35.05	20.50	4.40	4.40	8.00	9.45	2012.49	803.27	39.90	11.65	7.70
RGR F_4 4 x T_1	112.90	0.63	18.00	37.00	15.75	3.95	5.65	6.60	8.95	1217.82	475.07	39.00	9.85	7.35
RGR F_4 4 x T_2	124.80	1.63	17.90	37.90	20.00	5.05	4.40	8.70	10.10	1988.19	721.25	36.30	9.85	5.60
RGR F_4 4 x T_3	108.65	3.00	16.65	36.15	18.25	3.85	4.65	7.85	9.60	1925.69	723.24	37.55	11.30	6.90
RGR F_4 4 x T_4	98.15	2.75	16.75	38.10	22.25	4.85	3.65	10.50	10.40	2148.14	884.41	41.20	11.50	6.45
RGR F_4 5 x T_1	123.00	1.25	14.80	45.80	20.75	4.95	6.50	7.05	10.75	1883.56	724.47	38.45	11.55	6.90
RGR F_4 5 x T_2	151.90	3.00	9.25	36.80	15.75	5.40	5.90	6.25	13.00	2056.71	797.57	38.75	12.40	7.40
RGR F_4 5 x T_3	111.40	1.88	18.30	30.40	20.00	5.15	5.30	5.80	16.95	2331.01	875.96	37.60	9.35	5.60
RGR F_4 5 x T_4	144.50	4.00	14.65	28.80	22.00	4.60	3.75	7.65	8.95	2333.32	919.38	39.40	10.95	8.00
RGR F_4 6 x T_1	97.90	1.38	15.90	41.75	15.13	4.85	4.90	8.60	9.10	1928.50	767.71	39.80	9.45	6.30
RGR F_4 6 x T_2	80.25	1.75	15.75	26.55	20.63	3.75	4.15	6.45	9.55	2026.61	822.24	40.60	12.75	8.70
RGR F_4 6 x T_3	114.30	2.13	19.75	42.80	25.00	4.75	3.90	11.05	11.20	2261.10	867.85	38.35	9.70	7.15
RGR F_4 6 x T_4	93.90	3.13	11.65	36.65	21.00	5.20	4.40	8.40	6.70	2287.95	878.71	38.45	10.85	6.80
RGR F_4 7x T_1	124.25	1.25	16.40	31.25	18.88	4.65	2.70	11.65	9.40	1679.39	647.23	38.55	11.10	7.10
RGR F_4 7x T_2	104.05	1.50	16.75	28.15	25.13	4.65	5.25	5.35	5.90	1890.27	720.17	38.10	11.25	7.15
RGR F_4 7x T_3	117.75	3.38	15.50	30.40	20.50	5.75	4.80	6.30	8.80	2001.62	806.86	40.30	12.55	7.50
RGR F_4 7x T_4	106.50	3.50	15.30	29.65	19.63	5.10	5.15	5.80	12.25	2228.93	837.47	37.55	11.35	7.00
RGR F_4 8 x T_1	113.55	2.00	15.90	28.65	20.25	6.55	5.00	5.75	10.15	1396.98	551.01	39.40	11.60	8.15
RGR F_4 8 x T_2	102.30	3.13	16.40	33.05	19.88	4.15	4.80	7.10	11.95	1430.55	566.12	39.60	11.70	7.25
RGR F_4 8 x T_3	103.55	0.50	16.40	42.90	22.75	4.65	7.00	6.20	9.05	1859.72	729.35	39.25	10.60	7.55
RGR F_4 8 x T_4	120.30	1.88	18.00	27.65	23.88	4.50	5.25	5.30	9.20	1987.26	739.72	37.25	12.50	6.85
RGR F_4 9 x T_1	114.40	2.25	19.40	39.05	18.25	4.20	4.75	8.25	9.90	1781.02	705.65	39.60	11.30	7.90
RGR F_4 9 x T_2	108.80	1.25	21.50	29.75	17.38	4.85	7.15	4.20	8.50	1896.29	748.94	39.55	13.20	7.35
RGR F_4 9 x T_3	116.15	2.13	19.15	37.55	18.00	3.60	5.75	6.55	9.20	1964.35	734.19	37.40	13.45	7.90
RGR F_4 9 x T_4	116.30	1.50	19.40	38.15	27.75	4.80	6.15	6.25	9.50	2182.41	878.17	40.25	12.05	9.05
RGR F_4 10 x T_1	112.50	2.13	21.65	35.75	12.50	4.90	5.40	6.65	9.75	1372.68	501.97	36.65	9.10	5.60
RGR F_4 10 x T_2	102.75	1.25	15.55	43.15	18.88	5.05	3.90	11.15	9.10	1738.42	638.41	36.75	9.40	5.45
RGR F_4 10 x T_3	108.65	1.00	20.55	25.40	21.38	3.85	3.85	6.55	9.55	1928.93	736.77	38.30	13.15	8.15
RGR F_4 10 x T_4	115.55	1.75	19.65	44.65	22.00	5.25	4.65	9.60	8.75	2069.44	812.47	39.20	11.20	7.20
Mean	111.34	1.94	16.81	35.35	19.73	4.87	5.04	7.27	9.85	1923.78	742.84	38.63	11.27	7.18
Minimum	78.15	0.50	9.25	25.40	12.50	3.60	2.70	4.20	5.90	1217.82	475.07	36.30	9.10	5.45
Maximum	151.90	4.00	21.65	45.80	27.75	6.55	7.15	11.65	17.75	2724.07	1003.19	41.20	13.45	9.05

Table 6. Estimates of general combining ability effects of population II RGR F_4 lines (F_4 lines of DRGR-24-178 x DRGR-32-100) in evaluation of combining ability in segregating generations from heterotic box

F_4 line	Plant height (cm)	No. of Mono podia plant^{-1}	No. of Sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight (g)	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index (g)	Lint index (g)
RGR F_4 1	0.97	-0.12	-0.08	0.21	0.04	0.67	0.02	-0.07	-0.72**	133.22**	39.01*	-0.42	0.48	-0.02
RGR F_4 2	2.14	-0.40*	-0.37	-1.72**	0.43	1.38	0.34**	-0.42	1.52**	16.19	8.59	0.11	-0.18	0.47
RGR F_4 3	-10.96**	-0.15	-1.06	-1.25*	0.38	-0.57	0.22	-0.54*	-0.88**	-132.17**	-50.82**	-0.05	-0.17	-0.25
RGR F_4 4	-0.22	0.06	0.51	-0.67	-0.44	1.93	-0.45**	1.14**	-0.09	-103.82*	-41.84*	-0.12	-0.64*	-0.61
RGR F_4 5	21.35**	0.59**	-2.56**	-0.10	0.16	0.1	0.32*	-0.57*	2.56**	227.37**	86.51***	-0.08	-0.21	-0.21
RGR F_4 6	-14.75**	0.16	-1.05	0.71	-0.23	1.58	-0.70**	1.35**	-0.71**	202.26**	91.28***	0.66*	-0.58	0.06
RGR F_4 7	1.79	0.47**	-0.82	1.30*	0.17	-5.48**	-0.56**	0.009	-0.76**	26.28	10.09	-0.01	0.29	0.01
RGR F_4 8	-1.41	-0.06	-0.13	1.95**	0.09	-2.28*	0.47**	-1.17**	0.23	-255.15**	-96.28***	0.24	0.33	0.27
RGR F_4 9	2.57	-0.15	3.05**	0.62	-0.51*	0.77	0.91**	-0.95**	-0.57**	32.23	23.89	0.56*	1.23**	0.86*
RGR F_4 10	-1.48	-0.40*	2.53**	-1.04	-0.11	1.88	-0.58**	1.22**	-0.56**	-146.41**	-70.43***	-0.91**	-0.55	-0.58
CD (g_i) 5%	5.32	0.33	1.33	1.08	0.45	1.94	0.26	0.52	0.31	87.77	36.83	0.54	0.63	0.71
DSMR (T_1)	0.26	-0.47**	0.06	-2.27**	0.04	1.03	-0.01	0.26	-0.23*	-312.48**	-119.13***	0.06	-0.38	-0.22
DSG 3-5 (T_2)	0.02	0.09	-0.67	-0.29	0.07	-0.64	0.26**	-0.43*	-0.21*	-60.96*	-23.76*	-0.01	0.38	-0.07
DH 7225 (T_3)	-4.33*	-0.15	0.69	0.08	-0.07	-0.77	0.00	-0.24	0.02	88.11**	26.51*	-0.36*	-0.33	-0.02
DR 8 (T_4)	4.05*	0.52**	-0.08	2.48**	-0.04	0.38	-0.25**	0.42*	0.42**	285.36**	116.38***	0.32	0.33	0.31
SE (g_i)	1.66	0.11	0.42	0.34	0.14	0.61	0.08	0.16	0.10	27.44	11.52	0.17	0.20	0.22
CD (g_i) 5%	3.36	0.21	0.84	0.68	0.28	1.23	0.16	0.33	0.19	55.51	23.29	0.34	0.39	0.45

Table 7. Estimates of specific combining ability effects of population II RGR F_4 lines (F_4 lines of DRGR-24-178 x DRGR-32-100) in evaluation of combining ability in segregating generations from heterotic box

Derived F_1 (F_4 line x tester)	Plant height (cm)	No. of Mono podia plant^{-1}	No. of Sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight (g)	Sympodial length at 50% height (cm)	Reproductive points on sympodia	Inter boll distance (cm)	Inter branch distance (cm)	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Ginning outturn (%)	Seed index (g)	Lint index (g)
RGR F_4 1 x T_1	-4.18	0.16	-0.14	-1.28	-0.10	-2.91	-0.65*	0.34	0.21	-258.41**	-74.44*	1.33*	0.29	-0.54
RGR F_4 1 x T_2	3.97	0.47	0.75	1.23	0.36	4.52*	0.52*	0.09	0.33	83.12	35.05	-0.11	0.07	0.26
RGR F_4 1 x T_3	-2.33	-0.54	-1.27	-2.02	0.05	-7.10**	-0.06	-1.30*	-0.74*	-206.45*	-65.56	0.46	-1.72**	0.11
RGR F_4 1 x T_4	2.53	-0.09	0.66	2.08	-0.32	5.49**	0.20	0.88	0.21	381.74**	104.95**	-1.68**	1.36*	0.18
RGR F_4 2 x T_1	-3.50	-0.06	-0.60	4.53**	-0.04	-6.02**	-0.62*	-0.41	-0.74**	217.42	61.60	-1.19*	1.15	-0.53
RGR F_4 2 x T_2	5.15	0.00	1.14	0.04	-0.62	5.05*	0.50	0.29	-1.36**	-80.41	-4.99	1.47**	0.68	0.17
RGR F_4 2 x T_3	-3.35	0.12	-0.74	-2.71*	0.92*	1.33	-0.14	0.54	-2.89**	-28.84	-24.24	-0.67	-0.96	0.07
RGR F_4 2 x T_4	1.71	-0.06	0.20	-1.86	-0.26	-0.37	0.27	-0.42	5.95**	-108.18	-32.37	0.40	-0.87	0.29
RGR F_4 3 x T_1	-1.74	-0.04	-1.66	0.18	-0.44	2.85	0.99**	-0.78	0.92**	42.87	8.89	-0.40	0.64	0.29
RGR F_4 3 x T_2	3.41	0.87*	-0.52	-0.05	1.08*	-3.48	-0.03	-0.74	0.54	-7.27	-8.01	-0.28	0.12	0.24
RGR F_4 3 x T_3	-17.88**	-0.39	-0.20	0.32	0.17	0.75	-0.36	0.67	-1.53**	28.85	4.26	-0.32	-0.97	-0.97
RGR F_4 3 x T_4	16.22**	-0.44	2.38	-0.45	-0.81	-0.11	-0.60*	0.86	0.07	-64.45	-5.14	1.00	0.21	0.45
RGR F_4 4 x T_1	1.51	-0.91**	0.61	-1.03	-0.51	-1.32	1.07**	-2.07**	-0.58	-289.65*	-106.78**	0.43	-0.39	1.00
RGR F_4 4 x T_2	13.65*	-0.47	1.25	1.23	0.55	1.26	-0.45	0.72	0.54	229.19*	44.02	-2.20**	-1.16	-0.90
RGR F_4 4 x T_3	1.86	1.14**	-1.37	-0.90	-0.51	-0.37	0.06	-0.32	-0.18	17.62	-4.27	-0.60	1.00	0.34
RGR F_4 4 x T_4	-17.03**	0.22	-0.49	0.70	0.47	0.43	-0.67*	1.66**	0.22	42.84	67.03	2.37**	0.54	-0.44
RGR F_4 5 x T_1	-9.96	-0.81*	0.49	3.40**	-0.11	9.32**	1.14**	0.10	-1.43**	44.89	14.26	-0.16	0.88	0.15
RGR F_4 5 x T_2	19.18**	0.38	-4.32**	-3.58**	0.31	2.00	0.27	0.00	0.79*	-33.48	-8.01	0.21	0.96	0.50
RGR F_4 5 x T_3	-16.96**	-0.51	3.35*	0.29	0.19	-4.28*	-0.06	-0.65	4.51**	91.75	20.11	-0.58	-1.38*	-1.36
RGR F_4 5 x T_4	7.74	0.94**	0.48	-0.11	-0.38	-7.03**	-1.35**	0.54	-3.88**	-103.16	-26.35	0.53	-0.45	0.71
RGR F_4 6 x T_1	1.05	-0.25	0.08	-3.03**	0.17	3.78	0.57*	-0.28	0.19	114.94	52.72	0.44	-0.85	-0.72
RGR F_4 6 x T_2	-16.35**	-0.43	0.67	0.48	-0.96*	-9.74**	-0.45	-1.73**	0.62*	-38.47	11.88	1.31*	1.68**	1.53*
RGR F_4 6 x T_3	22.05**	0.18	3.29*	4.48**	0.18	6.63**	-0.44	2.66**	2.04**	46.95	7.21	-0.58	-0.66	-0.07
RGR F_4 6 x T_4	-6.75	0.50	-4.03**	-1.92	0.61	-0.67	0.32	-0.64	-2.85**	-123.42	-71.80	-1.16*	-0.17	-0.75
RGR F_4 7x T_1	10.85*	-0.68*	0.35	0.12	-0.43	0.36	-1.76**	4.11**	0.54	41.82	13.43	-0.13	-0.07	0.14
RGR F_4 7x T_2	-9.11	-0.99**	1.44	4.38**	-0.46	-1.07	0.51	-1.48**	-2.98**	1.18	-9.00	-0.52	-0.69	0.04
RGR F_4 7x T_3	8.95	1.11**	-1.19	-0.62	0.78	1.31	0.32	-0.73	-0.31	-36.55	27.41	2.04**	1.32*	0.33
RGR F_4 7x T_4	-10.69*	0.57	-0.61	-3.89**	0.11	-0.60	0.93**	-1.89**	2.74**	-6.46	-31.84	-1.39*	-0.55	-0.50
RGR F_4 8 x T_1	3.36	0.60	-0.84	0.84	1.55**	-5.44**	-0.50	-0.60	0.29	40.84	23.59	0.47	0.39	0.92
RGR F_4 8 x T_2	-7.64	1.16**	0.40	-1.52	-0.88	0.63	-0.97**	1.44**	2.06**	-177.12*	-56.67	0.73	-0.28	-0.13
RGR F_4 8 x T_3	-2.04	-1.22**	-0.97	0.98	-0.25	10.61**	1.48**	0.35	-1.05**	102.98	56.29	0.74	-0.67	0.12
RGR F_4 8 x T_4	6.32	-0.53	1.41	-0.30	-0.42	-5.79**	0.00	-1.21*	-1.30**	33.30	-23.21	-1.94**	0.56	-0.91
RGR F_4 9 x T_1	0.23	0.94**	-0.53	0.18	-0.20	1.90	-1.19**	1.67**	0.85**	137.49	58.05	0.34	-0.81	0.07
RGR F_4 9 x T_2	-5.13	-0.62	2.32	-2.67*	0.42	-5.73**	0.93**	-1.67**	-0.57	1.24	5.97	0.36	0.32	-0.63
RGR F_4 9 x T_3	6.58	0.49	-1.41	-2.42*	-0.69	2.20	-0.20	0.48	-0.09	-79.78	-59.06	-1.43*	1.27*	-0.13
RGR F_4 9 x T_4	-1.67	-0.81*	-0.38	4.92**	0.48	1.64	0.46	-0.48	-0.19	-58.95	-4.96	0.73	-0.79	0.69
RGR F_4 10 x T_1	2.38	1.06**	2.24	-3.91**	0.10	-2.52	0.95**	-2.09**	0.69*	-92.21	-51.31	-1.13*	-1.22	-0.78
RGR F_4 10 x T_2	-7.13	-0.37	-3.12*	0.48	0.22	6.55**	-0.81**	3.09**	0.02	22.01	-10.23	-0.97	-1.69**	-1.08
RGR F_4 10 x T_3	3.13	-0.38	0.50	2.60*	-0.85	-11.06**	-0.60*	-1.69**	0.24	63.46	37.86	0.94	2.76**	1.58*
RGR F_4 10 x T_4	1.63	-0.31	0.38	0.83	0.89	7.02**	0.46	0.69	-0.95**	6.74	23.68	1.15*	0.15	0.29
CD SCA, @ 5%	10.64	0.66	2.67	2.16	0.89	3.90	0.52	1.05	0.61	175.54	73.66	1.07	1.25	1.41

CONCLUSION

SCA variance were found higher than the GCA variance for important yield traits like number of bolls/plant and boll weight suggesting that non-additive gene action is predominant and it must be utilized for the hybrid development. Whereas GCA variance were found higher than the SCA variance for seed cotton yield and lint yield deciphering that additive gene action is predominant along with dominant gene action which must be utilized for cotton improvement. Lines having high *gca* effect can be utilized for crossing in breeding schemes and hybrids with high *sca* effect must be tested over locations for stability which can be notified in future.

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Bio-monitoring and Detection of Water Quality using Ephemeroptera, Plecoptera and Trichoptera (EPT) Complex in Karanthamalai Stream of Eastern Ghats

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Abstract: The health of an ecosystem can be studied by measuring the biodiversity of ephemeroptera, plecoptera and trichoptera complexes. The studies were done in Karanthamalai stream from August 2017 to January 2018. A total of 220 Specimens belonging to 16 genera, 11 families and 3 orders were collected during the study period. Hydropsychidae was the most ubiquitous family present there comprising about 3 genera and 3 species. *Chematopsyche sp* and *Indobaetis sp* were the most dominant and ubiquitous species present there. The results implies that this stream support most pollution sensitive taxa such as like Perlidae, Heptagenidae, Polycentropodidae and Stenopsychidae in the midstream and upstream compared to downstream due to anthropogenic disturbances. Shannon index was highest in August and December indicating the presence of higher diversity of Entomofauna in the ecosystem and lowest in September. Simpson's index was highest in December and lowest in September. The evenness value was almost similar in almost all months except it was relatively low in September. Low diversity of organisms was due to anthropogenic activity caused by pilgrims and due to lack of rainfall. This study implies that diversity of organisms was directly and indirectly influenced by ecological gradients and anthropogenic impacts.

Keywords: Anthropogenic impact, Bioindicator, Diversity, Pollution, Temperature

Biodiversity is an important component in studying the functioning of all natural and human made ecosystems. As the threat to biodiversity increases throughout the world, particularly in developing countries, the need to discover, describe, and determine biogeographic and phylogenetic relationships among the species also increases. Around the world there is an existence of 7,51,000 insect species of which 45,000 species of insects resides in freshwater ecosystems (Balaram 2005). Aquatic insects which are often the good indicators of water quality and they serve as a bioindicator of water pollution and also monitor the anthropogenic stress of the freshwater habitat. Aquatic insects mostly live in aquatic environments and they occur mostly in freshwater habitats and rarely in marine ecosystem (Segers and Martens 2005). Removal or loss of aquatic insects may cause downward displacement in the freshwater ecosystem's stability and diversity and are affected by the physical, chemical, and biological conditions of the water body and are mentioned as bio-indicators. They cannot escape from the pollution and are also sensitive to pollution. They display a wide range of responses to various pollutants in water and are less mobile than other freshwater living organisms like fish and it is also smaller than fishes and other macro invertebrates in the freshwater habitats. Studies of aquatic insects of freshwater habitat give more knowledge about species-habitat relationship and water quality of the habitat (Compin and Cereghino 2003, Azrina et al 2005). Now a day's pollution is a major concern in all parts of the environment, it causes certain adverse effects to aquatic ecosystem health. Due to pollution native species population declines and it gets replaced by foreign and exotic species which is not a good sign at all. Aquatic insects play a main role in functioning of the ecosystem. Thus their presence or absences in relation with the number of species present at a particular site in a stream tells about the water quality (Cushing and Allan 2001). Even if the small changes occur within the ecosystem, it collapses the entire food chain and food web of the stream habitat. This study aims to assess the diversity of Ephemeroptera, Plecoptera and Trichoptera (EPT) and to monitor the water quality using EPT complexes.

MATERIAL AND METHODS

Study area: Karanthamalai is an isolated hill segment located near Kuttupatti village in Natham Taluk, Dindigul District. The hill segment is present with two perennial streams and several intermitted streams. The stream of investigation, Manikyan Kadai waterfall, is along the footpath leading to three villages at top hills. The stream is a second order stream and follows several cascades, small waterfalls, run and riffles. Three sites were selected at 78 07'E, 78 14'E and 78 20'E and analyses were done.

Sampling and collection of insects: Samples of ephemeroptera, plecoptera and trichoptera complex were collected from three sites of Manikyan kadai waterfall. Water

samples were collected in the three sites such as water temperature, air temperature, pH, conductivity, water flow, dissolved oxygen, turbidity and humidity were analyzed using APHA manual (APHA, 2005). Collection was done with an aquatic Dnet and 1cm wide Kick-net (Burton and Sivaramakrishnan 1993) with mesh size of about 1mm. All insects were picked and preserved in 80 per cent ethyl alcohol. Collected samples were placed under stereomicroscope (Magnus Pro) and identified with the help of field guide by Sivaramakrishnan et al (1998) and by standard taxonomic literature. The data analysis was done with the help of the PAST software to measure the various diversity indices (Hammer et al 2001).

Table 1. Diversity indices of Karanthamalai stream

Months	Shannon	Simpson	Evenness
August, 2017	1.98	0.71	0.82
September	1.37	0.49	0.79
October	1.77	0.64	0.81
November	1.68	0.60	0.82
December	1.91	0.69	0.82
January, 2018	1.75	0.65	0.81

RESULTS AND DISCUSSION

The total of 220 species belonging to 16 genera, 11 families and 3 orders, Ephemeroptera, plecoptera and trichoptera (EPT) from the three sites during August 2017 to January 2018.

Biotic components: In the present study insects from three orders Ephemeroptera-(7 species of 4 families), Plecoptera-(1 species family Perillidae) and Trichoptera-(8 species of 6 families) were identified (Table 5, 6, 7). Hydropsychidae was the most ubiquitous family present there comprising about 3 genera and 3 species. *Chematopsyche* sp and *Indobaetis* sp were the most dominant and ubiquitous species present there. More number of EPT complexes was collected in the August and December and it is very much lower in the September. The results implies that this stream support most pollution sensitive taxa such as like Perlidae, Heptagenidae, Polycentropodidae and Stenopsychidae in the midstream and upstream compared to downstream, because they normally prefer high humid, unpolluted and cool environment for their survival. Shannon and Simpson indices indicate the total amount of diversity that might potentially be explained in Karanthamalai stream. Shannon index was highest in August (1.97) and December (1.91) indicating the presence of higher diversity of entomofauna in the ecosystem and lowest in

Table 2. Physico-chemical parameters from upstream in Karanthamalai

Parameters	August	September	October	November	December	January
Water flow (m s^{-1})	0.19	0.62	0.55	0.53	0.28	0.85
pH	7.6	7.9	8	7.9	7.5	7.9
Air temp (◦c)	26	26	22	21	20	22
Water temp (◦c)	22	24	20	19	18	19
Turbidity (NTU)	0.3	0.34	0.21	0.17	0.15	0.19
DO (mg l^{-1})	4.10	3.67	4.48	4.48	4.90	4.10
TDS (ppt)	0.12	0.21	0.23	0.20	0.18	0.20
Conductivity (µS cm^{-1})	25	34	31	27	23	24
Humidity (%)	70	64	65	69	72	68

Table 3. Physico-chemical parameters from midstream (Site II) in Karanthamalai

Parameters	August	September	October	November	December	January
Water flow (m s^{-1})	0.22	0.39	0.43	0.47	0.35	0.47
pH	7.5	7.8	7.4	7.5	7.6	7.7
Air temp (◦c)	26	25	22	22	21	24
Water temp (◦c)	21	24	20	19	18	21
Turbidity (NTU)	0.15	0.30	0.24	0.19	0.16	0.19
DO (mg l^{-1})	4.10	4.50	5.30	4.48	4.90	4.48
TDS (ppt)	0.17	0.22	0.24	0.21	0.21	0.20
Conductivity (µS cm^{-1})	19	34	32	24	21	22
Humidity (%)	63	59	59	63	64	58

September (1.36). Simpson's index was highest in December (0.82) and lowest in September (0.78). In this study Shannon and Simpson's index values were very less in the September and contains only of about 4 species belonging to 2 families and it exhibit less richness compared to other months and it also do not have any of the individuals from the order Plecoptera, which is the most sensitive of three orders, so this reveals that due to anthropogenic disturbances and lack of rainfall which makes the stream water polluted and causes less diverse organisms. During the pre-monsoon period due to this the organisms were tough to survive without that much water flow due to lack of rainfall. The evenness value was almost similar in almost all months except it was relatively low in September (0.4928). The high scores of Diversity indices, such as those of Shannon index and Simpson's index, indicate that clean or unpolluted rivers support more diverse taxa. The water flow in September was 0.62, 0.39 and 0.77 m s^{-1} in three sites respectively, which was very much less compared to other months. During the December, the water flow was high which leads to more EPT richness. Water temperature directly affects both the nature of aquatic fauna and species diversity as a consequence of oxygen saturation levels. At higher water temperatures, the oxygen carrying capacity of water decreases because of a diminished affinity of water for oxygen. In the present investigation, the water temperature was recorded 18°C to 24°C.

Normal dissolved oxygen (DO) level in the running water

Table 4. Physico-chemical parameters from downstream in Karanthamalai

Parameters	August	September	October	November	December	January
Water flow (m s^{-1})	0.25	0.77	0.38	0.45	0.41	0.42
pH	7.4	7.8	7.7	7.6	7.3	7.8
Air temp (◦c)	26	26	24	22	21	24
Water temp (◦c)	22	24	21	20	19	21
Turbidity (NTU)	0.16	0.12	0.19	0.19	0.18	0.21
DO (mg l^{-1})	4.49	3.67	5.30	4.10	5.71	4.90
TDS (ppt)	0.13	0.17	0.19	0.20	0.21	0.24
Conductivity (µS cm^{-1})	23	26	29	24	21	27
Humidity (%)	58	55	56	58	56	54

Table 5. EPT complex collected from Karanthamalai stream in downstream

Order	Family	Genus and species	August	September	October	November	December	January
Ephemeroptera	Baetidae	*Indobaetis* sp.	0	1	1	1	4	0
		Liebiebiella vera	1	0	0	1	0	0
	Heptageniidae	*Afronurus kumbakkaraiensis*	0	0	0	0	0	0
		Epeorus petersii	0	0	0	0	0	0
	Leptophlebiidae	*Isca purpurea*	0	0	0	0	0	0
		Choroterpes alargarensis	4	0	1	1	4	0
	Caenidae	*Caenis* sp.	0	0	1	0	0	1
Plecoptera	Perillidae	*Neoperla* sp.	0	0	0	0	0	0
Trichoptera	Rhyacophilidae	*Rhyacophila* sp.	1	0	0	0	1	0
	Stenopsychidae	*Stenopsyche kodaikanelensis*	1	0	0	0	1	0
	Polycentropodidae	*Polycentropus* sp.	1	0	0	0	2	0
	Hydropsychidae	*Hydropsyche* sp.	1	0	2	0	1	2
		Chematopsyche sp.	2	1	3	2	4	4
		Herbertorossia sp.	0	0	0	0	0	0
	Glossosomatidae	*Agapetus* sp.	0	0	0	0	0	0
	Economidae	*Economus* sp.	0	0	0	0	0	0
		Total	11	2	8	5	17	7

was 4.6-8.6 mg l^{-1}. In the present investigation the DO was low in September in the upstream and downstream and was 3.672 mg l^{-1} but in December was 5.712 mg l^{-1}. The lowest DO which might be caused by contamination from community wastewater, anthropogenic impacts and lack of rainfall and due to increase in temperature. The main source of dissolved oxygen for running water is from the atmosphere form the mixing process. It is different for standing water due to photosynthesis of algae and phytoplankton. Previous studies show significant mortality occurred during the experiments as the proportion of dead individuals increased exponentially with decreasing DO. In the present study the DO level shows decrease in the September, this leads to less EPT richness. Total dissolved solids which were in the normal permissible

Table 6. EPT complex collected from Karanthamalai stream in midstream

Order	Family	Genus and species	August	September	October	November	December	January
Ephemeroptera	Baetidae	*Indobaetis* sp.	1	2	1	2	5	0
		Liebiebiella vera	1	2	0	1	1	1
	Heptageniidae	*Afronuruskumbakkaraiensis*	0	0	0	1	0	0
		Epeorus petersii	0	0	0	0	0	0
	Leptophlebiidae	*Isca purpurea*	0	0	0	0	1	0
		Choroterpes alargarensis	10	0	2	2	4	2
	Caenidae	*Caenis* sp.	0	0	0	0	0	0
Plecoptera	Perillidae	*Neoperla* sp.	2	3	1	0	2	3
Trichoptera	Rhyacophilidae	*Rhyacophila* sp.	0	0	0	0	0	0
	Stenopsychidae	*Stenopsyche kodaikanelensis*	1	0	0	0	0	0
	Polycentropodidae	*Polycentropus* sp.	1	0	0	0	0	1
	Hydropsychidae	*Hydropsyche* sp.	4	0	2	1	2	4
		Chematopsyche sp.	4	3	3	3	7	4
		Herbertorossia sp.	0	0	1	0	0	0
	Glossosomatidae	*Agapetus* sp.	0	0	0	0	1	0
	Economidae	*Economus* sp.	1	0	0	1	0	0
		Total	25	10	10	11	23	15

Table 7. EPT complex collected from Karanthamalai stream in upstream

Order	Family	Genus and species	August	September	October	November	December	January
Ephemeroptera	Baetidae	*Indobaetis* sp.	2	2	3	5	9	2
		Liebiebiella vera	2	1	2	3	2	1
	Heptageniidae	*Afronuruskumbakkaraiensis*	1	0	0	0	0	0
		Epeorus petersii	1	0	0	0	0	0
	Leptophlebiidae	*Isca purpurea*	0	0	0	0	0	0
		Choroterpes alargarensis	5	0	0	2	3	2
	Caenidae	*Caenis* sp.	0	0	0	0	0	0
Plecoptera	Perillidae	*Neoperla* sp.	0	1	0	0	1	1
Trichoptera	Rhyacophilidae	*Rhyacophila* sp.	0	0	0	0	0	0
	Stenopsychidae	*Stenopsyche kodaikanelensis*	0	0	0	0	0	0
	Polycentropodidae	*Polycentropus* sp.	0	0	0	0	1	0
	Hydropsychidae	*Hydropsyche* sp.	3	0	0	0	1	2
		Chematopsyche sp.	4	1	4	2	3	4
		Herbertorossia sp.	0	0	0	0	0	0
	Glossosomatidae	*Agapetus* sp.	0	0	0	0	0	0
	Economidae	*Economus* sp.	0	0	0	0	0	0
		Total	18	5	9	12	20	12

limit of about 0.30 ppt which was recommended by WHO, so it supports EPT abundance and diversity. *Caenis* sp., which are only present in the most polluted water and in our study it was present in the October and January in the downstream. *Caenis* sp., which is normally an best biological indicator of agricultural impact (Selvakumar et al 2014) and this shows more agricultural practices were made in the downstream of the stream. Heptagenid mayflies such as like *Afronurus kumbakkaraiensis* and *Epeorus petersii* which were only present in the high water flow environment so they are abundant in midstream and upstream which have high water flow compared to downstream and these mayflies normally a good biological indicator of stream habitat and they generally prefer clean cobble substrate for their living. Due to case building behavior of the trichoptera they can able to survive also in the polluted downstream environment. The high diversity of Hydropsychidae was due to their feeding habits, they normally feed on the algae present in cobbles.

The pH values attain maximum level of 7.8, 7.8, 7.9 and found to be alkaline in the September and January in all the 3 sites. It is because of anthropogenic impact as people used to wash and bath in the stream and the water pH gets altered remarkably. Due to this also the EPT community gets affected and which makes only the more tolerant species only survives and less tolerant orders like Plecoptera were not found in these environment. Due to high water current in the September the mortality might be high because normally EPT organisms prefer low current environment for their survival. The turbidity level is in normal limit, due to this rich amount of EPT assemblages were seen in all the three sites.

The family Baetidae of order Ephemeroptera from this study can be proposed as an indicator of water quality and ecosystem health primarily because of its presence in both the polluted and unpolluted water. However, it appears to be sensitive to pollution as their number significantly reduced in the month of September and January. The genera *Baetis* sp. and *Caenis* sp. from earlier studies have been reported to be tolerant to organic pollution (Menetrey et al 2008). The less diversity of organisms in the month of September and January is due to lack of rainfall and anthropogenic impacts caused by the tourists and pilgrims thronging due to festivals during September and January.

CONCLUSIONS

The results of this study allows for a better understanding of the regional diversity and distribution of EPT complex in Karanthamalai stream of Eastern Ghats. Such information will provide a solid basis through which we can obtain a better understanding of the structure and functioning of the complex ecosystem in the Manikyan Kadai waterfall. The objectives of this study were mainly on diversity and distribution of EPT complexes and how ecological attributes and anthropogenic impacts directly and indirectly influence on the diversity of EPT. From the results it showed that this stream supports most pollution sensitive taxa such as like Perlidae, Heptagenidae, Polycentropodidae and Stenopsychidae in the midstream and upstream compared to downstream. In the downstream more anthropogenic impacts have been made which leads to more tolerant taxa like Caenidae. In order to conserve the ecosystem health and aquatic insects, routine monitoring of EPT complexes were to be done to assess this stream health. Compare to Western Ghats in the Eastern Ghats less amount of diversity work were done so we lack knowledge about the ecology and diversity pattern of EPT complex. Hence more work to be done on the abundance and regional diversity of EPT complex in Eastern Ghats.

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Impact of Industrial Wastewater Disposal on Surface Water Bodies in Kalingarayan Canal, Erode district

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Abstract: The Kalingarayan canal is crossing the major textile town Erode which is abundantly occupied by textile units. Major streams carrying the untreated / semi treated industrial effluents are mixed into the canal. However, the gradual introduction of a large number of new chemical compounds and the technologies has resulted in much higher number of contaminants. The original situation, which local intense pollution from a limited number of well-defined sources has been transferred into a situation with widespread contamination by a large variety of compounds from a multitude of sources. Continuous disposal of industrial effluents on canal, which has limited capacity to assimilate the pollution load, also leads to ground water pollution. Kalingarayan canal has helped to cultivate more than 6000 hectares but farmers are experiencing various problems. The area of cultivation is reduced to 3000 hectares because of the contamination in the canal by the different polluting industries like tanneries, textiles and dyeing units located in Erode and Tirupur taluk areas. The farmers and their cattle are affected by the pollution of the canal. Hence their yield on their lands has decreased to a certain extent. Thus, this study gives a clear picture of pollution source points, types of effluents added in the canal. The scope of the present study is to assess the impact on surface water of Kalingarayan canal, a comprehensive experimental study to identify the pollutant levels in the surface water of the Kalingarayan canal and to suggest a suitable remedial measure to handle this problem. The results of the analysis were correlated with the water quality standards of BIS. It shows that all the parameters studied are exceeding in the permissible limits. This is due to more discharge of industrial effluents into the canal and it should be regularly monitored and wastewater should be treated. This will control pollution and prevent the depletion of the quality of canal water.

Keywords: Industrial effluents, Kalingarayan canal, Pollution, Sewage water, Tanners and dyers

The Bhavani is a river of southern India, a tributary of the Kaveri. A small barrage across the river Bhavani was built by Kalingarayan in 1283 AD to feed the 56-mile-long Canal build for irrigation purposes, which joins the River Noyyal at Aavudaiaaparai, the canal which is now known by his name Kalingarayan Canal. Bhavani is more or less a perennial river fed mostly by the southwest monsoon. The northeast monsoon also supplements its water resources. Before the development of industries near the canal, the water in the canal was used for irrigation and drinking water. Because of significant industrial and agricultural development, as well as an increase in the city's population the water quality gradually deteriorated in the canal. There are 39 leather processing units, more than 10 major textiles processing units, more or less 150 Dyeing and Bleaching units present in the Kalingarayan canal command area. There are more than 57 bleaching units in command area operating without any approval. The amount of treated and untreated wastes discharged into water through our daily and industrial activities has deteriorated the water bodies and make them unfit for many of their purposes. The Kalingarayan canal near Bhavani town receives wastewaters at different places from industries along with domestic sewage. Chandan Chakraborty et al (2013) observed that water of Buriganga is highly polluted by both natural and anthropogenic activities (industries and agro chemicals). The water pollution cause undesirable changes in the chemical and physical properties of water which are not favorable to all those living utilizing water for their lives. Divya Tiwari et al (2014) investigated River Pandu, Kanpur for a period of one year (2009-2010) in which it was found that the quality of river water was extremely affected due to anthropogenic stress and disposal of industrial effluent without prior treatment. The study revealed that DO and transparency were low whereas TS, BOD, color and nutrient concentration were exceeding the limit quite high. The presence of heavy metals such as copper, chromium and zinc were also observed. Mohanakavitha et al (2019 a, b) assessed the Kalingarayan canal for its surface water quality in terms of Heavy metals. Parameters such as pH, EC, Fe, Cu, Zn, Cr, Mn, Cd, Pb and Ni were analyzed for a period of 2 years. In comparison with BIS & WHO standards, it was concluded that except cadmium and zinc all heavy metals exceeds the limit. This study showed that the canal is affected by human and industrial activity. Irfan Jamila and Yousuf (2018) examined Dal lake, Kashmir for its physico-chemical parameters for a period of 2 years. It was identified that Hazaratbal basin and Brarinumbal basin of Dal Lake were affected with

eutrophication due to the presence of high phosphorous from sewage, agricultural wastewater and organic wastes which has occupied the lake water. Sairendri Maharana et al (2019) investigated Chilika lagoon for its physico-chemical parameters. Parameters such as temperature, dissolved oxygen, salinity, pH, water transparency, nitrate, chloride and phosphate were analyzed at nine sites. It was observed that the salinity and temperature was more at the outer channels. The water was alkaline in nature all over the year. DO was found to be more during summer. Water transparency was more during winter. Chloride and nutrient concentration varied with seasons. By changing the types and amount of materials carried by water or by altering the physical characteristics of a body of water, the water is getting polluted. The contamination of water bodies such as lakes, rivers, oceans, aquifers and groundwater causes the environmental degradation when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds. The Kalingarayan Canal is one of the historically important sources of water for irrigation in the Erode district. The water in the channel was recently polluted by untreated tannery and textile effluents. It was therefore decided that a study on water quality and its polluting load should be carried out. The water quality is determined by the analysis of physicochemical characteristics. It was necessary to evaluate the quality of the water used in irrigation and other purposes in the Canal. This study assesses the quality of canal water and the impacts of industry effluents. This study will be very useful in understanding the impact of effluent dumping in the canal and the impact on water quality in terms of irrigation and environmental impacts.

MATERIAL AND METHODS

Study area: The Bhavani River, the second largest river in Tamil Nadu, begins in the Western Ghats ' upper regions of Nilgiris. In the district of Erode, a small amount of water from the Havani River is diverted into a canal called the Kalingarayan Canal near Bhavani Town for irrigation purposes. The Kalingarayan Canal is a 90123 m irrigation canal. The 750 year old Kalingarayan canal travels about 90000 m from Kalingarayan anicut to Avudayaparai. It was built by Kongu chieftain Kalingarayan and finished in the year 1283. The canal has been designed with a meandering route to maximize the benefit of the land. It is 162.76 m above sea level where it originates and 125.7 m above sea level, where it merges with the river Noyyal. The channel goes through a serpentine route. The canal connects the rivers Bhavani and Noyyal, the two main Cauvery tributaries. The land survey showed that the area irrigated is 6300 hectare.

Sample collection and sampling procedure: Study was conducted from January 2014 -2015 and seven water samples were collected from different sampling location on the way to the Canal, at a stretch of about 35km from Kalingarayan Anaicut to Colony Pudur. The study area of the canal was the starting place where the discharge of domestic sewage and washing of vehicles, bathing of animals, human activities releasing of municipal wastes as the main sources of pollutants in the Kalingarayan canal. Hence the study has been carried out to analyze the physicochemical parameters of the canal water. Surface water samples from the Kalingarayan canal were collected from different sampling sites Kalingarayan anicut, Chunnambu oodai, Convent school, Vairapalayam, Pallipalayam, Vendipalayam, and Colony pudur. Two litres of wastewater prior to mixing with the water courses from each station were collected in thoroughly rinsed plastic containers, labelled and brought to the approved laboratory on a monthly basis. The samples were analyzed using standard procedure (APHA 1995). The pH of water samples was measured in the field. Samples were subjected to filtration prior to chemical analysis. The samples were preserved in the laboratory at 4°C and various physicochemical parameters were determined (Tripathi et al 1990, 2012). All the samples analyzed were not having any objectionable colour, appearance, taste or odour (Table 1).

RESULTS AND DISCUSSION

pH and conductivity: All the samples had their pH values between 6.88 to 8.6 and these were well within the permissible limit of 6.5 to 8.5 prescribed for drinking water by Indian standards. The highest pH value was observed in running water into the canal at the two locations Chunambu Oodai and convent school (Table 2) and significant difference was noted in the observed pH which may be due to the dilution effect. The observed values, however, were well within the safe limit for crop production. Similar trend was also observed in case of conductivity. The values of conductivity ranged from 306 to 8280 mmhos cm^{-1}. Regarding the highest conductivity at convent school (Table 2) may be due to the mixing of dyeing waste water. The lowest conductivity may be due to the dilution effect of rain water. The conductivity value was found not within permissible limit.

Total dissolved solids: The total dissolved solid (TDS) of the different sites of canal water samples where flow of water in canal were found within the permissible limit (1000 mg l^{-1}) of WHO standards. Due to the nature of flow runoff water occurred during heavy rainy seasons certain variation may occurred but this variation did affect the irrigation system. The high TDS values of water samples collected in no flow of

Table 1. Parameters and methods for surface water analysis

Parameters of water analysis	Methods
pH in standard units	pH meter
Conductivity	Conductivity Meter
Total Solids in mg l^{-1}	Gravimetric method
Total Suspended Solids (TSS)	Oven/ Gravimetric method
Dissolved Oxygen, DOD in mg l^{-1}	Winkler's titrimetric method
Biochemical Oxygen Demand, BOD in mg l^{-1}	Winkler's titrimetric method
Nitrates in mg l^{-1}	Brucine method
Phosphate in mg l^{-1}	Stannous chloride method

water into the canal, which are in the Chunnambu Oodai and Convent School (Table 2). These two locations have dyeing units. These also confirms the fact that the discharge of effluents from dyeing units into the canal water may also be the reason for the very high TDS values observed for the samples collected from other locations which are having many dyeing units.

Total suspended solids: It is used to evaluate the strength of domestic waste waters and efficiency of treatment units. Suspended solids are objectionable in canal for many reasons. Suspended solids containing much organic matter

Table 2. Physicochemical parameters after the analytical study

Parameters	Seasons	Kalingarayan Anicut	Chunnambu Oodai	Convent School	Vaira palayam	Palli palayam	Vendi palayam	Colony pudur
pH	Pre- monsoon	7.38	7.58	7.69	7.61	7.70	7.61	7.40
	Monsoon	7.12	7.20	6.90	6.92	7.50	7.31	7.40
	Post- monsoon	7.90	8.12	8.60	7.94	7.40	7.20	7.30
	Summer	6.88	7.42	7.56	7.4	7.26	7.80	7.78
Conductivity	Pre- monsoon	306	314	521	400	420	417	420
	Monsoon	340	370	396	420	460	530	460
	Post- monsoon	1600	7850	8280	4600	500	510	480
	Summer	410	362	380	386	552	440	510
TDS	Pre- monsoon	230	246	394	310	326	320	324
	Monsoon	270	290	308	322	350	390	350
	Post- monsoon	1010	4042	4190	2510	2400	2300	3000
	Summer	308	266	270	278	380	310	356
TSS	Pre- monsoon	3.00	2.90	3.26	3.10	4.12	4.20	3.98
	Monsoon	9.00	8.40	8.10	12.00	11.00	12.40	13.00
	Post- monsoon	32.00	46.00	51.00	49.00	50.00	52.30	54.20
	Summer	11.00	8.60	9.30	14.60	12.00	11.20	14.60
COD	Pre- monsoon	41.00	90.00	84.00	72.60	70.10	84.00	48.00
	Monsoon	23.00	93.00	82.00	72.00	72.00	79.00	29.00
	Post- monsoon	69.00	174.00	179.00	148.00	84.00	83.40	82.30
	Summer	30.60	69.00	70.00	71.10	86.00	89.00	26.00
BOD	Pre- monsoon	8.10	14.00	13.10	10.40	10.80	11.90	7.90
	Monsoon	3.80	15.00	12.60	11.20	11.30	11.90	6.00
	Post- monsoon	9.10	29.00	22.00	16.00	13.20	12.30	5.30
	Summer	7.40	10.32	11.00	11.22	13.40	14.10	4.40
Nitrogen	Pre- monsoon	2.20	3.80	3.10	3.00	2.40	2.60	2.10
	Monsoon	1.30	4.10	3.60	3.10	2.90	2.92	1.80
	Post- monsoon	2.68	2.40	2.80	2.84	2.40	2.30	1.90
	Summer	1.36	3.92	3.42	3.21	3.14	2.80	2.20
Phosphate	Pre- monsoon	1.83	4.90	4.60	3.20	3.20	3.60	1.20
	Monsoon	1.63	5.12	4.40	3.90	3.90	4.00	2.14
	Post- monsoon	3.60	3.90	4.10	3.94	3.50	4.10	2.20
	Summer	1.70	4.90	4.30	3.84	4.22	3.88	2.30

All units are in mg l^{-1} except conductivity in mmhos/cm, and pH

may cause putrefaction and may be devoid of dissolved solids (Table 2). The concentration of TSS at all points where collected in no flow of water into the canal which may be attributed to the direct discharge of domestic and industrial waste.

Chemical oxygen demand: COD test is quite useful in finding the pollution strength of industrial waste and sewage. Chemical oxygen demand as is the amount of oxygen required for a sample to oxidize at its organic and inorganic matter. The COD value of the canal investigated ranged from 23 mg l^{-1} to 179 mg l^{-1}. The highest value of COD was observed at point Convent School (Table 2) which could link with the inflow of dyeing unit's effluent which is being discharged into the canal. The higher COD values in the samples indicate the presence of increased concentration of industrial pollutants containing inorganic and organic substances, thus showing greater toxicity level.

Biochemical oxygen demand: BOD determination is still the best available single test for assessing organic pollution. The observed BOD of water samples value was indication for entry of organic waste in the canal. The high BOD values suggest more waste product or pollutants are present in Chunnambu Oodai (Table 2). This may be as a result of escape of organic matter into the canal mostly from faecal deposition by the surrounding populace.

Nitrogen: The nitrogen content in irrigation water is generally considered beneficial, barring the nitrite form of nitrogen. It also contained that discharge of ammonium nitrogen and subsequent oxidation that could reduce the DO level in canal. The nitrogen concentration of the water sample ranged from 1.3 mg l^{-1} to 4.1 mg l^{-1} (Table 2). Both phosphate and nitrate are component of agricultural fertilizer commonly used by farmers within the state. These fertilizers may be leached into the soil and river bodies and this may account for significant concentration observed in this study.

Phosphate: Phosphates are obtained from the rocks converting them into its soluble forms and may also occur in agricultural runoff, industrial wastes, municipal sewage and synthetic detergents. The high concentration of phosphate is always indicative of eutrophic. The phosphate concentration of the canal ranged from 1.2 mg l^{-1} to 5.12 mg l^{-1} (Table 2), which was found to be above the permissible limit (0.1 mg l^{-1}). Maximum level of phosphate was found in the canal water where it receives maximum sewage, domestic wastes and human activities. Use of detergent may increase the phosphate concentration to great extent. The anthropogenic additions of phosphorus to the canal have a considerable effect on the quality of the water. Such phosphorus is derived mainly from domestic sewage and the runoff from agricultural areas. The quantity of phosphorus in the domestic sewage and land drainage have increased considerably in recent years due to the increased use of synthetic detergents which contain approximately by weight, the inorganic condensed purposes and the detergents would enhance the load of this element. A higher amount of phosphate represent high pollution loads and causes eutrophication of the aquatic body.

CONCLUSION

The analysis showed that the quality of the Kalingarayan canal in the study area is significantly affected by the discharge of toxic effluents and sewage water. It is observed that during non flow times of canal water the effluents discharged by the dyeing units and sewage discharged by the near by residences deposits in the canal itself which is cause of the increase pollution. Due to the discharge of sewage, domestic wastes and human activities the phosphate load in canal water exceeds the permissible limit. Since the sewage mixes with the canal, the canal water cannot be used for irrigation and drinking purposes. Regular monitoring of canal and taking suitable remedial measures like collection of domestic sewage and setting up the common treatment plant before discharge of sewage into canal. Wastewater should be treated. This will control pollution and prevent the depletion of the quality of canal water.

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Fertility Status of Soils under Different Land Uses in Lesser Himalayan region of Himachal Pradesh

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Abstract: The study was conducted to assess the soil fertility status of Lesser Himalayan region based on ninety five representative surface soil samples collected by systematic sampling methodology using GPS points to represent the cultivated soils (*Entisols, Alfisols* and *Inceptisols*) under major land use of Lesser Himalayan region. Out of 95 sites, 44, 38 and 13 sites represent the cultivated *Entisols, Inceptisols* and *Alfisols*, while 29, 22, 15, 15 and 14 sites represent the soils under maize-wheat, paddy-wheat, vegetables, tea gardens and orchards, respectively. Soils were medium in available N & K, low in available P & S, high in available Ca & Mg, sufficient in available Cu, Fe & Mn and deficient to sufficient in available Zn. As regards available nutrient status, Four nutrients *viz.,* N, P, S and Zn were deficient to the extent of 11, 45, 30 and 34 per cent, respectively.

***Keywords*:** Fertility status, Lesser Himalayan region, Macronutrients, Micronutrients, Nutrient index

Physiographically, the Himachal state has been divided into Outer, Lesser and Greater Himalayan regions covering 16.4, 44.3 and 39.3 per cent of its total geographical area, respectively. About 97 per cent of the total agricultural lands of the State lie in Outer and Lesser Himalayan regions of Himachal Pradesh. The climate of the Lesser Himalayan region varies from sub-humid to temperate wet with the LGP varying from 270 to 330 days. Mean annual temperature lies between 14 °C to 22 °C. The average annual rainfall is about 2000 mm. Generally, soil moisture and temperature regimes in the region are udic and thermic, respectively. In Lesser Himalayan region, majority of soils occurring on ridge tops are shallow in depth, coarse-loamy and acidic to neural in reaction and qualify for *Entisols*. The soils on terraces, valleys and gently sloping are deep to very deep, coarse to fine loamy and acidic to neutral and qualify for *Inceptisols* and *Alfisoils*. The agricultural lands of the study area are under maize-wheat sequence, paddy-wheat sequence, vegetable based cropping sequences, tea gardens and orchards. Apple and other temperate fruits are prevalent in Lesser Himalayan region. Therefore, the present study was conducted to understand the current soil fertility status of Lesser Himalayan region. This would help the farmers to make more informed decisions to increase the productivity of their lands and to improve their livelihood.

MATERIAL AND METHODS

The study was conducted in Lesser Himalayan region which comprises of 24.6 lakh ha area and its altitude ranging from 650 to 2200 m above mean sea level. It includesKangra, Mandi, Chamba, Solan, Kullu and Sirmaur districts of Himachal Pradesh (Fig. 1).

Collection and preparation of soil samples: An area of about one *kanal* (400 m^2) belonging to individual farmer was selected in each site for the collection a composite soil sample as per the recommended procedures. The surface soil samples were collected from croplands from October to November and from orchards during January to February at 0-15 cm soil depths. The collected samples were air dried, lightly crushed in wooden pestle and mortar to break clods and then subsequently passed through the 2 mm sieve and stored in polythene bags for soil analysis.

Laboratory analysis: The processed soil samples were analyzed for available macro-nutrient status of soils was categorized as low, medium and high by using the same limits as adopted by the state soil testing laboratories. A soil having available nutrient content ranging from 280 to 560 kg N ha^{-1}, 10 to 25 kg P ha^{-1}, 118 to 280 kg K ha^{-1}, 1.5 to 2.5 cmol (p+) Ca kg^{-1}, 0.5 to 1.0 cmol (p+) Mg kg^{-1} and 22.4 to 44.8 kg S ha^{-1} is rated as medium in the respective nutrient status. Using 0.2 mg Cu kg^{-1}, 4.5 mg Fe kg^{-1}, 1.0 mg Mn kg^{-1}, 0.6 mg Zn kg^{-1} and 0.5 mg B kg^{-1} as critical limits, soils were rated as deficient or sufficient in the respective micro nutrient. Soil nutrient indices (SNI) were also worked out to depict the overall available status of each macro-nutrient in major soils and crops by using the formula proposed by Parker et al (1951). A SNI value between 1.67 and 2.33 indicates the medium status of nutrients in soils.

RESULTS AND DISCUSSION

Status of Macronutrients

Soils under maize-wheat sequence: Available N (kg ha^{-1}),

P (kg ha^{-1}), K (kg ha^{-1}), Ca {cmol(p+) kg^{-1}}, Mg {cmol(p+) kg^{-1}} and S (kg ha^{-1}) in cultivated soils under maize-wheat sequence of Lesser Himalayan region varied from 224 to 563, 5.4 to 13.0, 138 to 375, 1.5 to 6.5, 0.5 to 2.1 and 11 to 37, respectively (Table 2). On the basis of SNI, soils were rated as medium (1.76), low (1.03), medium (2.17), high (2.62), high (2.45) and low (1.38) in available N, P, K, Ca, Mg and S, respectively. Per cent of total soils rating low in available N, P and S were 28, 97 and 62, respectively.

Soils under paddy-wheat sequence: Available N (kg ha^{-1}), P (kg ha^{-1}), K (kg ha^{-1}), Ca {cmol(p+) kg^{-1}}, Mg {cmol(p+) kg^{-1}} and S (kg ha^{-1}) in cultivated soils under paddy-wheat sequence varied from 267 to 710, 5.6 to 20.4, 156 to 372, 1.5 to 5.3, 0.56 to 2.4 and 12 to 49, respectively (Table 4). On the basis of SNI values, available N, P, K, Ca, Mg and S status in soils was medium (2.14), low (1.32), medium (2.32), high (2.68), high (2.59) and medium (1.68), respectively. Per cent of total soils rating low in available N, P and S were 9, 68 and 37, respectively.

Soils under vegetable based cropping sequences: Available N (kg ha^{-1}), P (kg ha^{-1}), K (kg ha^{-1}), Ca {cmol(p+) kg^{-1}}, Mg {cmol(p+) kg^{-1}} and S (kg ha^{-1}) in these soils varied from 293 to 710, 10.0 to 28.0, 180 to 372, 3.7 to 6.1, 1.2 to 1.7 and 22 to 69, respectively (Table 5). On the basis of SNI, soils were rated as high (2.60), medium (2.27), high (2.73), high (3.00), high (3.00) and medium (2.27) in available N, P, K, Ca, Mg and S, respectively. Per cent of total soils rating low in available S were 7.

Soils under tea gardens: Available N (kg ha^{-1}), P (kg ha^{-1}), K (kg ha^{-1}), Ca {cmol(p+) kg^{-1}}, Mg {cmol(p+) kg^{-1}} and S (kg ha^{-1}) in these soils varied from 572 to 725, 19.0 to 29.0, 202 to 397, 3.4 to 5.2, 1.1 to 1.7 and 35 to 64, respectively (Table 6). On the basis of SNI values, soils were rated as high (2.93), medium (2.33), high (2.67), high (3.00), high (3.00) and high (2.60) in available N, P, K, Ca, Mg and S, respectively.

Soils under orchards: Available N (kg ha^{-1}), P (kg ha^{-1}), K (kg ha^{-1}), Ca {cmol(p+) kg^{-1}}, Mg {cmol(p+) kg^{-1}} and S (kg ha^{-1}) in these soils varied from 325 to 653, 12.0 to 25.0, 185 to 410, 3.9

Table 1. Methods used for soil analysis

Parameter	Method	Reference
N	Micro-Kjeldahl method	Subbiah and Asija (1956)
P	Colorimetric method	Olsen et al (1954)
	Flame-photometric method	Black (1965)
Ca & Mg	Flame photometric/ Atomic Absorption Spectrophotometric (AAS) method	Jackson (1973)
S	Colorimetric method	Jackson (1973)
Cu, Fe, Mn & Zn	AAS method	Lindsay and Norvell (1978)

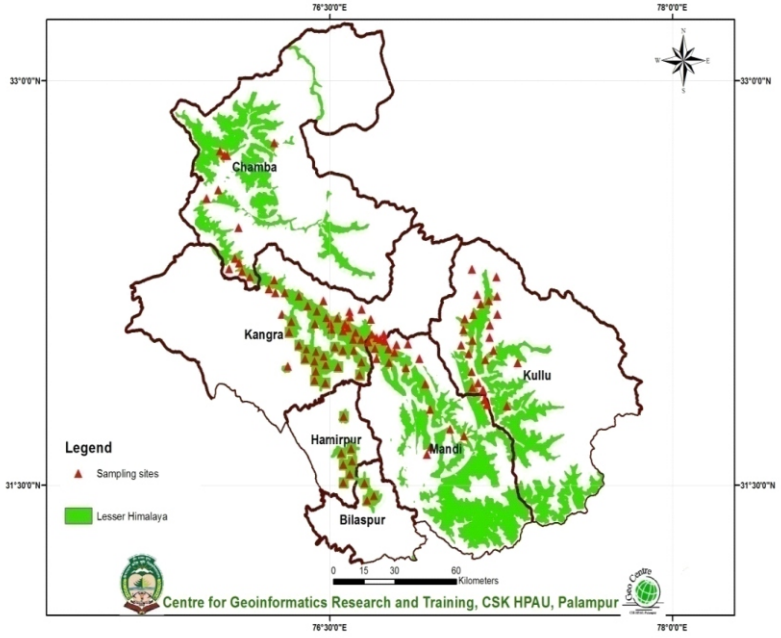

Fig. 1. Location of soil sampling sites in Lesser Himalayan region

Table 2. Available macronutrient status of soils under maize-wheat sequence

Site	Available macronutrients					
	N	P	K	Ca	Mg	S
	(kg ha^{-1})			{cmol(p+) kg $^{-1}$}		(kg ha^{-1})
Entisols						
Sainthi	242	6.4	138	1.6	0.6	12
Kaswar	283	9.2	190	3.1	1.0	22
Chhajoli	410	8.5	375	6.5	2.1	37
Khatta	280	8.4	191	3.9	1.3	22
Gharana	289	8.6	185	4.2	1.4	22
Behra	352	9.2	272	4.7	1.6	34
Bar Kalan	280	8.5	183	3.9	1.3	18
Soun	256	5.4	146	2.8	1.0	14
Kandi	380	7.8	295	4.8	1.6	22
Malehr	295	8.6	286	4.3	1.4	30
Mehar	290	8.4	184	1.6	0.7	14
Sarali	247	7.2	156	1.8	0.8	13
Chandpur	296	8.4	216	2.6	0.9	20
Hara Bagh	256	6.8	177	1.7	0.5	14
Golwan	268	6.4	148	2.1	0.7	15
Tikri	310	8.4	184	2.3	1.0	15
Panjla	268	5.4	178	2.6	0.8	14
Kaore	356	9.2	192	2.0	0.7	23
Gorat	224	6.8	144	1.5	0.7	11
Dhelu	310	8.4	174	2.1	0.7	18
Sukrayin	410	8.4	249	2.26	0.60	34
Mean ± SD	300±52.85	8±1.18	203±60.81	3.0±1.35	1.0±0.42	20±7.70
Inceptisols						
Dun	289	8.7	270	4.6	1.5	26
Kandi	371	9.7	312	4.0	1.3	30
Ulehrd	267	6.4	196	2.5	0.8	14
Chamari	293	8.4	173	3.9	1.3	22
Thamani	310	8.5	273	3.7	1.2	27
Sambar-8-mile	563	13	185	3.7	1.2	34
Ballu	372	7.5	339	3.5	1.1	24
Nag Moud	310	7.4	210	2.6	09	22
Mean ± SD	347±95.08	8.7±2.00	245±62.27	3.6±0.70	1.2±0.23	25±5.89
Overall Mean ± SD	313±68.61	8±1.47	215±62.52	3.1±1.23	1.1±0.38	22±7.47

Note: H=High, M=Medium, L=Low

Table 3. Available micronutrient status of soils under maize-wheat sequence

Site	Available micronutrients			
	Cu	Fe	Mn	Zn
	(mg kg^{-1})			
Entisols				
Sainthi	0.26	6.2	1.4	0.42
Kaswar	0.26	5.4	1.2	0.55
Chhajoli	0.28	8.0	1.7	0.64
Khatta	0.27	6.4	1.4	0.56
Gharana	0.27	6.5	1.5	0.53
Behra	0.32	6.6	1.5	0.61
Bar Kalan	0.24	5.8	1.3	0.44
Soun	0.24	5.2	1.1	0.40
Kandi	0.29	6.9	1.7	0.63
Malehr	0.25	5.7	1.3	0.61
Mehar	0.24	5.4	1.2	0.45
Sarali	0.21	5.0	1.0	0.49
Chandpur	0.24	6.1	1.3	0.51
Hara Bagh	0.21	5.2	1.3	0.54
Golwan	0.22	5.4	1.4	0.50
Tikri	0.24	5.2	1.2	0.38
Panjla	0.24	5.4	1.2	0.43
Kaore	0.26	5.2	1.2	0.54
Gorat	0.21	5.2	1.0	0.41
Dhelu	0.27	6.8	1.3	0.53
Sukrayin	0.24	10.2	1.4	0.62
Mean ± SD	0.25±0.03	6.1±1.22	1.3±0.19	0.51±0.08
Inceptisols				
Dun	0.25	5.7	1.3	0.63
Kandi	0.29	6.3	1.3	0.64
Ulehrd	0.22	5.2	1.3	0.56
Chamari	0.26	5.4	1.2	0.52
Thamani	0.25	5.8	1.3	0.62
Sambar-8-mile	0.35	10.6	1.9	1.10
Ballu	0.27	6.1	1.2	0.71
Nag Moud	0.26	6.2	1.1	0.73
Mean ± SD	0.27±0.04	6.4±1.74	1.3±0.24	0.69±0.18
Overall Mean ± SD	0.26±0.03	6.2±1.35	1.3±0.20	0.56±0.14

Note: S=Sufficient, D=Deficient

to 7.3, 1.2 to 2.4 and 22to 65, respectively (Table 7). On the basis of SNI values, soils were rated as high (2.71), medium (2.07), high (2.57), high (3.00), high (3.00) and medium (2.21) in available N, P, K, Ca, Mg and S, respectively. Per cent of total soils rating low in available S were 7.

Micronutrient status

Soils under maize-wheat sequence: Available Cu, Fe, Mn and Zn in soils ranged from 0.21 to 0.35, 5.0 to 10.6, 1.0 to 1.9 and 0.38 to 1.10 mg kg^{-1}, respectively (Table 3). All soils studied were sufficient in available Cu, Fe and Mn. Per cent of total soils rating deficient in available Zn were 62.

Soils under paddy-wheat sequence: Available Cu, Fe, Mnand Zn in soils ranged from 0.21 to 0.46, 4.5 to 26.4, 1.1 to 3.8 and 0.42 to 1.6 mg kg^{-1}, respectively (Table 4). All soils studied were sufficient in available Cu, Fe and Mn. Per cent of total soils rating deficient in available Zn were 36.

Soils under vegetable based cropping sequences: Available Cu, Fe, Mnand Zn in soils ranged from 0.29 to 0.53, 6.9 to 27.3, 1.7 to 4.1 and 0.49 to 1.41 mg kg^{-1}, respectively (Table 5). All soils studied were sufficient in available Cu, Fe and Mn. Per cent of total soils rating deficient in available Zn were 20.

Soils under tea gardens: Available Cu, Fe, Mn and Zn in soils ranged from 0.37 to 0.52, 11.6 to 29.0, 2.2 to 4.2 and 0.41 to 1.4 mg kg^{-1}, respectively (Table 6). All soils studied were sufficient in available Cu, Fe and Mn. Per cent of total soils rating deficient in available Zn were 13.

Soils under orchards: Available Cu, Fe, Mn and Zn in soils ranged from 0.28 to 0.49, 7.1 to 23.4, 1.5 to 4.0 and 0.49 to 1.2 mg kg^{-1}, respectively (Table 7). All soils were sufficient in available Cu, Fe and Mn. Per cent of total soils rating deficient in available Zn were 7.

The overall available N (kg ha^{-1}), P (kg ha^{-1}), K (kg ha^{-1}), Ca {cmol(p+) kg^{-1}}, Mg {cmol(p+) kg^{-1}}, S (kg ha^{-1}), Cu (mg kg^{-1}), Fe (mg kg^{-1}), Mn (mg kg^{-1}) and Zn (mg kg^{-1}) in Lesser Himalayan region varied from 224 to 725, 5.4 to 29, 138 to 410, 1.5 to 7.3, 0.52 to 2.4, 11 to 69, 0.21 to 0.51, 4.5 to 29, 1 to 4.2 and 0.38 to 1.6, respectively. Similar results were also reported by Singh and Rathore (2013) and Annepu et al (2017).The results revealed that the soils varied considerably in available nutrient content/ status. It may be attributed to the differences in pedo-genesis (gains, losses, transformation and translocation of materials), soil management practices, land use types, plant nutrient recycling processes, etc. In nutshell, soil fertility is controlled by soil forming factors/ processes and land management practices.

CONCLUSIONS

It may be concluded from the present investigation that deficiency of four nutrients, *viz.,* N, P, S and Zn may impose

Table 4. Available macro and micronutrient status of soils under paddy-wheat sequence

Site	Available macronutrients						Available micronutrients			
	N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn
	(kg ha^{-1})			{cmol(p+) kg $^{-1}$}		(kg ha^{-1})	(mg kg^{-1})			
Alfisols										
Khroth	396	9.2	236	3.95	2.42	23	0.32	6.9	1.7	1.40
Mutt	584	14.4	284	5.27	1.49	23	0.38	16.4	1.9	0.52
Lachun	692	16.2	324	4.81	1.28	23	0.46	18.2	2.1	0.73
Dadh	680	20.4	356	4.40	1.18	24	0.34	26.4	2.9	0.91
Bagoda	710	16.4	331	3.21	0.85	24	0.41	21.4	3.8	1.60
Dhramman	346	10.2	246	3.51	1.58	23	0.27	6.9	1.6	1.21
Mean ± SD	568±159.50	14.5±4.19	296±48.69	4.2±0.78	1.5±0.53	23±0.68	0.36±0.07	16.0±7.85	2.3±0.85	1.06±0.41
Entisols										
Bagla	268	5.6	156	1.58	0.74	14	0.21	4.5	1.1	0.49
Bharmala	695	16	225	4.4	1.4	49	0.41	21.4	3.8	1.60
Bsal	272	7.4	156	2.49	0.75	12	0.21	4.8	1.3	0.62
Mean ± SD	412±245.38	9.7±5.56	179±39.84	2.8±1.44	0.96±0.38	25±20.57	0.28±0.12	10.2±9.67	2.1±1.50	0.90±0.61
Inceptisols										
Sutiara	350	9.2	279	3.8	1.3	23	0.31	6.8	1.6	1.41
Panjlehr	470	11.1	372	4.3	1.4	39	0.43	9.4	1.7	0.64
Bari	320	8.3	224	2.37	0.83	19	0.28	5.6	1.4	0.72
Mahakal	296	6.4	172	1.5	0.56	18	0.24	5.9	1.4	0.63
Khedlu	293	6.5	290	4	1.3	27	0.27	6.9	1.6	0.52
Haritygar	287	6.4	183	3.8	1.2	27	0.26	5.4	1.2	0.51
Banna	384	8.4	210	3.32	1.05	23	0.26	5.8	1.6	0.48
Bagdu	346	9.4	210	2.37	0.83	20	0.30	5.9	1.4	0.71
Kolri	305	7.0	291	4.9	1.6	30	0.28	6.9	1.7	0.50
Lahdu	267	7.2	184	2.52	0.84	15	0.24	6.4	1.2	0.53
Mehla	310	7.4	224	2.45	0.82	19	0.28	6.4	1.1	0.42
Dadaman	320	8.4	224	3.22	1.52	21	0.24	7.8	1.2	1.03
Malara	372	9.2	244	2.29	0.98	23	0.32	6.9	1.6	1.21
Mean ± SD	332±53.57	8.1±1.42	239±56.0	3.1±0.98	1.1±0.32	23±6.42	0.29±0.05	6.6±1.07	1.4±0.21	0.72±0.31
Overall Mean ± SD	407±155.87	10.0±4.04	246±62.43	3.4±1.08	1.2±0.42	24±8.01	0.31±0.07	9.7±6.45	1.8±0.77	0.84±0.39

Note: H=High, M=Medium, L=Low, S=Sufficient, D=Deficient

Table 5. Available macro and micronutrient status of soils under vegetable based cropping sequences

Site	Available macronutrients						Available micronutrients			
	N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn
	(kg ha^{-1})			{cmol(p+) kg $^{-1}$}		(kg ha^{-1})	(mg kg^{-1})			
Entisols										
Takoli	710	28	372	4.5	1.5	69	0.49	27.3	4.1	1.41
Deor	510	11.2	195	4.0	1.3	34	0.46	9.5	1.8	0.72
Kalehi	293	10.2	180	3.7	1.2	22	0.29	6.9	1.7	0.53
Jia	563	17.8	286	4.6	1.5	30	0.38	16.4	1.9	0.92
Pirdi	610	20.5	311	5.2	1.7	37	0.48	14.0	3.8	0.79
Bandrol	603	21	293	5.1	1.7	36	0.49	14.1	3.9	0.88
Bhlogi	640	27	330	4.6	1.6	56	0.53	23.2	3.8	1.12
Dobhi	620	25	325	6.1	1.2	43	0.51	26.5	3.5	1.20
Duwara	640	27	339	6	1.2	62	0.51	24.2	3.7	1.22
Mean ± SD	577±119.68	20.9±6.71	292±64.70	4.9±0.82	1.4±0.21	43±15.58	0.46±0.08	18.0±7.53	3.1±1.01	0.98±0.28
Inceptisols										
Gurkhadi	483	10	298	5.3	1.7	26	0.29	7.5	1.9	0.51
Seu	650	26	343	4.5	1.5	53	0.49	27.3	4.1	1.41
Barai	293	11	281	4.1	1.4	23	0.35	7.0	1.7	0.49
Nair	557	16.5	263	4.6	1.5	36	0.34	14.6	1.8	0.82
Nagwain	560	17	272	4.7	1.7	43	0.35	15.2	1.9	0.69
Bharatkoop	623	25	339	5.1	1.7	47	0.48	21.4	3.9	0.91
Mean ± SD	528±128.86	17.6±6.76	299±34.31	4.7±0.43	1.6±0.13	38±11.89	0.38±0.08	15.5±7.89	2.6±1.13	0.81±0.34
Overall Mean ± SD	557±121.36	19.6±6.69	295±53.15	4.8±0.67	1.5±0.19	41±14.02	0.43±0.09	17.0±7.50	2.9±1.06	0.91±0.31

Note: H=High, M=Medium, L=Low, S=Sufficient, D=Deficient

Table 6. Available macro and micronutrient status of soils under tea gardens

Site	Available macronutrients						Available micronutrients			
	N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn
	(kg ha^{-1})			{cmol(p+) kg $^{-1}$}		(kg ha^{-1})	(mg kg^{-1})			
Alfisols										
Chatter	556	17.3	178	3.0	1.0	34	0.37	11.6	2.2	0.41
Taragarh	623	21	287	3.6	1.2	52	0.48	14.0	3.8	0.73
Banotu	615	20	263	3.6	1.2	35	0.49	14.6	3.8	0.70
Sungal	703	27	389	4.8	1.6	51	0.49	28.5	4.0	1.31
Banuri	693	23	380	4.5	1.5	53	0.51	28.2	3.9	1.13
Gopalpur	720	29	397	5.2	1.7	51	0.50	29.0	4.2	1.22
Palampur	618	21	270	3.6	1.2	42	0.49	14.7	3.8	1.28
Mean ± SD	647±59.59	22.6±4.09	309±82.12	4.0±0.80	1.3±0.26	45±8.26	0.48±0.05	20.1±8.00	3.7±0.67	0.97±0.35
Inceptisols										
Thandol	644	26	353	4.5	1.5	64	0.52	28.0	3.9	1.27
Thandol	705	27	355	4.8	1.6	62	0.50	28.3	4.0	1.33
Darang	725	29	394	4.9	1.6	61	0.52	29.0	4.2	1.40
Majherna	613	20.5	339	4.6	1.5	54	0.49	26.5	3.4	1.09
Raipur tea estate	618	21	273	4.1	1.4	37	0.47	14.5	3.9	0.83
Tarked	695	23	331	4.8	1.6	45	0.47	28.0	3.9	0.92
Stain	625	22	315	4.4	1.5	47	0.51	26.0	3.5	0.51
Kyori	572	19	202	3.4	1.1	38	0.38	17.4	2.4	0.74
Mean ± SD	650±52.20	23.4±3.52	320±59.08	4.4±0.49	1.5±0.17	51±10.83	0.48±0.05	24.7±5.55	3.7±0.57	1.01±0.31
Overall Mean ± SD	648±54.21	23.1±3.68	315±68.33	4.3±0.66	1.4±0.22	48±9.82	0.48±0.05	22.6±6.97	3.7±0.59	0.99±0.32

Note: H=High, M=Medium, L=Low, S=Sufficient, D=Deficient

Table 7. Available macro and micronutrient status of soils under orchards

Site	Available macronutrients						Available micronutrients			
	N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn
	(kg ha^{-1})			{cmol(p+) kg $^{-1}$}		(kg ha^{-1})	(mg kg^{-1})			
Entisols										
Jia	578	19	305	4.8	1.6	33	0.38	14.5	2.1	0.81
Bashing	483	10	171	3.8	1.3	22	0.28	7.8	1.5	0.49
Nangabagh	642	26	315	5.9	1.2	52	0.49	23.4	4.0	0.88
17 mile Rampur	520	13.7	183	5.9	1.2	29	0.40	9.8	1.9	0.71
Naroi	325	12	287	4.4	1.5	26	0.32	7.1	1.7	0.62
Chakki	565	16	190	3.9	1.3	35	0.32	10.4	1.8	0.91
Siula	563	17	405	7.0	2.3	37	0.38	16.2	1.9	1.08
Groth	495	15	387	6.1	2.0	30	0.32	10.1	2.0	0.78
Jadhoga	564	18	402	6.6	2.2	31	0.34	11.4	2.1	0.72
Drabad	579	18	410	7.3	2.4	46	0.39	16.9	1.9	0.90
Karjan	564	15.1	185	3.9	1.3	36	0.40	11.4	2.1	1.17
Mean ± SD	534±81.99	16.4±4.19	295±98.41	5.4±1.30	1.7±0.47	34±8.61	0.37±0.06	12.6±4.76	2.1±0.66	0.82±0.21
Inceptisols										
Bhuntar	560	15.2	220	4.5	1.5	32	0.32	10.7	1.8	0.92
Hat	653	25	328	6.4	1.2	65	0.49	23.4	3.8	1.12
Mirni	590	21	315	4.2	1.4	50	0.48	13.5	3.8	1.20
Mean ± SD	601±47.47	20.4±4.93	288±58.96	5.0±1.19	1.4±0.15	49±16.61	0.43±0.10	15.9±6.67	3.1±1.15	1.08±0.14
Overall Mean ± SD	549±79.52	17.2±4.50	293±89.40	5.3±1.25	1.6±0.44	37±11.74	0.38±0.07	13.3±5.12	2.3±0.86	0.87±0.22

Note: H=High, M=Medium, L=Low, S=Sufficient, D=Deficient

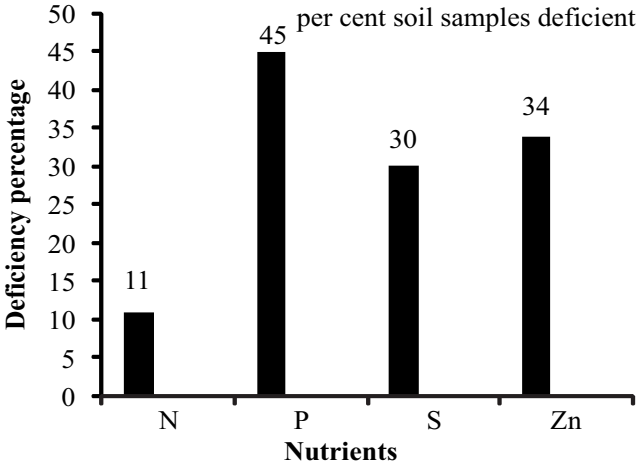

Fig. 2. Nutrient deficiency status in soils of Lesser Himalayan region

threat to sustain the soil productivity in Lesser Himalayan region. This study would help the farmers to increase the productivity of their lands and to improve their livelihood by formulating sound fertilizer recommendations.

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Impact of Probability of Well Success on Unit Cost of Irrigation in Karnataka

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Abstract: The negative binomial probability of drilling a successful well in hard rock areas of Karnataka is estimated to be around 0.3, which has fallen from 0.60 during the 1990s. By incorporating the weighted probability of well success and failure, it has been estimated that out of the total investment on drilling and casing of irrigation well in hard rock areas, the investment on failed wells formed around 70 percent of the total investment. Thus, by improving the probability of well success by adopting sustainable cropping pattern and suitable coping mechanisms such as drip irrigation, recharging of borewells, sharing of borewell among siblings, substantial investment on failed wells could be saved which is worthwhile for small and marginal farmers. The current unit cost of well irrigation by NABARD underestimates the loan sanctioned to the tune of 60 per cent, which imposes substantial costs on marginal and small farmers. It is therefore crucial to revise the methodology of estimating unit cost by NABARD as proposed in this study.

Keywords: Borewell irrigation, Cost of drilling and casing, Negative binomial distribution, Probability of well success

India's agricultural production journey from external dependency to meet foodgrain requirements at the time of Independence to self-sufficiency today is intricately tied to the groundwater resources of the country (Dipankar 2019). But, today the ever growing demand for agri-horticultural and dairy products from peri-urban fringes is adding to the increasing dependence on groundwater resource where the resource is being over exploited. These areas also suffer from limited recharge attempts/efforts on small and marginal farms where natural resources are limited (Kalphana 2018). About 65 per cent of the geographical area of the country constitute hard rock area (Roopal 2016) fraught with low groundwater recharge, below 10 percent of the rainfall. The resulting probability of well success is fast reducing. Nevertheless to mention that borewells have been the order of the day. In these areas, in order to strike a successful well farmers drilled more than a well or a couple of wells depending upon the probability of success of well widely varying from farmer to farmer (Kiran 2014 and Nagaraj et al 1996). Thus, the probability depends upon the history of drilling experience, which involves the initial and premature failures of wells prior to obtaining a successful well. Accordingly, investment on all types of wells needs to be accounted in costing of irrigation well. Usually farmers consider the investment on water yielding (or successful) well, treating non-yielding wells (or failed) wells as redundant.

The cost of groundwater irrigation thus need to reflect the investment/cost of initial failure, premature failure and success wells and cost of coping mechanisms such as water storage structures, drip system and so on, weighted with the probability of well success. There have been seldom attempts towards costing groundwater, due to issues inter alia such as (1) definition of well – to include or exclude the variable cost of drilling and casing, the fixed cost of water extracting structures (motor, pump, electrical installation), water delivery structures (pipes, drip / sprinkler systems) (2) incorporation of probability of well success and probability of well failure in the costing of irrigation wells, (3) internalization of externality of groundwater irrigation reflected in increasing initial failure, the associated (4) determination of life and age of well. Due to these complications, it was easy for Commission for Agricultural Costs and Prices (CACP) to treat investment on irrigation well as fixed cost and by assuming a fixed number of years of life, could compute depreciation as the (fixed) cost of irrigation. The purpose of this article is to explore whether the probability of well success has increased or reduced over time, how does the probability of well success varies with adoption of coping mechanisms to combat the predicament of groundwater irrigation and to examine the influence of incorporation of probability of well success and failures in estimation of investment on irrigation borewell.

MATERIAL AND METHODS

A total of 120 sample farmers representing four categories such as farmers sharing well water among

siblings (n=30), farmers with drip irrigation for broad spaced crops (n=30), farmers who have recharged irrigation borewell/s (n=30) from Chitradurga district and farmers who have adopted drip irrigation for narrow spaced crops (n=30) from Kolar districts of Karnataka state were selected. Farmers sharing well water and those who have recharged irrigation well/s were selected following snow ball sampling. Random sampling technique was followed to select drip irrigation farmers. Kolar and Chitradurga are the hard rock areas representing Eastern and Central Dry Zones of Karnataka. The primary data pertaining to size of land holding, year of drilling of borewell, investment made on drilling and casing of borwell, year of functioning of borewell, depth of well, yield of functioning well, cropping pattern etc., were elicited from sample farmers using well structured interview schedule.

Probability of well success: The NBD probability function with probability of success 'p' and probability of failure 'q' (=1-p) is given (Manjunatha et al 2014) as under

$$P_x\{nb(x;r,p)\} = \binom{x+r-1}{r-1} p^r q^x$$

$$; for\ x = 0,1,2,3,..., r-1, r \geq 0; 0 < p < 1$$

$$Mean = \frac{rq}{p} \quad and\ Variance = \frac{rq}{p^2}$$

NBD probability of borewell success (r >1) is

$$p = \frac{r}{(r + Mean)} = \frac{Mean}{Var}$$

and q = (1-p) is the probability of borewell failure. The Chi-Square statistic is employed to test the goodness of fit of the distribution.

Estimation of economic investment on irrigation borewell: The estimated total investment to obtain one successful borewell = {(l/p) (p) (cost of successful borewell) + (1-p)/ (p) (cost of failed borewell)}= (cost of successful borewell) + (q)/ (p) (cost of failed borewell)

RESULTS AND DISCUSSION

The sample farmers who are sharing irrigation water among their siblings have experienced the largest probability of obtaining successful borewell of 0.68, in Chitradurga district receiving a modest rainfall of around 450 to 650 mm (Central Dry Zone). They experienced a higher probability of obtaining successful borewell, by sustainably using groundwater, which resulted in honoring isolation distance between wells and reducing proliferation of irrigation wells. However, the situation was different in the case of other three sample categories whose probability of well success was modest ranging from 0.27 to 0.32 (Fig. 1). Thus, with the low probability of well success, farmers in Eastern Dry Zone having drip irrigation for narrow spaced crops had to drill three borewells to get one successful well. Similarly, farmers in Central Dry Zone having drip irrigation / recharged borewell had to drill four borewells to get one successful well. The number of wells to be drilled to obtain successful borewell by shared well farmers was just equal to one (Table 1). From the preceding results it could be inferred that the probability of well success on farm in general was modest at 0.30. While the probability of well success observed during 1990's was in the range of 0.55 to 0.66. Reducing probability of well success is apparent over the years. It might be due to violation of isolation distance, cumulative interference due to

Table 1. Estimated Negative binomial probability of obtaining successful borewell in hard rock areas of Karnataka adopting various coping mechanisms

Particulars	Drip farms connected to narrow spaced crops	Drip farms connected to broad spaced crops	Farms with borewell recharged	Farms sharing their well water with relatives
No. of farms with zero borewells drilled before one successful well (= No. of farms with no failures)	6	15	6	21
No. of farms with one borewell drilled before one successful well	7	3	6	5
No. of farms with two borewells drilled before one successful well	6	4	6	3
No. of farms with three borewells and above drilled before one successful well	11	8	12	1
Total no. of farms	30	30	30	30
Total no. of wells on all farms in each category	139 (27.36)	150 (29.53)	159 (31.30)	60 (11.81)
Negative Binominal probability of obtaining one successful well= 1/(1+Mean)	0.32	0.28	0.27	0.68
Mean number of successful borewells per farm	2.06	2.57	2.70	0.47

Note: Values in parenthesis indicate percent to grand total number of wells (508)

Table 2. Estimated cost of borewell incorporating probabilities of well failure and success in hard rock areas

Particulars	Drip farms connected to narrow spaced crops	Drip farms connected to broad spaced crops	Farms with recharged borewell	Farms with shared borewell
Cost of drilling and casing per successful well (Rs)	100207	30519	31180	27459
Cost of drilling and casing per failed well (Rs)	77929	32003	26779	24828
Probability of successful well	0.32	0.28	0.27	0.68
Probability of failed well	0.68	0.72	0.73	0.32
Weighted cost of successful well {(3/3)*(1)}	100207 (37.70)	30519 (27.05)	31180 (30.10)	27459 (70.15)
Weighted cost of failed well {(4/3)*(2)}	165599	82292	72401	11684
Estimated investment on drilling and casing of an irrigation well = (5+6)	265806	112811	103581	39143
Total number of wells to be drilled to obtain one successful well	3.13	3.57	3.7	1.47
Average depth of borewell (ft)	717	342	342	274
NABARD's unit cost of casing and drilling for the average depth of borewell	96888	41162	41162	32656
Deviation in unit cost fixed by NABARD (%)	-63.54	-63.51	-60.26	-16.57

Note: Values in parenthesis indicate percentage of weighted cost of successful well in total investment

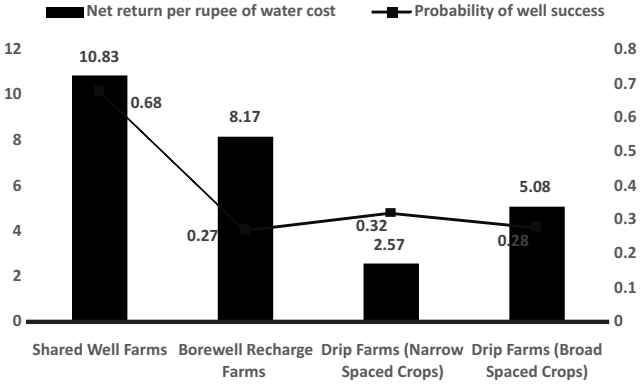

Fig. 1. Economic efficiency and probability of well success on farms with different coping mechanism

mushrooming of borewells and increasing negative externality. The influence of probability of well success and failure/s was incorporated in the estimation of investment on irrigation well by assigning appropriate weights. Accordingly, the proportion of weighted cost of successful well ranged from 27 to 38 per cent for the drip farms connected to narrow spaced crops, broad spaced crops and on borewell recharge farms. The rest proportion was accounted for cost of failed wells which formed 73 to 62 per cent of the total cost of well. This was due to violation of isolation distance between wells, which resulted in mushrooming of irrigation borewell and the consequent effect of cumulative interference in increasing negative externality. The proportion of cost of failed well was the lowest in the case of shared well farms (30%) due to non violation of isolation distance and reduction in proliferation of irrigation wells.

The average depth of borewell was 717 feet in the case of drip farms connected to narrow spaced crops, 342 feet in drip farms connected to broad spaced crops and borewell recharged farms and was 274 feet in shared well farms. The estimated unit cost by NABARD for this depth worked out to Rs. 96888, Rs. 41162 and Rs. 32656. The percentage deviation in estimated economic investment on irrigation borewell from NABARD's unit cost ranged between -16.57 to -63.54 percent. Hence, the funding agency like NABARD needs to consider the probability of well success and failure while estimating the unit cost of irrigation well in hard rock areas (Table 2). The economic investment on irrigation borewell was Rs. 265806, Rs. 112811, Rs.103581 on farms with broad spaced crops, borewell recharged farms and shared well farms. Thus, the probability of well success played a crucial role in the overall cost of drilling and casing of irrigation well (Table 2).

CONCLUSIONS

The probability of well success has reduced over the years. Improvement in the probability of well success could save 70 per cent of the investment on drilling and casing of borewells. The NABARD's current procedure of providing unit cost of borewell is lower by about 60 percent, since it ignores the weighted probability of well success and failure. The methodology adopted in this study will benefit NABARD and in turn scores of small and marginal farmers in availing appropriate unit cost for borewell.

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Water Use Efficiency and Yield of Baby Corn under Different Drip Irrigation Regimes in Sandy Loam Soil

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Abstract: A field experiment was conducted to determine the best irrigation practice for baby corn through drip irrigation in sandy loam soil to optimise yield and optimum water use efficiency. Soil samples were collected at weekly interval and estimated the soil moisture content in the root zone using gravimetric method under two irrigation treatments daily and alternate day irrigation 1.0 ET_c, 0.8 ET_c, and 0.6 ET_c. The corn yield was observed to be maximum in 1.0 ET_c daily irrigation as (5.2 t ha^{-1}), whereas in alternate day irrigation was 4.2 t ha^{-1} in 100 per cent crop water requirement irrigation treatment (1.0 ET_c). Water use efficiency was highest in 0.8 ET_c (27.7 kg ha^{-1}-mm) and lowest in 0.6 ET_c irrigation (11 kg ha^{-1}-mm). The soil moisture content was maximum in 1.0 ET_c and 0.8 ET_c at daily interval. The interaction effect showed significantly higher cob yield with application of irrigation at 0.8 ET_c.

Keywords: Baby corn, Soil moisture content, Water use efficiency, Yield

Drip irrigation has the ability to highly control the location, quantity, and timing of water. At each stage the cultivator can accurately apply the proper volume of water to optimize the growth potential. It provides a better application of water to the soil profile for germination and spoon feeds nutrients in early vegetative stages. With drip irrigation the soil condition and nodal root development can be optimized by optimizing the air and water balance in the soil. The drip irrigation system maximized maize grain yield and water use efficiency compared to the sprinkler irrigation system (Abd El-Wahed and Ali 2013). Irrigation distributes nutrient directly to the root zone to allow for peak uptake of critical nutrients in the silking and tasseling stage the available water to the plant is optimal for proper kernel development. Each step is providing the farmer with the opportunity to utilize water to maximize yield. With increasing concern about declining water resources, there is a great intension to improve water management in farming systems to improve water use efficiency (Buttar et al 2006). It is proved to be an efficient method in increasing water use efficiency as compared to the conventional surface method of irrigation where water use efficiency is only about 35-40 per cent. The general goal of drip irrigation system design is to provide irrigation water efficiently and uniformly to a crop, to help meet the evapotranspiration needs. It is essential to know the water requirement of a crop which is the total quantity of water required from its sowing time to harvest. Present investigation was carried out to assess the best irrigation practice to optimize the yield and water use efficiency of baby corn under drip irrigation.

MATERIAL AND METHODS

The experiment was carried out at field irrigation laboratory with an area of 270 m^2 (30 m x 9 m) beside mango orchard at the back of workshop building at College of Agricultural Engineering, Bapatla. It is geographically situated at 15^0 54' 00" N latitude and 80^0 28' 0" E longitudes and at an altitude of 6m above mean sea level. The experimental site lies in humid sub tropical area. The summers are dry and hot, where as winter is cool. The experimental site consists of sandy soil with well drained conditions (Table 1). The irrigation water quality was analyzed using standard methods pH, Ec_w were 6.68 and 0.41 dS/m. Sodium adsorption ratio and Residual sodium carbonate were 0.75 and 1.17 milli equivalent per liter.

Details of experiment: An experiment was laid out with two main treatments, three sub treatments and replicated three times. Different irrigation schedules were to arrive at optimal irrigation scheduling for enhancing water use efficiency. The irrigation interval proposed was daily and alternate day irrigation. The amount of irrigation application was planned at 1.0 ET_c, 0.8 ET_c and 0.6 ET_c where 1.0 ET_c for 100 per cent Irrigation, 0.8 ET_c for 80 per cent Irrigation and 0.6 ET_c for 60 per cent Irrigation. The dripper lines were laid at 1.2 m apart with an emitter spacing of 40cm for discharge rates of 4 l hr^{-1}. The end plugs (caps) were fixed to all main, sub main and laterals to facilitate maintenance of the system. Baby corn seeds were hand dibbled @ 1 seed $hill^{-1}$ at a depth of 3 cm by adopting plant to plant distance of 40 cm and plant row to row spacing is 90cm. Soil samples were taken at three different depths namely 10, 20 and 30cm at regular intervals in all plots. Moisture content was determined by gravimetric

Table 1. Physical properties of soil in the experimental field

Particulars	Value
Mechanical analysis	
a) Sand (%)	59.73
b) Silt (%)	15.17
c) Clay (%)	25.10
Texture	Sandy loam
Bulk density (g cm^{-3})	1.48
Field capacity on volume basis (%)	28.2
Permanent wilting point on volume basis (%)	14.1
Saturation point (%)	40.8
Hydraulic conductivity (cm hr^{-1})	7.1

method, the samples are oven dried for 24 hr at 105^0C.

$$\text{Moisture content (\%)} = \frac{\text{Weight of wet soil – Weight of dry soil}}{\text{Weight of dry soil}} \times 100$$

The baby corn crop was harvested after 70days two rows either side on the lateral in each plot were harvested. Plant height, root length and width, Number of baby corns recorded, yield and water use efficiency. The total yield of baby corn for different experimental plots was weighed separately from all plots.

Water use efficiency: It includes the use of water stored in the soil and rainfall during the growing season.

$$\text{Water use efficiency (kg ha}^{-1}\text{ mm}^{-1}\text{)} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Water applied (mm)}}$$

RESULTS AND DISCUSSION

Growth parameters: The plant height with 1.0ET_c of irrigation application was 200 cm. Optimum moisture with application of full irrigation water might have aided the plants to increase in plant height. Lowest plant height was recorded with 0.6 ET_c of water application. This clearly indicates the sensitivity of crop to soil water stress and there by its effect on growth of plant. In fully irrigated plots with optimum discharge rates, there would be better availability of moisture during entire crop growth period which favored the growth attributes (Shankar et al 2008).

The longest root length and width was in 1.0 ET_c (Table 2) both daily and alternate day irrigation. This is due to application of water with drip system and the root distribution pattern is mainly concentrated under and beside the laterals. The reduced availability of water in 0.6ET_c resulted in reduction in root length. There is a significant decrease in root width because of limited availability of the water at shallow depth due to drip. It is well known that the water application regime and water distribution pattern in the soil affect the pattern of root system development. **Number of baby corns:** The number of baby corns varied in different irrigation. The 1.0 ET_c irrigation treatment shown more baby corns (461) followed by 0.8 ET_c and 0.6 ET_c (Table 3). The baby corns recorded were highest in daily irrigation compared to alternate day irrigation (Fig. 1).

Yield: The yield in 1 ET_c, 0.8 ET_c, 0.6 ET_c were 5923, 5466 and 3010 kg ha^{-1} respectively (Table 3). The maximum yield in 0.6 ET_c might be due to adequate application of water at frequent intervals near the root zone and where as in alternate day irrigation yield was lowest.

Water use efficiency: Water use efficiency can be increased either by increasing the yield or by reducing the quantity of water applied. Total amount of water applied was 246.47 mm in meeting the full irrigation requirement and daily interval.

Even though there is an increase in yield in 1.0 ET_c compared 0.8ETc irrigation treatment but the water use efficiency is more in the second treatment in which there is 20 per cent saving of water. Hence, the irrigation scheduling of applying 0.8 ETc irrigation water at daily interval can be recommended for increasing productivity of baby corn. It was highest in 1.0 ET_c irrigation i.e 17.0 kg ha^{-1}-mm and lowest in 0.6ET_c (Table 4 and Fig. 2, 3). The WUE is high in daily irrigation interval compared to alternate day irrigation in all treatments due to availability of optimum moisture content in the root zone throughout the crop duration. The water use

Table 2. Variation of root length and width in daily and alternate irrigation treatments

Type of irrigation treatment	Daily irrigation		Alternate day irrigation	
	Root length (cm)	Root width (cm)	Root length (cm)	Root width (cm)
1.0 ET_c	14.9	8.1	14	5.80
0.8 ET_c	12.2	10	11.8	5.50
0.6 ET_c	11.2	6.9	10.45	5.23

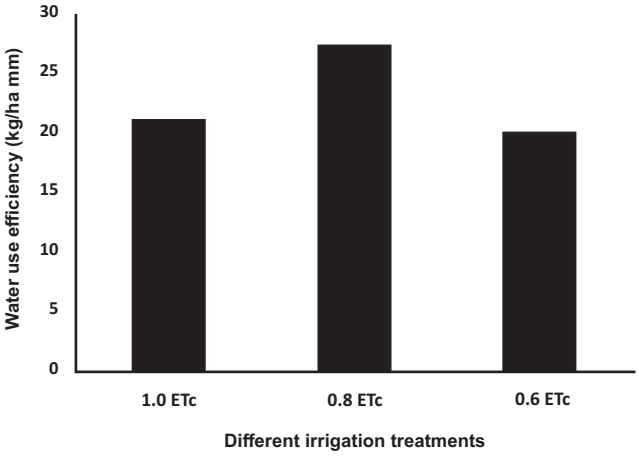

Fig. 2. Irrigation vs water use efficiency in daily irrigation

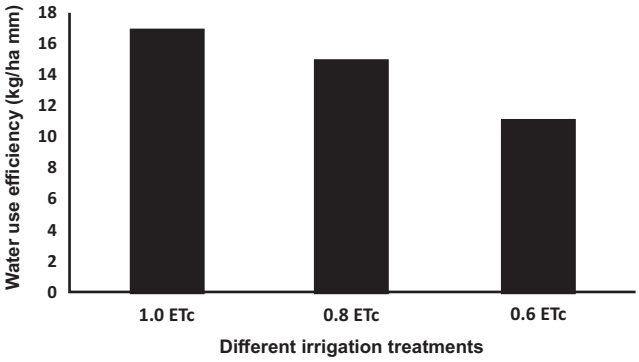

Fig. 3. Irrigation vs water use efficiency in alternate day irrigation

efficiency (WUE) was increased with decrease in irrigation. Water use efficiency can be increased with controlled water delivery. It ensures greater utilization of applied water for ET the measures for this include on-farm water management practices and improving the conveyance of water.

Moisture content of baby corn at different depths: In daily treatment moisture content was highest in $1ET_c$ at 10 cm depth compared to 20 and 30 cm depth of root zone of baby corn. Since, the water is applied through drip; the moisture availability is more at 10 cm shallow depth. With the increase in the crop growth stage, the moisture content was gradually decreased (Fig. 5 & 6). This may be due to increased

Table 3. The number of baby corns recorded in daily and alternate irrigation

Type of irrigation treatment	Daily irrigation treatment			Alternate day irrigation treatment	
	Yield (kg ha^{-1})	Amount of water applied (mm)	Water use efficiency (kg ha^{-1}-mm)	Yield (kg ha^{-1})	Water use efficiency (kg ha^{-1}-mm)
1 ET_c	5923	246.47	21.47	4198	17.032
0.8 ET_c	5466	197.17	27.7	2914	14.77
0.6 ET_c	3010	147.88	20.35	1630	11.0

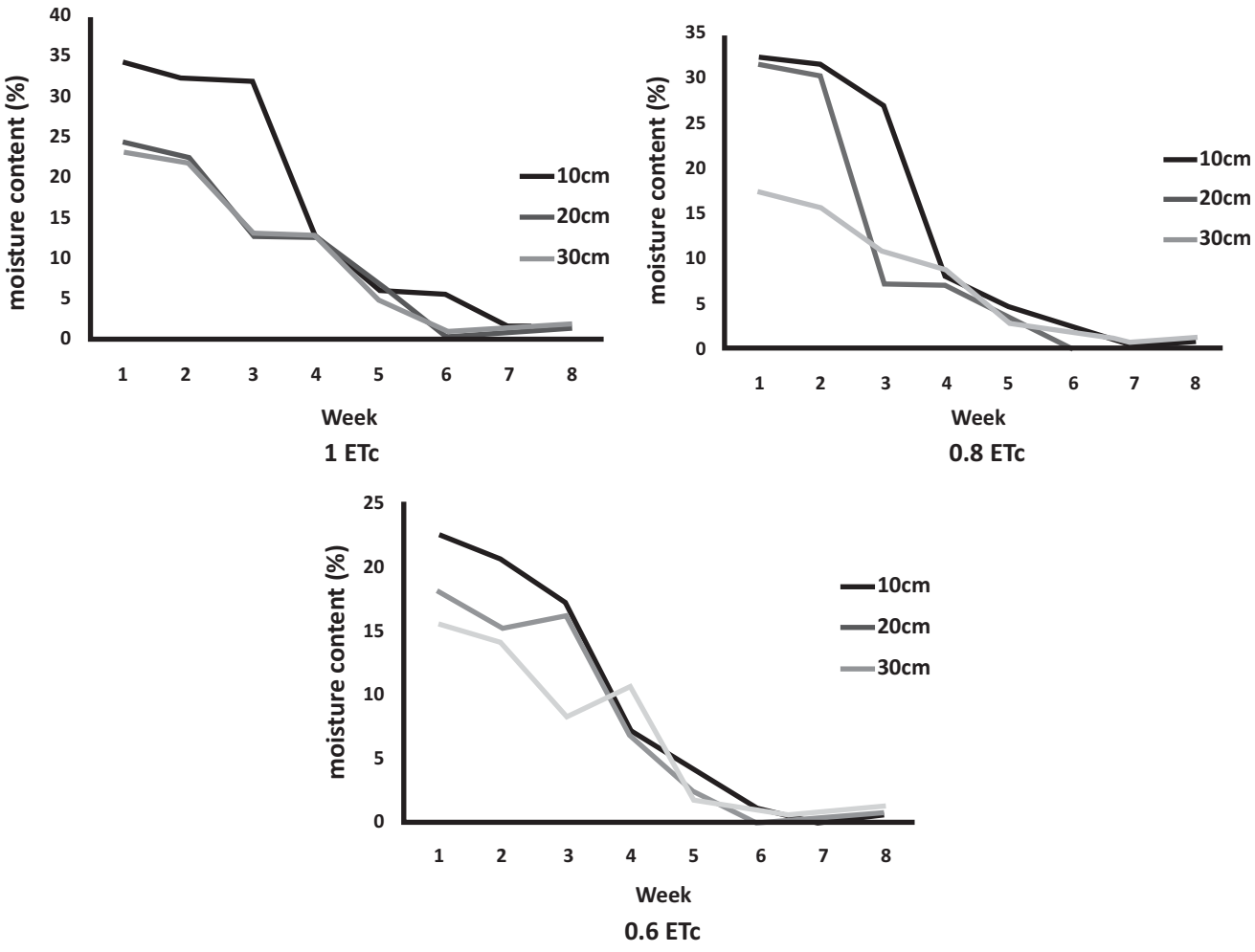

Fig. 4. Moisture content at different depths in various in daily irrigation

requirement of water and as summer progressed towards the end of growing season evaporation losses increased. In 0.8 ET_c, there was no significant variation between different depths of soil moisture content. Due to summer, the extraction of soil moisture was similar at 10cm, 20 cm and 30 cm depth below the drip system (Fig. 4 & 5). In 0.6 ET_c, the moisture content even in the initial stage of crop growth was less than field capacity. The moisture content was lowest in 30 cm depth. The moisture content distribution at 10, 20 and 30 cm depth was almost similar from the beginning of development stage. This clearly indicates the degree soil moisture loss depends on availability of water (Mthandi et al 2013). Moisture content of baby corn at different depths in alternate day irrigation was highest in 10 cm depth due full application of water in alternative days. It was lowest for 30 cm depth (Fig. 6). Moisture content of baby corn at different depths in 0.8 ET_c alternate day irrigation there is little variation in soil moisture content from the 6th week of crop growth. Even in the initial stage of crop growth, the moisture content in the root zone at different depths were less that observed for the same volume of water applied at daily interval. In 0.6 ET_c during the late stage of crop period the moisture content at different depths was decreased. Moisture content was lowest at 30 cm depth of soil.

Correlation between different irrigation treatments and growth parameters of baby corn: Correlation among all parameters was positive (Table 4). The highest positive correlation was observed between no. of baby corns (r = 0.974) and yield, followed by amount of water applied (r = 0.953) and root length. There is least correlation between water use efficiency and amount of water applied.

Interactions between different irrigation treatments and growth parameters of baby corn: The interaction effect showed that highest water use efficiency was in 0.8ET_c (27.6 kg ha^{-1}-mm) daily irrigation treatment, maximum plant height was in 1 ET_c daily irrigation (Table 4). Similarly maximum root

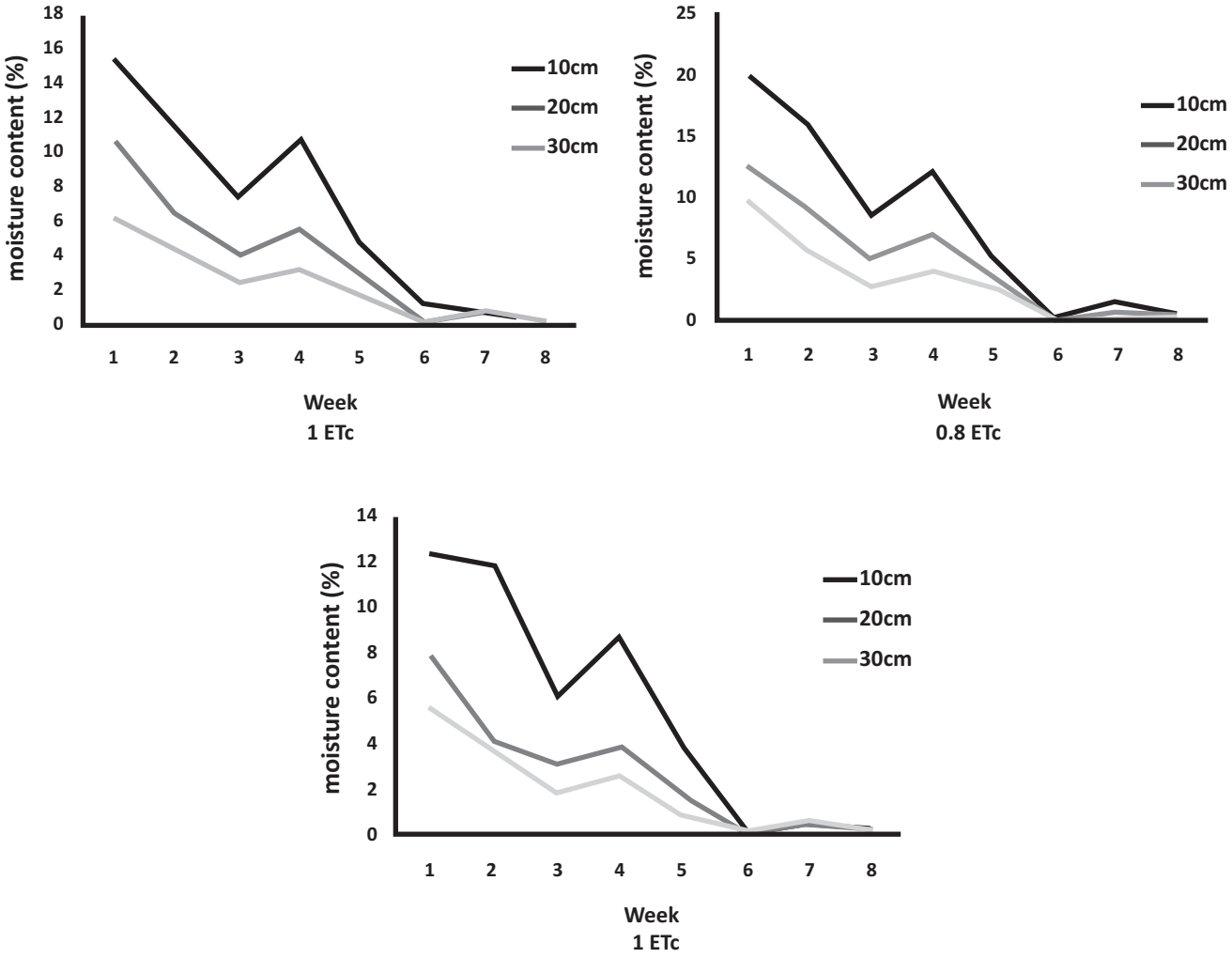

Fig 5. Moisture content of baby corn at different depths in alternate day irrigation

Table 4. Correlation between different irrigation treatments and their parameters of baby corn

Parameters	Amount of water applied	Plant height	Root length	Root width	No. of baby corns	Yield	Water use efficiency
Amount of water applied	1						
Plant height	0.854	1					
Root length	0.953	0.886	1				
Root width	0.214	0.592	0.300	1			
No. of baby corns	0.644	0.762	0.736	0.749	1		
Yield	0.665	0.824	0.738	0.830	0.974	1	
Water use efficiency	0.129	0.397	0.258	0.885	0.830	0.816	1

Table 5. Interactions between irrigation levels and growth parameters of baby corn

Irrigation treatments		Plant growth parameters					
		Plant height (cm)	Root length (cm)	Root width (cm)	No. of Baby corns	Yield (t ha^{-1})	Water use efficiency (kg ha^{-1}-mm)
Daily	1.0 ET_c	200	14.9	8	461	5.29	21.4
	0.8 ET_c	180	12.2	10	449	5.45	27.6
	0.6 ET_c	150	11.2	6.9	382	3.6	24.3
Alternate	1.0 ET_c	173	14	5.8	401	4.3	17.44
	0.8 ET_c	165	11.8	5.5	319	2.9	14.5
	0.6 ET_c	149	10.45	5.23	194	1.62	10.95
Mean		169.5	12.42	6.92	367.66	3.76	19.39
Standard error		0.079	0.69	0.75	40.48	0.62	2.53
Confidence level		0.20	1.78	1.93	104.07	1.58	6.51

length and width were in 1 ET_c and lowest yield, plant height, root length and width were in 0.6 ET_c alternate day irrigation. Mean of number of baby corns in both daily and alternate irrigation was 367.66.

CONCLUSIONS

The yield was maximum in 1.0 ET_c daily irrigation because of meeting total demand of crop water requirement at daily interval which maintained the optimum moisture in root zone. 1.0 ET_c irrigation was more effective than other treatments for baby corn in sandy soil because it had higher yield. The 0.8ET_c irrigation has highest water use efficiency there is 20 per cent saving of water. Hence, the irrigation scheduling of applying 0.8 ET_c irrigation water at daily interval can be recommended for increasing productivity of baby corn. The soil moisture content was maximum at shallow depth of baby corn. The soil moisture distribution below root zone clearly indicated the amount of water applied. Drip system delivers water at a very low volume and hence adequate moisture will be available for shallow depth. Hence, crops should be planned keeping that point in view in addition to flow rate and other parameters.

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Assessment on the Water Quality of Tsurang River, Nagaland Affected by Coal Mining Drainage

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Abstract: The present study aims to investigate the affects of coal mining in the water quality of Tsurang river. Water samples were collected from September, 2018 to August, 2019 covering the four seasons; winter, spring, summer and autumn. The physico-chemical parameter values recorded are temperature (20-23.6^{O}C), pH (3.3-6.3) TDS (113-177.6 mg l^{-1}), DO (4.5-8.3 mg l^{-1}), BOD (2.2-4.1 mg l^{-1}), chloride (34-74.7 mg l^{-1}), potassium (3.2-9.1 mg l^{-1}), conductivity (181.6-230.4 µS cm^{-1}), total hardness (86-135.3 mg l^{-1}), calcium hardness (40.8-62.6 mg l^{-1}), magnesium hardness (9.5-17.3 mg l^{-1}), alkalinity (125-208.3 mg l^{-1}), phosphorus (0.23-0.45 mg l^{-1}), nitrate (2.53-4.7 mg l^{-1}), sulphate (174.3-293.3 mg l^{-1}) and free CO_2 (8.8-25.6 mg l^{-1}). The present study revealed that sulphate in spring, summer and autumn, pH and BOD throughout the four seasons, alkalinity in winter (S3) and free CO_2 in summer (S1, S2) were not in the drinking water permissible limit given by BIS (2012) and WHO (2017).

***Keywords*:** Coal mining, Water quality, Tsurang river, Permissible limit

Coal mining and its related hazardous issues on environment is a trend that coincides with unscientific excavation and inapt measures. Starting from excavation to loading and unloading, coal produces dusts and radiation which have a direct negative impact on the ecology, biodiversity, and health of the surrounding communities (Chaulya et al 2011). The long-term and continuous mining of coal deteriorates the natural environment as it sheds negative influences on the nearby water bodies and soil (Guha 2014). Water pollution from the disposal of wastewater is one of several problematic environmental issues associated with coal mining (Tiwary 2000). The primary cause of degradation of water quality and the declining trend of biodiversity in the water bodies of the mining area is attributed to the acid mine drainage, which makes the water highly acidic and rich in heavy metal concentration. In India, Gupta et al (2000) and Singh et al (2012) reported that mine water quality deteriorates over time due to alteration of the water chemistry. Northeast India, Swer and Singh (2004) has worked at Jaintia coal fields and revealed that the water bodies are affected by AMD, low pH, high conductivity, high concentration of sulphates, iron and toxic heavy metals, low DO and high BOD which characterize the degradation of water quality. Nagaland, a state in the northeast India is situated along the Indo-Myanmar biodiversity hotspot, lies between latitude of 25^{0} 06´ N and 27^{0} 04´ N and longitude of 93^{0} 20´ E and 95^{0} 15´ E. For decades, open cast coal mining in an unscientific manner has been taking place in large scale, along the adjoining hill slopes and plains of Changki in Mokokchung district. There have been major destructive phenomena due to coal mining in the streams, rivers and the adjacent forests polluting the ecosystem. The Tsurang river which arises from the west of Chungliyimsen village passing through the Tsurangkong range adjoining Changki and Longtho receives the effluents of the drainages from the coal mines. This can have adverse affect on the water quality which in turn can be detrimental causing health hazards. Moreover, the river water is used for irrigation purpose and fulfils the demands of water shortage to a whole lot of population living alongside the river. Therefore, there is an urgent need to emphasize about the river water physico-chemical properties. Hence, the present study has been taken up with a view to estimate the changes in the water quality parameters affected by coal mining drainage at Tsurang river and compare the results with drinking water permissible limit given by BIS (2012) and WHO (2017).

MATERIAL AND METHODS

Sampling and analysis: Water samples were collected at three stations (S1, S2 and S3) of Tsurang river from September, 2018 to August, 2019 covering the four seasons of winter, spring, summer and autumn (Fig. 1.). Physico-chemical parameters such as temperature, free CO_2 and total dissolved solids were analysed at the sampling spot. Further, the river water was collected in Tarsons water bottles and taken to the laboratory to estimate parameters likePO_4-P following Ammonium molybdate using Spectrophotometric method, potassium (flame photometer), sulphate by turbidimetric method, NO_3-N by Brucine method, pH,

alkalinity, hardness, dissolved oxygen (DO) by Winklers' titrimetric method, biochemical oxygen demand (BOD), chloride following standard protocols given by Trivedi and Goel (1986) and A.P.H.A (2012).

RESULTS AND DISCUSSIONS

Free Carbon dioxide: The free CO_2 ranges from 8.8 to 25.6 mg l^{-1}, the highest being recorded at summer (S1) and lowest at winter (S1). The values of free CO_2 in summer (S1, S2) were beyond the permissible limits given by WHO (2017). The runoff litter waste from the forest along with agricultural, domestic sewages into the river during rainy summer seasons and the rise in temperature elevates rate of microbial respiration and decomposition of organic matter which tends to increase free CO_2 in water. Low free CO_2in water during winter is due to inactive microbial activity as organic contents and water temperature decreases.

Water temperature: The water temperature was highest in summer at S2 (23.6^{0}C) and lowest in winter at S1 (20^{0}C). With the rise in atmospheric temperature during summer, water temperature also rises. The fluctuation of temperature in the river water depends on the season, geographiclocation, sampling time and temperature of effluents entering the river (Ahipathy and Puttaiah 2006). The temperature of river water is also governed by the interaction of natural environmental processes including air temperature, solar radiation, conduction from soil etc, as well as anthropogenic disturbances of the natural thermal regime by deforestation Benyahya 2008).

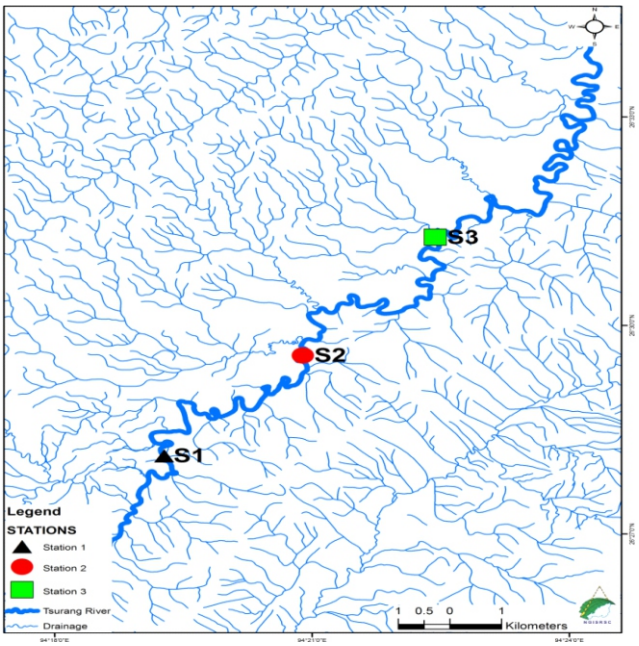

Fig. 1. Drainage area map at the three sampling stations of Tsurang river

Total dissolved solids: The highest TDS was in autumn S3 (177.6 mg l^{-1}) and lowest in winter S1 (113 mg l^{-1}). The dissolved combined contents of organic and inorganic substances including ionized, molecular or micro-granular like colloidal sol in a suspended form in the river increases TDS during the post monsoon and autumn season.

pH: The observed range of pH (3.3-6.3) was not in the permissible limit given by BIS (2012) and WHO (2017). The highest pH was 6.3 at S3 in winter and minimum 3.3 at S1 in summer. The river water was acidic throughout the four seasons. Sulfates combine with water molecules and form sulfuric acid which is mainly responsible for acidity of the coal mining contaminated water (Swer and Singh 2004). The coal mining drainages that flow into the river during the rainy-summer seasons carry sulphates and its associated salts which attributes to low pH of the water.

Dissolved Oxygen (D.O): The maximum DO was in winter at S1 (8.3 mg l^{-1}) and minimum in summer S1 (4.5 mg l^{-1}). Warmer surface water requires less dissolved oxygen to attain 100 per cent air saturation compare to cooler water. Hence, temperatures have direct influence over the concentration of DO in water, higher temperature at summer season influenced low DO and low temperature in winter accumulates higher DO.

Biochemical oxygen demand (B.O.D): BOD ranges between (2.2- 4.1 mg l^{-1}), which were beyond the permissible limit given by BIS (2012) and WHO (2017). The BOD was lowest at S1 in summer (2.2 mg l^{-1}) and highest in autumn at S3 (4.1 mg l^{-1}). The recorded values of BOD indicate the presence of high organic waste in the river and active microbial respiration rate throughout the year.

Chloride: The chloride value ranges from 34 to 74.7 mg l^{-1}. The maximum was observed at S3 (autumn) and minimum at S1 (winter). Runoff sewages from agricultural and domestic household waste increase chloride in the river water during the autumn or post-monsoon season. Raised value of chloride in water is due to mixing of municipal sewages and domestic waste in river water (Singh and Shrivastava 2015).

Potassium: The minimum potassium value was 3.2 mg l^{-1} at S1 during winter and the maximum was 9.1 mg l^{-1}at S3 during summer. The increase of potassium in the river water at summer can be attributed due to leaching of fertilizers from agricultural fields which are situated along the banks of the river.

Conductivity: The minimum value was 181.6 µS cm^{-1} from winter at S1 and maximum of 230.4 µS cm^{-1} at S1 during summer. The more the value of electrical conductivity indicates higher concentration of dissolved salts in river water. The rainy-summer seasons brings runoff waste into

Table 1. Seasonal variations (mean±S.D) in physico-chemical properties of water at the three stations of Tsurang river

Parameters	Winter			Spring			Summer			Autumn			Range	WHO (2017)	BIS (2012)
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3			
Free CO_2 (mg l^{-1})	8.8±2.2	9.53±3.3	11.7±3.3	15.4±4.5	14.66±4.5	13.2±2.2	25.6±2.5	22±2.2	17.6±2.2	19.±4.4	19.06±3.36	20.5±1.27	8.8-25.6	22	NA
Temperature (^{0}C)	20±2	20.6±2.51	20.3±3	21±1.73	22±1.73	22.3±1.52	22.6±0.57	23.6±0.57	23±1	21.6±1.52	22.6±1.5	23±1	20-23.6	NA	NA
TDS (mg l^{-1})	113.3±9.71	123.6±13.2	139±16.52	123.6±17	141±18.33	141.3±19.08	148±10	158.3±10	172.3±4.5	147.3±4.5	161±5.56	177.6±6.11	113-177.6	600	500
pH	6.1±1.05	6.1±1	6.3±0.95	5.8±0.77	6±0.81	6.03±0.7	3.3±0.55	3.6±0.72	3.6±0.6	4.13±0.6	4.4±0.5	4.5±0.52	3.3-6.3	6.5-8.5	6.5-8.5
DO (mg l^{-1})	8.33±0.75	8.01±0.9	7.5±1.21	6.9±0.94	6.8±0.52	6.4±0.5	4.5±0.75	4.6±0.35	4.8±0.11	6.2±0.61	6±0.2	6.4±0.41	4.5-8.3	NA	4
BOD (mg l^{-1}l)	3.5±0.30	3.2±0.34	3.6±0.2	3.6±0.41	3.1±0.64	3.1±0.25	2.2±0.11	2.5±0.50	2.9±0.65	3.4±0.46	3.4±0.41	4.1±0.23	2.2-4.1	2	3
Chloride (mg l^{-1})	34±7.56	37.8±6.41	43.3±8.2	34.5±3.5	36.4±2.9	39.7±1.4	56.3±6.3	58.6±6.7	64.3±7.8	66.5±4.5	70±5.71	74.7±5.92	34-74.7	250	250
Potassium (mg l^{-1})	3.2±1.1	3.4±0.63	4±0.9	5.3±1.3	5.1±0.92	6.1±1.17	8.1±0.88	8.6±0.66	9.1±0.65	6.7±0.66	7±1.35	7.7±1.1	3.2-9.1	NA	NA
Conductivity (µS cm^{-1})	181.6±9.86	186.9±3.4	182.3±11.5	194.7±5.98	183.8±13.9	178.5±9.39	230.4±18.02	218.6±15.02	206.7±13.9	206±19	194.8±20.4	188.6±16.25	181.6-230.4	NA	NA
Total hardness (mg l^{-1})	135.3±8.08	128±17.3	133.3±10.2	112±11.1	112.6±14.04	122±10	92.6±20.03	102±22	102±18.3	90.6±6.4	86±8.7	88.6±9.86	86-135.3	200	200
Calcium hardness (mg l^{-1})	58±2.01	62.6±5.03	61.9±12.1	47.2±12	48.6±13.6	54.6±14.2	44±15.9	44.6±14.03	51.9±5.24	40.8±11.64	42.3±6.85	49.3±7.56	40.8-62.6	75	75
Magnesium hardness (mg l^{-1})	15.3±2.34	15.8±3.34	17.3±1.12	15.7±0.28	15.5±1.26	15.6±1.32	11.8±0,98	13.9±2.02	12.1±3.2	10.5±0.81	10.6±0.81	9.5±0.76	9.5-17.3	50	30
Alkalinity (mg l^{-1})	188.3±18.92	195±18.02	208.3±18.92	186.6±16.07	195±5	203.3±12.5	150±18.02	158.3±16.07	168.3±12.5	125±5	138.3±5.7	146.6±7.6	125-208.3	200	200
Phosphorus (mg l^{-1})	0.23±0.03	0.28±0.035	0.26±0.003	0.23±0.037	0.27±0.075	0.3±0.075	0.37±0.026	0.45±0.043	0.43±0.020	0.31±0.035	0.42±0.047	0.39±0.047	0.23-0.45	NA	NA
Sulphate (mg l^{-1})	199±25.05	184.3±26.2	174.3±23.28	201±17.34	191.6±16.5	184.3±22.1	293.3±16.8	282.3±16.8	264±11	271.3±16.8	251±8.18	239±7	174.3-293.3	250	200
Nitrate (mg l^{-1})	2.53±0.66	3.1±0.6	2.9±0.65	2.8±0.5	3.1±0.6	3.4±0.56	4.1±0.36	4.7±0.36	4.4±0.51	3.7±0.53	4±0.66	4.1±0.25	2.53-4.7	50	45

the river, this includes salts of various chemicals, dissolved solids, trace metals, colloidal substances and ions which increases conductivity.

Total hardness: Total hardness ranges from 8.6 mg l^{-1} at S1 during autumn to 135.3 mg l^{-1} at S1 during winter Rise in water hardness can be attributed due to domestic sewage and industrial effluents into the river water as reported by Radhakrishnan et al (2007). The raised value of calcium and magnesium hardness in the river water during winter has direct impact in the increase of total hardness.

Calcium hardness: The maximum calcium hardness was from S1 of autumn (40.8 mg l^{-1}) and minimum at S2 of winter (62.6 mg l^{-1}). Surface runoff limestone deposits, weathering of rocks and domestic sewages increases calcium concentration in water which also tends to increase total hardness. Calcium hardness in all the water samples from the four seasons was within the desirable limit.

Magnesium hardness: Magnesium hardness was lowest in Autumn S3 (9.5 mg l^{-1}) and highest in winter S3 (17.3 mg l^{-1}). Domestic sewages containing magnesium salts can elevate magnesium hardness which in turn can raise total hardness of water. Magnesium hardness values of all the water samples from the four seasons were in the permissible limit given by BIS (2012) and WHO (2017).

Total alkalinity: Total alkalinity fluctuated from 125 mg l^{-1} (S1) to 208.3 mg l^{-1} (S3) during winter and autumn. The total alkalinity at S3 during winter was beyond the permissible limit given by BIS (2012) and WHO (2017). Increase of alkalinity during winter is caused by carbonates, bicarbonates, OH ions, silicates, borates and phosphates from municipal and household waste.

Inorganic phosphorus: The concentration of phosphorus was high in summer at S2 (0.45 mg l^{-1}) and low in winter at S1 (0.23 mg l^{-1}). The runoff waste from agricultural fields situated alongside the river banks where fertilizers are extensively used for irrigation can be responsible for the increase of phosphorus during summer seasons.

Sulphate: The highest concentration of sulphate in the river water was during the summer season at S1 (293.3 mg l^{-1}) and the lowest in winter at S3 (174.3 mg l^{-1}). The high concentration of sulphates is mainly due to presence of iron sulphide in coal and rocks and its reaction with water and oxygen (Swer and Sing 2004). As the pyrite wastes from coal mines are chemically broken down, ions of sulphate are introduced in runoff water which is responsible for the rise in sulphate concentration during the rainy-summer seasons. The value of sulphate in spring (S1), summer and autumn was beyond the permissible limit given by BIS (2012) and WHO (2017).

Nitrate-nitrogen: The nitrate was lowest in winter at S1 (2.53 mg l^{-1}) and highest in summer at S2 (4.7 mg l^{-1}). The rise of nitrate concentration in summer may be due to influx of nitrogen rich floodwater that brings large amount of contaminated sewages from agricultural fields. Meanwhile the fixing of atmospheric nitrogen into nitrates by the nitrogen fixing microorganism is also a significant contributor to nitrates in water.

CONCLUSION

The present study conducted on various water physico-chemical parameters of Tsurang river has revealed that the water quality is degraded and not potable. This indicates serious detrimental condition for aquatic life as well as humans depending on the availability of the river water. The flow of coal mining drainages and domestic agricultural sewages into the river has deteriorated the water quality. During the investigation it has been observed that the range of sulphate, free CO_2, BOD, and pH in particulars were not in the permissible limits. However, further research on regards to contamination of water catchments will require characterization of heavy metals to check the toxicity level of the river water. An urgent necessary step will be to investigate the microbial vitality and activity in water systems. Therefore, the discharged of coal mining effluents should be treated and other wastes into the Tsurang river should be controlled and enforced by laws.

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Physico-chemical Properties of Soil Affected by Different Sources of Nutrients

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Abstract: The effect of different sources of nutrients on physico-chemical soil properties in sorghum sudan grass hybrid–oat cropping system was observed from *Kharif* 2017 to *Rabi* 2018-19. The soil pH remained on the acidic spectrum with application of FYM @10 t ha^{-1} + *Azotobacter* + PSB and 100 per cent of recommended fertilizer. Bulk density was not significantly influenced by FYM and biofertilizers and fertilizers application. An increase in soil organic carbon, biomass carbon and available NPK was observed with the application of FYM @10 t ha^{-1} + *Azotobacter* + PSB and 100 per cent recommended fertilizer over the initial status. Combined application of FYM @10 t ha^{-1} and *Azotobacter* + PSB while remaining at par with FYM @10 t ha^{-1} registered significantly higher available NPK content of soil than *Azotobacter* + PSB. Application of 100 per cent of recommended fertilizer had significantly higher available NPK content than control *i.e.* no fertilizer.

Keywords: FYM and biofertilizers, Fertilizer levels, Sorghum sudan grass hybrid-oat

Forages are the mainstay of livestock and the quality fodder is prerequisite for success of livestock industry which largely depends on the supply of sufficient quantity of nutritious green forages. Country faces a vast deficit of 35.6 per cent of green fodder, 10.9 per cent of dry fodder and 44 per cent of concentrates (Anonymous 2013). Sorghum sudan grass is becoming very popular among the farmers due to low levels of HCN (prussic acid) compared to sorghum. Moreover, it is highly suitable under predominantly rainfed conditions of Himachal Pradesh. Oat is the most important cereal forage crop growing during winter season under irrigated and rainfed conditions. Both these forage crops are quick growing, better palatability, succulent, and nutritious having luxuriant growth. Use of high analysis fertilizers in imbalance and indiscriminate manner had developed many problems of soil organic matter, increase in soil salinity, sodicity, soil pollutants and hazards of pests and diseases (Chakraborti and Singh 2004). The higher doses of inorganic fertilizers are applied in order to meet out the fodder demand which is uneconomical for fodder production and continuous use of high amount of chemical fertilizers had deleterious effect leading to decline in productivity due to limitation of one or more micronutrients. Judicious use of nutrients in forages may improve the yield and quality of fodder and optimize its production cost (Gupta et al 2005). The cost of chemical fertilizers is very high, it becomes imperative to substitute chemical fertilizers by some other available sources of organic manures *viz.* farm yard manure and bio-fertilizers in an integrated manner to meet the crop requirement, to maintain soil health and augment the efficiency of nutrients. Keeping these aspects in view, the present study was undertaken to study the effect of integrated use of organic manures and biofertilizers and inorganic fertilizers alone on physicochemical properties of soil.

MATERIAL AND METHODS

The field experiment was conducted during the rainy (*Kharif*) and winter (*Rabi*) seasons of 2017-18 and 2018-19 at Research Farm, Department of Agronomy, Forages and Grassland Management, CSK HPKV, Palampur, Kangra, Himachal Pradesh. The climate is mild temperate with annual rainfall of 1500-2500 mm per annum and average of 2000 mm. The crop sequence received total annual rainfall of 2463.7 mm in 2017-18 and 2668.8 mm in 2018-19 during the crop growth period. Soil samples from 0-15 cm soil depth were collected randomly from different spots and composite soil sample was prepared before the commencement of experiment and analysed for physico-chemical properties of soil. The soil of the region was silty clay loam in texture and acidic with a pH of 5.67. It was medium in organic carbon (0.67 %), available phosphorous (17.6 kg ha^{-1}) and available potassium (206 kg ha^{-1}) and low in available nitrogen (242 kg ha^{-1}).

The experiment was laid out in a factorial randomized block design with three replications. The treatments consisted of four levels of FYM and biofertilizers (control, FYM @ 10 t ha^{-1}, *Azotobacter*+ PSB, O3-FYM @ 10 t ha^{-1} + *Azotobacter* + PSB) and four levels of fertilizers (control, 50% NPK 75 % NPK 100% NPK). FYM was applied at the

time of land preparation as per the treatments. The seed was treated with the culture of *Azotobacter* and PSB @20g kg^{-1} seed prior to the sowing using 10 per cent sugar syrup. The crops were sown in a plot size of 3.60 × 4.50 m^2. Sorghum sudan grass (Red Rasili) and oat (Palampur-1) were sown using seed rates of 45 and 100 kg ha^{-1} with a spacing of 30 and 22.5 cm (R×R) spacing, respectively. The required quantity of seed for experimental area was worked @ 45 and 100 kg ha^{-1} for sorghum sudan grass hybrid and oat, respectively. The recommended dose of inorganic fertilizer was 90:60:30 and 120:60:40 kg N, P_2O_5, K_2O kg $ha^{-1}$for sorghum sudan grass hybrid and oat, respectively. Nitrogen, phosphorous and potassium were applied through urea, single super phosphate and muriate of potash, respectively. In both the crops, half dose of N and whole of P and K was applied at the time of sowing. The remaining 1/4th dose was top dressed after 30-35 days of sowing of crop and remaining 1/4th was applied after first cut. Treatment wise soil samples were taken from 0-15 cm soil depth at the end of experiment after two years and analysed for same physico-chemical properties. Soil pH was determined in the soil: water (1:2.5) by expand pH meter (Jackson 1967). Organic carbon was determined by method of Walkley and Black (1934). The available N, P and K content in soil was estimated by using standard methods.

RESULTS AND DISCUSSION

Soil pH was not influenced significantly by FYM and biofertilizers and fertilizer levels (Table 1) and remained in the acidic spectrum. The bulk density was also not significantly influenced by FYM and biofertilizers and fertilizer levels. The increase in soil organic carbon and soil biomass carbon content was observed in all the treatments over the initial status. Application of FYM @10 t ha^{-1}+ *Azotobacter* + PSB and FYM @10 t ha^{-1} were at par with each other but was significantly better than rest of the treatments in terms of organic carbon. The effect of 50, 75 and 100 per cent recommended fertilizer was same giving significantly higher organic carbon content than no fertilizer *i.e.* control. FYM as organic manure might resulted in organic carbon build up in soil and created favourable condition for microbial growth and carbon build up, hence ultimate improvement in soil organic carbon and microbial biomass carbon in all treatments involving FYM application. Chandrakala (2008) also observed improvement in soil organic carbon with addition of FYM after the completion of crop season. Marked variations were observed in the amount of soil biomass carbon at the end of two years. The combined application of FYM @10 t $ha^{-1}$and *Azotobacter* + PSB improved the soil biomass carbon as compared to applied alone either FYM @10 t ha^{-1}or *Azotobacter* + PSB and no FYM and biofertilizers. The effect of 75 and 100 per cent recommended fertilizer also showed significantly higher biomass carbon than control. Higher biomass carbon with FYM @10 t ha^{-1} + *Azotobacter* + PSB and higher levels of fertilizer may be due to better plant growth and better root proliferation. The better root space in the rhizosphere provides more space for growth and development of microbes which ultimately resulted in more biomass carbon (Kumar 2010).

Available NPK status of soil at the expiry of experiment showed improvement in the status of soil over the initial

Table 1. Effect of different treatments on physico-chemical properties of soil

Treatments	Soil pH	Bulk density (Mg m^{-3})	Organic carbon (%)	Soil biomass carbon (µg g^{-1} soil)	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})
FYM and biofertilizers							
Control	5.68	1.32	0.67	74.96	235	15.9	199
FYM @10 t ha^{-1}	5.64	1.30	0.74	83.37	244	17.1	205
Azotobacter + PSB	5.63	1.30	0.70	81.66	239	16.9	200
FYM @10 t ha^{-1}+ *Azotobacter* + PSB	5.69	1.29	0.75	87.91	248	18.0	208
CD (p=0.05)	-	NS	0.03	3.69	8.17	0.91	7.03
Fertilizer levels							
Control	5.68	1.31	0.68	74.10	232	15.8	198
50 % RDF	5.67	1.30	0.71	81.86	240	16.2	202
75% RDF	5.66	1.31	0.73	85.04	244	17.6	204
100 % RDF	5.64	1.29	0.74	86.91	250	18.4	209
CD (p=0.05)	-	NS	0.03	3.69	8.17	0.91	7.03
Initial status	5.67	1.31	0.66	70.66	242	17.6	206

RDF- Recommended dose of fertilizer

values. Significantly higher available nitrogen, phosphorous and potassium was noted under application of FYM @10 t ha^{-1} + *Azotobacter* + PSB registering significant increase over *Azotobacter* + PSB and control but at par with the alone application of FYM @10 t ha^{-1}. Application of fertilizer also had significant effect on available nitrogen, phosphorous and potassium content of soil at the end of experiment. Application of 100 per cent recommended fertilizer had higher available nitrogen than no fertilizer *i.e.* control and 50 per cent of recommended fertilizer. However, the effect of 75 and 100 per cent of recommended fertilizer remaining at par with each other resulted in significantly higher available phosphorous than rest of the fertilizer levels. Available potassium was also influenced significantly by different fertilizer levels and the effect of 50, 75 and 100 per cent recommended fertilizer was same resulted in statistically similar available potassium content in post harvest soil. The release of nitrogen, phosphorus and potassium into the soil from the mineralization of FYM during the later stages of crop also resulted in higher values after the completion of experiment. The organic acids produced during the mineralization of the added FYM solublized the insoluble form of nutrients to the soluble form making it available to the crop as well as enhancing the available NPK content after the harvest of the crop. *Azotobacter* might have improved the N content of soil by fixing the biological-N, which takes in the rhizosphere of the plants. However, PSB might be beneficial in solubilizing the applied as well as native phosphorous, which consequently increased the available phosphorous status of soil (Sharma and Verma 2005). Similarly, the treatment with highest amount of NPK to the soil through fertilizer showed highest available NPK content in soil. Significantly lowest available NPK content was in control treatment in which no FYM and biofertilizers or no fertilizers were added. Since no NPK was added in control treatment and whatever quantity of these nutrients was removed from the soil through its uptake by crop was from the reserves present in the soil which resulted in significantly lowest available NPK after the harvest of crop. Many earlier workers reported that net soil available nitrogen, phosphorous and potassium was higher with the application of FYM + biofertilizers and 100 per cent recommended fertilizer, respectively (Barthwal et al 2013, Jat et al 2014, Kumar and Chaplot 2015, Deva 2015, Singh et al 2015).

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CONCLUSION

The application of FYM @10 t ha^{-1} + *Azotobacter* + PSB and 100 per cent of recommended fertilizers holds promise to improve the soil organic carbon, biomass carbon and NPK content in soil at the end of experiment after two years. Application of FYM @ 10 t ha^{-1} + *Azotobacter* + PSB and recommended NPK application had favourable effect on soil available N, P and K over initial status.

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Nutrient Status of Runoff Water from Rice and Wheat Fields of Ludhiana District of Indian Punjab

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Abstract: A study was undertaken to monitor the status of nitrogen (N), phosphorus (P) and potassium (K) in the runoff water from rice and wheat fields. A total 50 samples of runoff water from rice and wheat fields from different villages of Ludhiana district of Indian Punjab were collected. The analysis of collected samples indicated a significant variation in concentration of N, P and K. The highest values of N, P and K concentrations were computed to be 33.7, 5.5 and 20.0 ppm in the runoff water from rice fields, whereas 33.3, 6.5 and 20.0 ppm in the runoff water from wheat fields, respectively, which are being above permissible drinking water standards. The values of N and K concentration exceeding the permissible limit were 12 and 50 per cent of the collected water samples from rice and wheat fields respectively. Thus, the long term use of runoff water from agricultural fields for recharging groundwater aquifers without its treatment is not recommended.

Keywords: N, P, K Support vector machine (SVM), Runoff water, Rice, Wheat, Water band index

Punjab occupies about 1.57 per cent of geographical area of the country having 83 per cent of its land in agriculture compared to national average, which is only 40.4 per cent (Gupta 2009). At present, the total sown area is about 2.5 times of that during late sixties and the cropping intensity more than 190%. Out of the total cropped area of the state, 72.5 per cent area is irrigated through tube wells, 26.2% through canals and the rest 1.3 per cent by others (GoI 2019). The agriculture in the state has become intensive in terms of land, capital, energy, nutrients, agricultural inputs and water. The fertilizer consumption particularly nitrogen (N) and P_2O_5 has significantly increased in Punjab compared to the country. Punjab alone uses nearly twice of the fertilizers (N and P_2O5) used at national level. The total consumption of chemical fertilizers (NPK) has increased from 213 thousand tons (37.5 kg ha^{-1}) in 1970-71 to 1936 thousand tons (246.0 kg ha^{-1}) in 2011-12. As per GoI (2014), the national fertilizer consumption was 84.54, 33.44 and 10.36 kg respectively for N, P_2O_5 and K_2O in 2012-13. Whereas, it was 188.47, 58.67 and 3.05 kg for N, P_2O_5 and K_2O, respectively in Punjab. In Punjab, N and P_2O_5 applications were nearly 2.3 and 1.8 times of that of India in 2012-13. However, the application of potash was nearly one third of that at national level GoI (2014). Groundwater (drinking water) pollution through excessive concentrations of nitrate has become a serious challenge in Malwa region particularly in Bathinda, Faridkot and Ferozepur districts. About 95% samples of groundwater were reported to have nitrate content (Sharma et al 2016). The maximum concentration of nitrate was 90 mg l^{-1} at Bathinda. However, according to WHO (1984) and BIS (1991), the concentration of N, P and K should not be higher than 10, 5 and 12 ppm respectively.

The higher concentration (above normal) of fertilizers (N, P and K) in agricultural runoff or drainage water during past has created a potential for groundwater contamination in Punjab state. Many studies in past have highlighted the situation of groundwater contamination through agricultural chemicals. Singh (2019) has pointed out the negative impact of excessive use of agricultural fertilizers (mainly N, P, K) on fresh groundwater resources of the state. The agricultural runoff, particularly from rice and wheat fields, which is being directed in to groundwater aquifers, is contributing to contamination. Hence, it becomes of utmost importance that the water recharged from agricultural fields should be analysed for its quality before it reaches to the groundwater table. Keeping this in view, the present study was undertaken to study the N, P and K status in runoff water from agricultural fields (rice and wheat) of Ludhiana district.

MATERIAL AND METHODS

Description of study area: This study was carried out at Punjab Agricultural University, Ludhiana to investigate the status of nutrients available in runoff water from the agricultural fields of rice and wheat crops. Ludhiana district falls in central part of Indian Punjab and is bounded between latitude 30°33`` to 31°01``N and longitude 75°25`` to 76°27``E having geographical area of 3767 km^2. The climate of Ludhiana district can be classified as tropical steppe, hot and semi-arid which is mainly dry with very hot summer and cold winter except during monsoon season. The normal annual rainfall of the district is 680 mm with uneven distribution with an average value of 544 mm. The south west monsoon sets in from last week of June and withdraws in end

of September, contributes about 70-80% of annual rainfall with July and August being the wettest months. Fifty locations (different villages) were selected in Ludhiana district for collection of runoff water samples from rice and wheat fields. The water samples were collected in autoclaved bottles and the bottles were opened under sterilized conditions as per WHO guidelines on water sampling.

Laboratory analysis: The testing and analysis of collected runoff water samples were carried out in the Department of Soil Science.

Determination of nitrogen: A 0.1 per cent stock solution of practical grade chromotropic acid disodium salt (CTA) in concentrated H_2SO_4 was prepared by dissolving 1.84 g of CTA in 1 litre of reagent grade H_2SO_4 (specific gravity=1.84 g cc^{-1}). A 0.01% working solution of CTA was prepared by diluting 100 ml of the 0.1% stock solutrated H_2SO_4. The yellow CTA-NO_3 complex was developed from 3 ml aqueous aliquots of NO_{3-} samples and 7 ml of the 0.01% CTA working solution. Light absorption spectra were determined by CTA-NO_3 solutions containing final concentrations of 0, 0.5, 1, 2, 3 and 6 ppm NO_3^-N. The reference solution consisted of 3 ml of distilled water and 7 ml of CTA. These and all subsequent light absorption measurements were made with a Bausch and Lomb "Spectronic 20D+" spectrophotometer and cuvettes with 1.3 cm path lengths and 430 mu wavelength.

Determination of phosphorus: 0.1% stock solution of practical grade ascorbic acid in concentration H_2SO_4 was prepared by dissolving 1.056 g of ascorbic acid in 139 ml of reagent grade H_2SO_4 (specific gravity=1.84 g/cc). A 0.01% working solution of ascorbic acid was prepared by diluting 100 ml of the 0.1% stock solutrated H_2SO_4. The blue ascorbic acid- PO_4^{3-}-P complex was developed from 20 ml of the aqueous aliquots of PO_4^{3-} samples in 25 ml flask and 4.5 ml of the 0.01 % ascorbic acid working solution. 25 ppm solution of P diluted by 5 times. Light absorption spectra were determined by ascorbic acid- PO_4^{3-}-P solutions containing final concentrations of 0, 0.1, 0.2, 0.4, 0.6 and 0.8 ppm PO_4^{3-}-P. The reference solution consisted of 3 ml of distilled water and 7 ml of ascorbic acid. These and all subsequent light absorption measurements were made with "Spectronic 20D+" spectrophotometer and cuvettes with 1.3 cm path lengths and 760 mu wavelength.

Determination of potassium: The filter of the standard solution of potassium (10 ppm) was fed to the automizer and reading was noted which was displayed by the digital flame photometer. Air pressure was set in between 0.4 to 0.75 kg cm^{-2} by air compressor and galvanometer as 100.

RESULTS AND DISCUSSION

Concentration of N, P and K in runoff water from rice fields: The highest value of N concentration was 33.73 ppm at Brahman Majra village. The values of N concentration at Janta colony-Gillan, Jassowal, Ramgarhia colony, Paddi, Pamal and Dakha villages ranged between 10.32 and 21.55 ppm respectively (Table 1), which were found beyond the limit from drinking water standard may be due to either excessive use of nitrogen in the area or sampling of runoff water immediately after the fertilizer application. According to WHO (1984) and BIS (1991), the concentration of N should not be higher than 10 ppm in drinking water. The lowest value of N concentration was 0.1 ppm in Jaspal Bangar village, being within permissible limit. The concentration of P in water samples collected from rice fields of various villages of Ludhiana district was found to be in range of 0.04 to 5.47 ppm (Table 1) with maximum value of in runoff water of rice field from village Alamgir. The lowest value of P in rice field water sample was 0.04 ppm in Jassowal village. The concentration of K was observed to be in the range of 0.2-20 ppm (Table 1). The highest value of K concentration was 20 ppm in

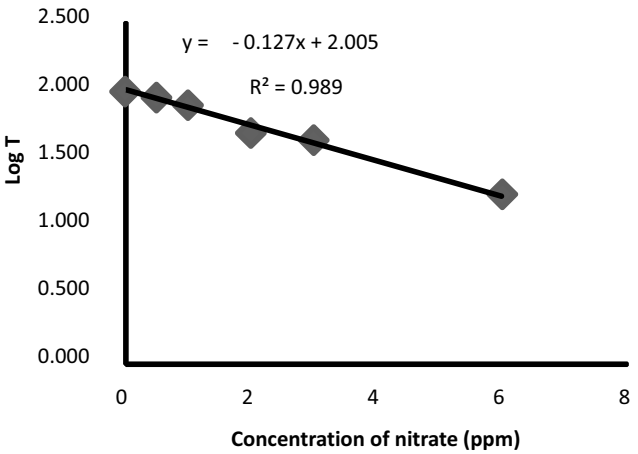

Fig. 1. Standard curve for nitrogen

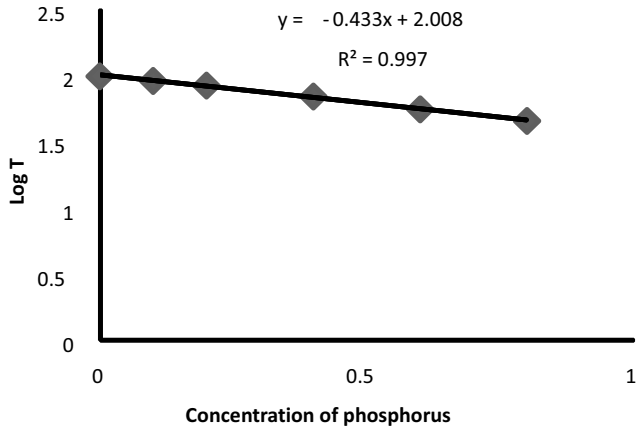

Fig. 2. Standard curve of phosphorus

Table 1. Concentration of N, P and K observed in rice fields

Name of location	N (ppm)	P (ppm)	K (ppm)
Brahman Majra, Gillan	33.73	1.52	6.00
Janta Coloney, Gillan	14.82	0.62	4.70
Rania	3.63	0.12	3.40
Bulara	0.30	3.45	1.00
Malerkotla Road, Alamgir	0.23	5.47	5.00
Sarinh	0.27	0.41	0.50
Chupki	6.83	1.61	2.00
Jassowal	10.32	0.04	4.00
GGS Road, Humayunpura	1.43	0.12	2.10
Humayunpura	0.63	2.67	15.00
Kheri	6.19	1.95	3.50
Dhandra	0.30	0.31	0.40
Muhammadpura	0.93	0.51	0.30
Near Sigma Road, JaspalBangar	0.20	1.46	5.60
JaspalBangar	0.10	0.35	0.20
Harnampura	6.00	4.11	20.00
Khanpura	0.60	0.23	4.00
Khanpura-Jassar Road	5.92	0.13	4.80
Jassar	0.83	0.54	4.30
Paddi (outskirts)	0.40	0.19	15.00
Paddi	11.10	0.05	5.30
Ayali	4.42	0.24	0.90
Near Ramgharhia Road, Jhande	9.60	0.05	6.10
Jhande	5.26	0.83	2.00
LaltoKhurd	3.10	1.13	4.10
Akalgarh	6.29	0.61	5.40
Lalto Kalan	2.33	1.20	10.30
Pamali	2.90	0.30	8.20
Pamal	14.11	2.31	11.40
Hassanpura	5.16	0.38	6.00
Bhanohad	4.93	1.00	2.70
Dakha	21.54	4.25	4.00
Kaind	5.76	0.24	3.50
Near Malerkotla Road, Sayan	3.80	1.14	9.00
Sayan	5.93	0.72	3.60
Bool	6.26	0.07	7.50
Near Delhon Road, Shankar	6.13	0.07	14.20
Rudka	6.13	0.13	0.50
Sanead Road, Gurma	6.19	1.26	18.10
Gurma	5.86	1.27	2.50
Rarha Sahib Road, Bhutta	6.13	3.77	16.00
Mukandpur	6.03	0.70	3.20
Bhutta	6.00	4.82	9.50
Kuwaddi	5.80	0.41	1.10
Kuwaddi-Jadhkhad Road, Kuwaddi	6.03	1.07	19.00
Jadhkhad	4.60	0.29	9.40
Barhundi	5.90	0.46	5.50
Aalarhu	5.50	0.77	10.50
Jandd	5.20	0.19	7.50
Delhon	5.63	1.19	4.00

Table 2. Concentration of N, P and K observed in wheat fields

Name of location	N (ppm)	P (ppm)	K (ppm)
Khanpur	2.47	0.16	19.70
Brahmanmajra	7.79	0.09	12.10
Bulara	21.11	0.24	20.00
Dangora	12.60	0.94	8.90
G.T. Road, Gillan	2.50	0.64	20.00
Sareenh-Ludhiana Road	10.55	0.67	13.90
Paddi	21.25	0.12	19.20
Malerkotla Road, Alamgir	10.21	1.05	20.00
Rania	21.70	2.37	20.00
Link Road, Rania	6.29	0.05	12.30
State Highway 11- Bulara	10.21	0.08	5.90
Kuwaddi	1.38	0.58	20.00
Chupki	15.36	0.16	20.00
Jarkhad-Dangora Road, Dangora	2.61	0.13	5.50
Aassi Kalan	18.89	0.06	08.10
Jassowal	10.10	0.34	17.40
Janta Colony, Gillan	24.62	0.12	8.40
Humayunpura	13.37	0.15	8.40
Guru Gobind Singh Road, Humayunpura	10.84	0.42	8.80
Nasaraali	2.30	5.17	20.00
Jarkhad	12.10	0.22	6.90
Latala	8.20	4.51	10.00
Sareenh	8.52	0.41	10.00
Kherhi	1.87	0.16	7.60
Sarabha	23.33	0.86	10.70
Dhandra	5.46	5.35	10.10
Mannewal	13.30	1.12	12.30
Delhon	8.86	6.53	16.10
Aalarhu	2.64	4.34	11.20
Raqba	10.38	1.35	13.40
Jandd	1.51	3.19	15.20
Barhundi	17.77	3.98	6.60
Bhutta College Road	15.10	0.99	9.10
Mukandpura	6.17	3.45	15.10
Rarha Sahib Road, Bhutta	7.05	2.85	12.60
Gurma	18.90	0.99	17.90
Rudka	0.13	0.63	13.10
Sayan	0.45	1.20	9.20
Near Delonh Road, Shankar	14.44	3.65	13.70
Near Malerkotla Road, Bool	17.35	0.27	17.50
Bool	1.38	0.16	8.30
Kaind	0.36	1.49	3.00
Mullanpur Road, Dakha	0.36	1.21	12.00
Baraich	33.32	0.25	12.10
Bhanohad	11.62	0.71	6.20
Pamali	8.48	0.44	16.10
Ayali	7.22	1.21	3.60
Lallto	0.27	1.23	1.80
LalltoKhurd	1.71	5.51	12.50
Jhande	2.06	0.57	5.40

Harnampura village. The values of K concentration were above permissible limit of limit (>12ppm). in Humayunpura, Paddi, Shankar, Sanead Road, Rarha Sahib Road, and Kuwaddi-Jadhkhad Road respectively . The lowest value of K was observed to be 0.2 in Jaspal Bangar village.

Concentration of N, P and K in runoff water from wheat fields: The highest value of N was 33.32 ppm at Braich village (Table 2). The value of N concentration ranged from 0.27 to 33.32 ppm with minimum and maximum values at Lalton and Baraich respectively. The lowest value of N concentration was 0.13 ppm in Rudka village being within permissible limit for drinking purposes. The concentration of P in water samples collected from wheat fields was in range of 0.05 to 6.53 ppm (Table 2) with the maximum value in water sample collected from the wheat field of village Delhon. The values of P concentration in water of wheat fields Nasarali, Dhandra, and Lalto-Khurd respectively were being above the permissible limits for drinking water (<5 ppm). The P content in the wheat fields were found within permissible limit from drinking water standard. The concentration of K in wheat fields was in the range of 15.2-20 ppm (Table 2). The value of K concentration was 20 ppm in 7 villages (Table 2). lowest value of K was 1.8 in Lallto village.

CONCLUSIONS

The highest concentrations of N, P and K in the runoff water were computed to be 33.73, 5.47 and 20 ppm from rice fields, whereas 33.32, 6.53 and 20 ppm from wheat fields respectively, being above permissible drinking water standards. The values of N and K concentration exceeding the permissible limit were found to be about 12 and 50% of the collected water samples from rice and wheat fields, respectively. Thus, the runoff water from agricultural fields without its treatment is not recommended for recharging groundwater aquifers.

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Fishery Policies and Acts in Present Context-Experiences from Coastal Bangladesh

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Abstract: This paper reviewed five policies and laws, which include the Protection and Conservation of Fish Act, 1950; The Marine Fisheries Ordinance, 1983; The Protection and Conservation of Fish Rules, 1985; National Fisheries Policy, 1998; and Coastal Zone Policy, 2005. Some sections of the policies and laws are seen to be damaging the fishing resources. It is high time for the Department of Fisheries (DoF), People's Republic of Bangladesh to review these fishery policies and laws as per stakeholders' recommendations.

Keywords*:* Bangladesh, Coastal fishing communities, Laws, Policies, Well-being

Bangladesh is one of the countries in Southern part of Asian continent, which is about 147,570 sq. kilometres. The beautiful country is reticulated by its vast rivers, which branched with their tributaries and distributaries, proving that Bangladesh has the world's biggest deltaic zone. Rural areas in Bangladesh turn out to be a giant reservoir of freshwater for nearly every year during monsoon season. The banks alongside the expanse of saline water within the Bay of Bengal give a golden opportunity for an enormous and extensive fisheries sector. Bangladesh integrates 710 kilometres associated an Exclusive Economic Zone (EEZ). There are stunningly different views of the coastal areas on the boundary line. The traditional read is that the land that's flooded by the high and low tides is termed the coastal belt (Islam et al 2019). Coastal zones are the areas where the land and ocean meet. There are three indicators for the determinative the landwards; influence of current waters, salinity intrusion and cyclones/storm surges. These phenomena have directly or indirectly affected a total of 19 districts of the country. In order to control the effects, these districts are cooperating with all sub-district/police station. The traditional fisheries involving fishing households (as opposed to commercial companies), use relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips close to shore for local consumption. In practice, definition varies between countries, e.g. from gleaning or a one-man canoe in poor developing countries, to more than 20-m. trawlers, seiners, or long-liners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. They are sometimes referred to as small-scale fisheries.

Small-scale fisheries or commonly known as artisanal fisheries are not the main living supply for countryside fishers. However, it is considered to be their lifestyle to fish as it is traditionally practiced from the dynamics of the social and natural setting. For obvious reasons, wherever labour suppleness during a densely-populated society in Bangladesh who is not congested by law, culture, political and other factors, and subordinate society in the country is only limited to enter open access fisheries and they have to make sure that their incomes from similar economies are not reaching above other fishermen (Deb 2009). The coastal fisher folk communities do not have their own institutional platform are able to secure their rights and basic human needs. Lives and livelihoods of fishing communities greatly depend upon production trends, shock and seasonality over that they need restricted or no management.

Considering the range and quality of interacting drivers that have an effect on fisher communities' living and impoverishment, the four-dimensional aspects of their economic condition, and therefore the distinctive setting of each community. It is impractical to assume that a one size fits in all policies, which might be simply applied across totally different contexts (Macfadyen and Corcoran 2002, Allison et al 2011). However, Bangladesh features a comprehensive set of policy instruments, laws, and fishery management approaches for protection and facilitation the development of fishing communities. Sadly, despite the fact that they have been within the fisheries sector for generations, they lack the voice once it involves policies and laws. Moreover, they are not knowledgably concerning clauses of the fisheries law though they are penalized beneath these laws (Rashid 2019). The main objective of this paper is to review relevant policies and laws of fisheries sectors in Bangladesh. An endeavour was taken to in brief articulate main options of

those policies and laws. Finally, this paper suggest for amending major clauses founded on present context that came up from series of participants' consultations, particularly with fishing communities in coastal areas in Bangladesh.

MATERIAL AND METHODS

The data were gathered, assessed and analysed through a mixed methodology, which adapted both qualitative and quantitative strategies. A total of five policies and laws i.e. The Protection and Conservation of Fish Act, 1950 (East Bengal Act XVIII of 1950); The Marine Fisheries Ordinance, 1983; The Protection and Conservation of Fish Rules, 1985; National Fisheries Policy, 1998; and Coastal Zone Policy, 2005 were reviewed. Community Development Centre (CODEC), a non-governmental organization (NGO) that was initiated by Danish International Development Agency (DANIDA) in 1985 and dealing in coastal belt of Bangladesh, organized thirty-two consultation workshops in 2018 at Sub-District, District, and Divisional level. A total of twenty workshops were organized in coastal sub-districts where 432 fishermen representative participated at the side of different stakeholders. A complete of nine workshops was expedited in sea-facing districts wherever 434 (Male-406 and Female-28) participants attended. Divisional workshops were placed in Chittagong, Barisal, and Khulna divisions wherever 166 (Male-144 and Female-22) participants attended. In all, CBO/NGO representatives, governing body, non-public sector representatives, local government leaders, civil society representatives, fishermen, and different professional teams attended in thirty-two consultation workshops. Participants of stakeholder consultations in the main worked in teams to seek out issues of fishery policies and laws in present context mainly coinciding with lives and livelihoods of marginalized fisher folk communities. They came up with issues and suggestions in comprehensive. Stakeholders' recommendations were the outputs of thirty-two consultations organized at different levels, including sub-district, district and divisional levels. Main sections of relevant fishery policies and laws were mentioned among participants through facilitation.

RESULTS AND DISCUSSION

The Protection and Conservation of Fish Act, 1950 gave authority to the government for creating rules and regulations. The Marine Fisheries Ordinance, 1983 provided some prohibited activities for conservation of fishery resources. National Fisheries Policy was adopted in 1998 that encouraged finest utilization of coastal and marine resources in conjunction with culture fishery. Coastal Zone Policy, 2005 provided problems with strategic partnership, non-public sector investment, strengthen environment, coordination, and governance of coastal resources for empowerment and poverty reduction.

The Protection and Conservation of Fish Act, 1950 (East Bengal Act XVIII of 1950): The government has introduced some rules and regulations. It is clearly stated that any violation of section three and four; the defaulter shall be imprisoned more than one year to two years, or fined up to five thousand taka (5000), or both. Section four of the law stated that a defaulter shall be imprisoned not less than three years, or not more than five years with fine not more than Taka (BDT) 10,000 (USD111.64). An accused person shall be imprisoned not less than a year which may be exceeded to three years and shall be fined not more than BDT5000 (USD58.82) or both. Based on section three of the law, the government has created a rule known as the Protection and Conservation of Fish Rules, 1985, which include in the management of the licensing of fishing in marine waters. There are eleven sections of the rules concerning various measures of protection and conservation and a couple of schedules specifying waters during which the catching and selling any prohibited fish species without a legitimate license and owning many types of licenses for catching of corps at any prohibited area. Regulation three (3) stated about the prohibition of using mounted engines in rivers and canals. Any fisherman is forbidden to use poison or explosives, as indicated in regulation four and five. The rules are directive, some of them are compulsory and the rest are prohibitive. It is also included in the provision that the government has implemented some rules relating to the employment of any the destroying and explosive for catching fish, prohibited season and the amount of fish caught. However, the jurisdiction of this instrument is restricted from the 18.29 meter depth line to the limit of territorial waters. This excludes shallow waters wherever shrimp fry catching placed (Hoq 2007, Shamsuzzaman et al 2017).

The Marine Fisheries Ordinance, 1983: The provisions of the ordinance clearly specified that the Marine Fisheries wing of the DoF is authorised to handle considerations in terms of marine fisheries exploitation, licensing and observance of fishing vessels, management, and conservation of marine fisheries, supervising and development of marine fisheries. Some of the concerns are regarding local fishing watercraft as well as the accessibility of giving license of the domestic fishing vessel and forbidden activities. They are not directly with the concerns of the application in coastal fishery, but they are indirectly strengthen the regulations within the case of coastal fishing. This ordinance has additionally mentioned some prohibited activities. In order to reinforce the power

Table 1. Stakeholders' recommendations about fishery policies and laws in Bangladesh

Policies and laws	Recommendations	Explanation
The Marine Fisheries Ordinance, 1983 *Issue:* Foreign fishing vessel is allowed to get license for fishing in Bangladesh territory.	To cancel issuing license for foreign fishing vessel.	Fishermen of Bangladesh are not getting sufficient fishes due to its production decline. Moreover, foreign fishing vessel use modern & sophisticated fishing gears. They discard huge small fishes in the sea and pollute environment.
Bangladesh Gazette- SR and No. 24 Act/88; The Protection and Conservation of Fish Rules, 1985 *Issue:* It is prohibited to use nets which mesh size is 4.5 centimetres or less.	To change this, in general, mesh size.	It is necessary to permit such nets, that is, mesh size 4.5 centimetres or less for using on the nature of coastal areas. This mesh size is applicable for restriction to catch *jatka* (juvenile hilsa) from November to May. Unfortunately, law enforcing agencies don't have sufficient knowledge in this regard.
Bangladesh Gazette- 21 September 2002; The Protection and Conservation of Fish Act, 1950. *Issue:* Prohibition about Current Jal.-(1) No person shall manufacture, fabricate, import, market, store, carry, transport, own, possess or use Current Jal.	To implement this section of law urgently.	Members of law enforcing agencies seize Current *Jal* (monofilament net) from fishermen and burn it. As a result, fishermen are being indebted to moneylenders. It is important to strongly prohibit the import or production in factory rather than burn out the monofilament net.
The Protection and Conservation of Fish Act, 1950 and The Marine Fisheries Ordinance, 1983 *Issue:* Anybody can be arrested by law enforcing agency without showing warrant.	To change this section of both laws.	Any innocent person may be insulted by misuse of these laws.
The Marine Fisheries Ordinance, 1983 *Issue:* Any boat will not be able to catch fish without registration. The boat owner will not get license without registration.	To have scope for registration of boat on area basis. Renewing of license time should be within *Ashar* (July-August) and *Ashwin* (October-November).	It is difficult, costly and time consuming to go Chittagong for registration purpose. Fisherman has available money during *Ashar* (July-August) and *Ashwin* (October-November).
The Ministry of Fisheries and Livestock slapped the ban to prevent the catching of *jatka*. The sanctuaries which are- 100 km of lower Meghna estuary Shatnol to Char Alexander of Chandpur-Lakshmipur, 90km tributary of the River Meghna from Char Ilsha to Char Pial of Bhola, 100km of River Tetulia from Bheduria to Char Rustam of Bhola-Patuakhali, 40km of River Andharmanik from Kalapara-Golbunia point of Patuakhali to the confluence of the Bay of Bengal, 20 km of lower Padma from Tarabunia to Bhomkara of Satkhira and 82km of River Tetulia from Hijla to Mehendiganj of Barishal.	Other employment initiatives like aquaculture, cage culture, net making/mending, poultry and duck rearing, livestock, small-enterprise, share cropping, driving, fishing in trawler, interest-free loans and grants should be arranged.	The government provides 120 kilograms rice to each fishing family during *jatka* catching ban period. This support is not sufficient. Alternative employment opportunities should be arranged by the government for survival of fishing community.
National Fisheries Policy, 1998 *Issue:* Bengali word '*Jele*' is not included in National Fisheries Policy.	To include Bengali word '*Jele*' in National Fisheries Policy.	Many elite rich-men entered in fishing in 1960. Then aristocratic Bengali word '*Motshojibi*' had been introduced instead of '*Jele*'. Noteworthy, '*Jele*' word is not included in fisheries act, rules, ordinance, and policy though *Motshojibi*and *Mas-Chashi*are included in such documents. According to National Fisheries Policy 1998, near about 1.2 million people in full-time and 12 million people were engaged in part-time at fisheries sector.
National Fisheries Policy, 1998 *Issue:* Marginalized fishermen will get priority to access in water bodies and *khas* (government owned land).	To implement this declaration immediately.	Majority of fishermen are landless. They don't have arable land; even homestead land. Access of fishermen to water bodies and *khas* land will increase their sustainable income.
Coast Guard Act, 1994 Issue: Suppression of destructive and terroristic activities occurring in the maritime zones of Bangladesh, and rendering assistance in this behalf to other authorities.	To implement this activity immediately.	Fishing is a risky occupation. Fishermen are frequently attacked by sea pirates. Professional dedication of coast guard can protect lives and livelihoods of disadvantaged fishermen.

presented by section fifty-five of the Marine Fisheries Ordinance, 1983, the government has introduced The Marine Fisheries Rules, 1983, and amended in 1993, which are applied to represent the method to file an application for license including the cases of domestic vessel and foreign fishing vessel, format of license, quantity of fee for the applying of license, conditions for application for license, time that the license shall be granted, size of net that shall be used for fishing, space of fishing, prohibited technique of fishing. Gazetted fishing areas are determined in step with the kind of fishing rig used, for instance, for fishing with set bag nets, up to forty meters' depth in marine waters at the high water.

National Fisheries Policy, 1998: In 1998, National Fisheries Policy was adopted, which outlined the status and vary of application of the national fisheries policy. It was introduced to represent the scheme for catching fish for beneficial purposes within the open fresh areas; fish culture and management policy in closed water banks; coastal fisheries and cultivation policy; marine fisheries resource development, exploitation, and management policy. The policy is succeed to inspire optimum utilization of coastal and marine resources to fulfil the demand for animal macromolecule, to push economic process, and to gain foreign currency through export of fish and fishery product. It is also included that natural water bodies and marine biodiversity shall be preserved. Trawlers shall strictly follow the prohibition on fishing for coastal areas below the forty m depth line. It is also shall be compulsory on the employment of the set bag net (locally referred to as *behundi*), which is to blame for the destruction of juvenile shrimps and different fish species (Article 8.2.2). Estuaries, rivers, and canals get extremely inhabited with shrimp fry through larval migration. To shield the shrimp population, catching of sure species of shrimp (*bagda, chaka, harina*) from the breeding ground shall be prohibited (Article 8.2.3).

Coastal Zone Policy, 2005: As an initiative of Ministry of Water Resources, Bangladesh Coastal Zone Policy was implemented, in order to validate that the coast of Bangladesh is protected as a zone of vulnerabilities. It is vulnerable to natural disasters like cyclone, storm surge and flood. The mingle of natural and human generated hazards, like erosion, high arsenic content in mineral water, water logging, earthquake, water and soil salinity, resulting many sorts of pollution, risks from climate change, have adversely affected lives and livelihoods within the coastal zone and stalled the pace of social and economic developments in region (Ali et al 2014, 2016). The coast opens opportunities for development which will be contributed to decrease rates of poverty and also for the whole country. The zone has diversity of natural resources as well as coastal fisheries and shrimp, forest, salt and minerals.

Stakeholders' recommendations: A total of thirty-two consultations were organized at totally different levels wherever stakeholders of wide-ranging backgrounds participated. They gave a collection of recommendations for modification of existing fishery policies and laws in present context for well-being particularly of fishermen. They raised concern to cancel issuance of license for foreign fishing boat, to vary mesh size, prohibiting of manufactory of current net, and prosperity of marginalized fisher folk communities (Table 1).

CONCLUSION

Fishery policies and laws are not pro-poor, particularly for capture fishers. Issuing license for foreign fishing boat destructs fishery resources. It is necessary to ban the import or production of monofilament net. Fishermen are compelled to pass terribly crucial time throughout prohibition periods of juvenile hilsa. They are often attacked by maritime pirates. These factors taciturnly kill growth and development of fisher folk and fishery resources. Fishing communities of coastal Bangladesh are vulnerable due to completely different shocks. Their lives and livelihoods are being vulnerable by many internal and external factors. They are a Policy Victim and unnoticed segments by policy makers. The policies and laws of fishery are not poor-friendly particularly for capture fishers. In distinction, these living documents have protective interests of wealthy business folks that freshly penetrate in this sector. Moreover, these policies and laws do not sufficiently address coastal potentials and the Blue Economy, for poverty reduction and overall development. This paper suggests the government of People's Republic of Bangladesh (GoB) to address stakeholders' recommendations and further amends as well as implement several sections for the well-being of fishing communities.

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Food Availability and Diet Composition of the Eurasian Otter *Lutra lutra* (L. 1758) in Saharan Aquatic Ecosystem, Dam of Djorf Torba's, Bechar-Algeria

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Abstract: The European Otter, *Lutra lutra* (L.1758) diet has been studied during two seasons (winter-spring) in a Saharan aquatic ecosystem in south-western part of Algeria. The inventoried fish fauna is composed of eight species namely barbell (*Luciobarbus pallaryi*), pseudorasbora (*Pseudorasbora parva*), carassin (*Carassius carassius*), common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), large mouth carp (*Aristichthys nobilis*), common bleak (*Alburnus alburnus*) and tilapia (*Oreochromis niloticus*). A total of 189 faeces samples (spraints) were collected from January to June which helped in identifying 419 preys divided into five categories (arthropods, fish, amphibians, reptiles and birds). The relative frequencies of occurrence, abundance and biomass of preys have been calculated. The Eurasian Otter feeds on a variety of fish species, which constitute about 80% of relatives occurred and 89% of total biomass ingested by this animal where the only dominant species was the barbel, as an endemic species which remains the favourite prey of the Mustelidae. Additionally, other preys completed the animal's diet such as arthropods, amphibians, reptiles and birds. With regards to the seasonal variations, the barbel remains always the most abundant prey.

Keywords: Algeria, Barbel, Diet, Djorf Torba's dam, Otter

Eurasian otter *Lutra lutra* (L. 1758) has one of the largest population distributions in the world (Kruuk 2006). It is widespread in Europe, parts of North Africa and Asia. It can be found in different locations, for instance highlands, lakes, rivers and streams, marshes, swamp forests and coastal areas. In Europe, its range extends on the Boreal, Atlantic, Alpine, Continental, Pannonian, Anatolian, Black Sea and Mediterranean biogeographic regions (Lanszki et al 2016). Klaa (1993) counted 52 sites visited by the mustelid in Algeria. The same author reported that otters' populations are especially subservient to the coastal zones (El Kala, Jijel, Beni Belaid). In the center of the country, fingerprints were found on the banks of Hamiz, Mazafran river's edges and Cheliff river. Le Berre (1990) reported that the Otter exists in the Saoura Valley, in Igli, in the Saharan Atlas (Tiout, Djebel Ammour) and Beni Abbes. He considered that the animal was trained further to the south during a flood.

The Otter saw is fragmentally distribution and shrunken throughout Algeria. However, it disappeared completely in certain sites, such as Bordj El Kiffan (Piquet 1960) which is due certainly to high pollution and scarcer resource of some aquatic environments. Because of its vulnerability, the Otter is listed in Appendix I of the Convention on International Trade in Endangered Species of Fauna and Flora realised by the International Union for the Conservation of Nature (IUCN). The Otter has been protected since 1983 and has begun to recolonize certain aquatic environments in view of the fact that the water quality and the food availability which has been greatly improved (repopulation of certain aquatic environments in carp species). Although it is widespread from the Morocco Atlantic coast to Tunisia, its distribution is not well known in Algeria. Reported in the 1930s by Heim De Balsac, cited by Kowalski and Rzebik-Kowalska (1991), the Otter recolonized the Djorf Torba's dam located in an arid environment.

The Otter's diet is highly variable (temporally and geographically) and may include a wide variety of aquatic animals, including fish, amphibians, reptiles, crayfish, crustaceans, aquatic insects, birds and mammals (Lanszki and Sallai 2006, Prigioni et al 2006, Gorgadze 2013, Krawczyk et al 2016, Bouroş and Murariu 2017). The otter's diet is quite well known in Europe but much less known in Algeria, especially in arid zones. It is to be mentioned that only one previous study containing data of about 18 years in the El-Kala National Park (Algeria) was realized (Libois et al 2015). In order to better respond to the conservation issues and the sustainable use of the environment and biodiversity, initial study on fish prey availability and the diet composition of the Eurasian Otter in a Saharan aquatic ecosystem was conducted.

MATERIAL AND METHODS

Study area: The spraints was sampled upstream and downstream of Djorf Torba dam, this latter is aquatic environment located in a Saharan territory of 2770 km^2 area. The dam located in Bechar Province, in the South-West of Algeria at 980 km from the capital Algiers. It is limited from the North by two mountains (Djebel Antar 1960 m and Djebel Horriet 1461m) and the Hamada of Oum Sbaa, from the South by Chabket Mennouna, from the East by Djebel Bechar (1500 m) and from the West by the Kenadsa region. The dam is located at 60 km west of the capital of the province of Bechar and 25 km from the town of Kenadsa, with an average altitude of 800 m (31°30'19"N, 02°46'10"W). The dam was built on Guir river in 1969.

This latter is a river that has its source in eastern Morocco and extends into southwestern Algeria. The dam controls a catchment area of 22000 km^2 and its reservoir capacity is 360 million m^3 (Kabour et al 2015) (Fig. 1).

Otter's spraints sampling: A total of 189 spraints were collected at two sites from January to June 2011. The first site corresponds to the upstream dam and the second to its downstream. In general, the collection was carried out along the places frequently used by the animal when it comes out of the water on transects of 10 meters.

Available food sampling: The Mustelid is the only predator of the fish populations. A study was conducted to determine the prey consumed by the Otter. Boats and nets were put at our disposal by the authorized fishermen for the exploitation of the piscicultural fauna. A total of six trips were organized for the nets placement (four in March and two in June 2013).

Spraints treatment: Each sample was disaggregated in clear water and then passed through a 0.6 mm mesh screen and dried (Libois et al 1987a, Weber 2008) in order to collect identifiable elements, and spraints were sorted out.

Identification and preys' enumeration: As we are dealing with a piscivorous species, parts retained are pharyngeal bones, maxilla, premaxilla, and dental. Determination of teleost is based on identification of bones characteristics of each species using the osteological atlas (Libois et al 1987a,b, Libois and Hallet-Libois 1988). Other preys such as birds' remains have been determined using feathers fragments, while reptiles are determined from molts and insects by elytra remains. However, some fish species (case of carp species, pseudorasbora, tilapia, barbel) found in the dam, are not shown in the osteological atlas, which is made particularly for European fish species. Thus, we prepared a reference collection of cephalic parts for all fish settling in the site.

Cephalic pieces preparation: In order to recover the cephalic parts of different collected fish, their heads were cut and boiled. The bones (pharyngeal bone, maxilla, premaxilla and dental) were removed and soaked for two minutes in water containing a few drops of sodium hypochlorite. Later, the pieces were collected and rinsed thoroughly to avoid the subsequent crumbling. After drying, they are kept in a pillbox containing the following information: date, site and species name.

Data analysis: To express data relative to the diet and to be able to interpret them, three parameters have been used: relative occurrence, relative abundance and relative biomass (Libois et al 1987a, 1991, Libois and Rosoux 1989, 1991, Libois 1995-1997). Occurrence frequency and relative occurrence revealed that they are the most commonly methods used in otter's diet studies (Mercier 2003, Polednik et al 2004, Sales-Luís et al 2007, Carss and Parkinson 2009).

Relative abundance (RA), frequency of occurrence (FO) and relative of occurrence were calculated using the following formulae.

$$RA = \frac{\text{Number of prey of a species}}{\text{Total number of prey}} \times 100$$

$$FO = \frac{\text{Number of spraints containing a species prey}}{\text{Total number of spraints}} \times 100$$

$$RO\% = \frac{\text{Number of spraints containing a species prey}}{\text{Sum of occurrences of all prey groups}} \times 100$$

As for preys' biomass estimation represented in the diet by a given taxa, it has been calculated by weighting preys number by average individual number for each fish species found in spraints (Libois et al 1987b). As for other preys, proceeded with the same way than Libois et al (2015) by giving 2g to arthropods, 100g to amphibians, 100g to reptiles and 60g for birds. The Chi-square test was used to examine differences in otter diet between two seasons (Winter-Spring). The JMP 8.0.2 statistical package was used for the processing of the data obtained.

RESULTS AND DISCUSSION

Food availability identification: Ichtyofauna inventoried within Djorf-Torba's dam is composed of the following eight species: Barbell *Luciobarbus pallaryi* (Pellegrin 1919), Pseudorasbora *Pseudorasbora parva* (Temminck and Schlegel 1846), Carassin *Carassius carassius* (L. 1758), Common carp *Cyprinus carpio* (L.

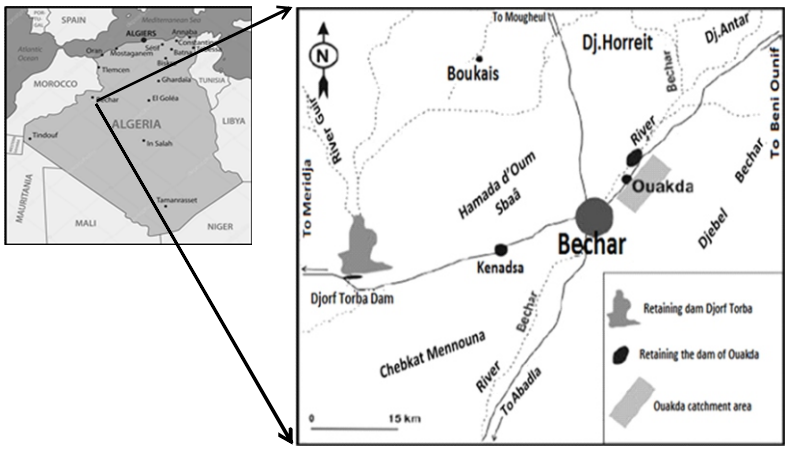

Fig. 1. Geographical situation of Djorf Torba's dam

1758), Silver carp *Hypophthalmichthys molitrix* (Valenciennes 1844), Large mouth carp *Aristichthys nobilis* (Richardson 1845), Common bleak *Alburnus alburnus* (L. 1758) and Tilapia *Oreochromis niloticus* (L. 1758). The majority of fish species retained for osteological atlas belong to the Cyprinidae family and only one species is part of Cichlids (*O. niloticus*).

Otter's overall diet: The analysis of the collected 189 spraints allowed the identification of 419 preys divided into five categories (Table 1). Generally speaking, the Eurasian otter shows a diversified diet composed of arthropods, fish, amphibians, reptiles and birds. In another expression, the Otter exploits simultaneously earth and aquatic resources. It also seems to be widely selective for collected species, considering that *Aristichthys nobilis* and *Hypophthalmichthys molitrix* have not been detected in any analysed samples.

Preys consumed by the otters are essentially fish with a rate of 80.88% in relative occurrence (80% of total biomass ingested), the remaining preys are represented by arthropods, amphibians, reptiles and birds. In terms of relative occurrence, among cyprinids, the *L. pallaryi,* which is an endemic species of the region, stays the prey the most hunted by the otter, as it dominates with over 32%. This latter was followed by *P. parva, A. alburnus*, undetermined cyprinidae, reptiles, *C. carpio*, amphibians, *C. carassius*, *O. niloticus* and occasional preys (arthropods and birds).

In the second time, the symmetrical parts enumeration allows expressing results in terms of relative abundance. The most abundantly ingested preys are, again, the Barbel (31.5%) followed by Pseudorasbora, Common bleak, Cyprinidae and remaining composed of reptiles, common carp, amphibians, tilapia, carassin with a rate under 7%.On the other hand, arthropods and birds represent only a total abundance of 2.86%.Preys consumed by the otter have almost the same classification order as well for relative occurrence and for relative abundance, while relative biomass gives another approach on diet. The Barbel is always the main prey swallowed by otter with biomass of 64.08%, followed by common carp, while carassin was consumed in small numbers; its biomass was more important (10.79%). Other fishes which are collected in large number and having a very weak relative biomass not exceeding 1.24%, such as pseudorasbora the common beak and tilapia. Other preys' categories include reptiles and amphibians; arthropods and birds; where their rate does not exceed 5.50%.

Seasonal variations: In terms of occurrence frequencies, relative occurrence, abundance and relative abundance; fishes represent the large majority in the diet during the two sampling seasons with rates of occurrence and abundance exceeding 94% in winter and over 70% in spring (Table 2). In winter, the Barbel remains the most predated prey; it dominates with 27.20% in relative occurrence and 29.07% in relative abundance, followed by other fish species such as pseudorasbora, tilapia, bleak and other species achieving food diet, with arthropods, amphibians and reptiles. During this same season, birds have not been captured by otter. During the spring season, fish's always represent the most consumed prey by otter, with over 70% in relative occurrence and in abundance. The high uptake of barbell with relative occurrence and abundance were of 36.08 and 33.20% respectively. Reptiles reach an important peak during this period with more than 14% in relative occurrence and 11.34% in relative abundance. Tilapia has not been predated during this period. Reptiles, which were nearly absent in winter, appear broadly and come in second position in relative occurrence in spring.Statistical analysis for the season variable (winter-spring), shows highly

Table 1. Overall composition of otter's diet in Djorf Torba's dam

Preys	Occurrence	Abundance	Biomass (g)
Luciobarbus pallaryi	55.03 (32.60)	132 (31.50)	33897.60 (64.02)
Pseudorasbora parva	19.05 (11.29)	68 (16.23)	263.84 (0.50)
Alburnus alburnus	15.87 (9.40)	51 (12.17)	657.39 (1.24)
Cyprinus carpio	12.17 (7.21)	27 (6.44)	6634.17 (12.53)
Carassius carassius	10.05 (5.96)	21 (5.01)	5714.94 (10.79)
Oreochromis niloticus	8.47 (5.02)	22 (5.25)	325.38 (0.61)
Cyprinidae undetermined	15.87 (9.40)	34 (8.11)	- -
Total fish	- (80.88)	355 (84.71)	47493.32 (89.69)
Arthropods	3.70 (2.19)	8 (1.91)	16 (0.03)
Amphibians	11.11 (6.58)	23 (5.49)	2300 (4.34)
Reptiles	15.34 (9.09)	29 (6.92)	2900 (5.48)
Birds	2.12 (1.25)	4 (0.95)	240 (0.45)

Figures in parentheses are in percent

Table 2. Otter's diet composition during winter-spring 2011

Preys	Winter		Spring	
	Occurrence	Abundance	Occurrence	Abundance
Luciobarbus pallaryi	49.28 (27.20)	50 (29.07)	58.33 (36.08)	82 (33.20)
Pseudorasbora parva	37.68 (20.80)	47 (27.33)	8.33 (5.15)	21 (8.50)
Alburnus alburnus	10.14 (5.60)	8 (4.65)	19.17 (11.86)	43 (17.41)
Cyprinus carpio	24.64 (13.60)	19 (11.05)	5.00 (3.09)	8 (3.24)
Carassius carassius	13.04 (7.20)	9 (5.23)	8.33 (5.15)	12 (4.86)
Oreochromis niloticus	23.19 (12.80)	22 (12.79)	0 (0)	0 (0)
Cyprinidae undetermined	13.04 (7.20)	10 (5.81)	17.50 (10.82)	24 (9.72)
Total fishs	- (94.40)	165 (95.93)	- (72.15)	190 (76.93)
Arthropods	4.35 (2.40)	3 (1.74)	3.33 (2.06)	5 (2.02)
Amphibians	4.35 (2.40)	3 (1.74)	15 (9.28)	20 (8.10)
Reptiles	1.45 (0.80)	1 (0.58)	23.33 (14.43)	28 (11.34)
Birds	0 (0)	0 (0)	3.33 (2.06)	4 (1.62)

Figures in parentheses are in percent

significant difference for all the prey consumed by the otter (χ^2 = 105.036, P (0.0001, ddl = 10) of occurrence frequency.

The Otter diet is well understood the primary food of otters is fish (Richard-Mazet 2005, Kruuk 2006, Lemarchand 2007, Gorgadze 2013, Krawczyk et al 2016, Bouroş and Murariu 2017). The otter's diet analysis in the Saharan ecosystem confirms that the species is essentially piscivorous. The otter menu is supplemented by other prey items such as arthropods, amphibians, reptiles and birds. In the present study the relative occurrence of fishes consumed by otters reaches up to 80%, and they represent about 90% of total biomass ingested (Clavero et al 2003). In otter's diet, cyprinids is the only family better represented simultaneously in terms of relative occurrence frequency, in relative abundance and in total biomass ingested by otters, respectively (75.86%, 79.46% and 89.08%). From this study and among the cyprinids, it appears that the barbel populating the Djorf Torba dam belonged to the *B. antinorii* species (Bouhadad 1993), but recently Brahimi et al (2016) have attached to the genus *Luciobarbus* and then becomes *L. pallaryi*. It occupies the first place in the otter menu with an occurrence and relative abundance reaching 32.60% equivalent to a total biomass of 64.02%. The same prey dominates with three species of barbels (*L. labiosa*, *L. fritschii* and *Labeobarbus paytoni*) in the otter menu in Morocco (Libois et al 2015). Among the work done in the dam, some authors confirm the predominance of the barbel on the otter menu (Nait Larbi 2011). Among ichtyofauna subservient of dam, only the *L. pallaryi* is endemic to the region. Three carp species: silver carp, common carp and large mouth carp, were subject of release in the 80's (Meddour et al 2005), followed by other species such as pseudorasbora, common bleak, carassin, and Nile tilapia. Certain fishes such as the sunfish, *Lepomis gibbosus* (L 1758), black bass *Micropterus salmoides* (Lacepède 1802), common bream *Abramis brama* (L. 1758) and the glaucous catfish *Silurus glanis* (L. 1758) were introduce in 1986 and recorded by the direction of fishing in the province of Bechar but do not appear in our inventory.

Lemarchand (2007) notes among cyprinids predated by otter, *B. barbus* are in the first place in otter's diet in Auvergne, the same fish has been revealed in 50% of spraints in Cevennes Park (Fonderflick et al 1995). Ruiz-Olmo (2006) in the Marais Poitevin reported that the otter shows a great eclecticism food. Libois et al (2015) that in National Park of El-Kala small sizes fish (pseudorasbora and barbels) dominate diet, 62% are less than 12.5cm. According to Libois (1997) and Kloskowski (2000) consumption of very small fish seems to be as an usual phenomenon. Kloskowski (2005) in Poland note that otter inflicts a lot of losses on the Common carp. This latter, dominates the diet with 43 %. In terms of numbers, it tends to capture small species such as Russian carp *Carassius auratus* gibelio (27%) and Roach *Rutilus rutilus* (12%). In aquatic environment, small sized species are generally much more abundant than the large ones, case of barbell *L. pallaryi* in Bechar, which is probably attractive by its small size and its abundance. It is therefore most often encountered by otter. Moreover, in certain Mediterranean biotopes, young otters prefer young barbels (Ruiz-Olmo et al 2002, Libois et al 2015).

CONCLUSION

The piscivorous diet of Eurasian Otter's diet *Lutra lutra* in aquatic Saharan environment is confirmed. It adapts according to seasons and prey's abundance. Otter captures and feeds on all fishes' settlement on the dam. Fish predominate and are in the first ranking in the food diet, where the barbel, *L. pallaryi* remains the main consumed prey. Otter externalizes an important flexibility in its food diet and adapts it according to seasons, and spots. Three fish species: *P. parva*, *A. alburnus* and *O. niloticus* were captured. They complete dam's Ichtyofauna listing prepared by Fisheries Department. It is noteworthy that *P. parva* may involve a threat for barbel survival from Djorf Torba's dam as an autochthon species. In the interest to fully understand the diet of the mustelid, additional analyzes should be conducted on other collection sites in order to have an idea both more general and more specific about its diet in the dam. This type of study is essential in conservation biology and in the implementation of relevant management policies for sites and national heritage.

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Native Species Displacement by Invasive Alien Species Yellow Crazy Ant: *Anoplolepis gracilipes* (Smith 1857) (Hymenoptera: Formicidae)

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Abstract: Invasive alien species yellow crazy ant *Anoplolepis gracilipes* have been observed in huge number within the Berhamapur Univeristy Campus, Ganjam, Odisha since 2015. This piece of work was undertaken to know the impact of this species on the native ants and other small crawling invertebrates. For better precise identification of this ant, its COI gene sequencing and molecular phylogeny analysis was also carried out. The pit fall traps were applied both in the invasive area and nearby non-invasive area in the pre-monsoon and post-monsoon period during 2018-19. The results showed very low number of native ant species and other crawling invertebrates in the invasive area as compared to the nearby non-invasive area, which indicates displacement of native species by the yellow crazy ant.

Keywords: Invasive species, MinION, Native species Displacement, Alarming sign

As per the convention on biological diversity (CBD), Invasive alien species (IAS) are species whose introduction and/or spread outside their natural past or present distribution threaten biological diversity. The yellow crazy ant: *Anoplolepis gracilipes* (Smith 1857) (Hymenoptera: Formicidae) is listed as one of the world's 100 worst invasive alien species by the International Union for Conservation of Nature (IUCN) and in the Global Invasive species database. These ants have been declared as 'Class 1 pest' under the Land Protection (Pest and Stock Route Management) Act 2002 of the Australian government. The report of devastation caused by the yellow crazy ant have been witnessed in many islands under Australian territories in generals but in the Christmas Island in particular, where it caused an “Invasional meltdown” in the ecosystem; which also includes the dramatic declines in the endemic red land crab: *Gecarcoidea natalis*, a keystone species within this island (O'Dowd et al 2003, Csurhes et al 2012). The detrimental effect of yellow crazy ant to biodiversity by killing range of invertebrates, small reptiles, nesting birds and displace native fauna have been evident from many literature. Some studies also highlighted about the interaction of the yellow crazy ant with the native pollinators, thereby affecting the entire ecosystem (O'Dowd et al 2003, Laester et al 2004, Mezger et al 2011). The recent report of the reproductive and 'trophic egg chefs' potential of the 'physogastric' workers might be adding to the adaptive advantage of this species and the quick invasion of the species (Lee et al 2017). The invasiveness of this ant species within the Berhampur University campus, Ganjam, Odisha, India have been observed since 2015. The invasiveness of these ant species have been observed within the 32-37 hectare out of approximately 102 hectare of Berhampur University Campus, Ganjam, Odisha (19^{O}17' 49.50" N, 84^{O}52' 58"^{O}E).Therefore, in order to study their present abundance and impact of the native ant or other small crawling invertebrates both in the identified invasive area and nearby non invasive area, we carried out a survey and inventorization work. For better precision in their identification, we also sequenced their COI gene by using next generation sequencing approach.

MATERIAL AND METHODS

To verify our preliminary observation, sampling of the ants through random sampling using pit fall trap (one pit fall trap in one square meter area) during the period 2018-19 both in pre-monsoon and post-monsoon period was carried out. After one day interval, the number of ants and other ants or any other insects/invertebrates which felt in the pit fall trap were counted. The process had been repeated at a frequency of one day per week and the average number of ants per fit fall trap were being recorded during each season. The pit fall traps were applied only in the vegetation area. The sampling was carried out only in the vegetation area of both the invasive and adjacent non invasive area. During rainy season, pit fall trapping were very difficult to employ as it had been filled with rain and ground water. The map (Fig. 1) of the study area was done by taking outline image of Google earth pro with known scale, direction and sampling point.

These ants were identified as per the standard features (Csurhes et al 2012). For molecular identification of the yellow crazy ant, we sequenced its Cytochrome C oxidase I gene (COI) gene. DNA isolation from Tissue samples was done using the EX pure Tissue DNA isolation kit developed by Bogar Bio Bee stores Pvt Ltd. The primers used in this study both for PCR and sequencing are: LCO 1490: 5'-GGTCAACAAATCATAAAGATATTGG-3' and HCO 2198: 5'-TAAACTTCAGGGTGACCAAAAAATCA-3'. The 25 µL of PCR reaction volume for COI gene included 5 µL of isolated DNA, 1.5 µL of forward primer and reverse primer, 5 µL of deionised water and 12 µL of Taq Master Mix, which was composed of Taq DNA polymerase supplied in 2X Taq buffer , 0.4 mM dNTPs, 3.2 mM $MgCl_2$ and 0.02 per cent bromophenol blue.The PCR thermal profile consisted of an initial denaturation step for 4 minute at 95°C, followed by 30 cycles for 45s at 95°C, 30s at 40°C annealing temperature, 50s at 72°C for extension and a final step for 10 min at 72°C. Unincorporated PCR primers and dNTPs from PCR products were removed by using Montage PCR Clean up kit. The quality, quantity (App.100ng/µl) and formulation of the PCR product was checked using Qubit Fluorometer 3.0. For sequencing we used the Next generation sequencing (NGS) platform for COI gene of the YCA using MinION as per the procedure described by Oxford Nanopore sequencing technology. NGS platform for sequencing of COI gene for YCA have been done for the first time. We performed the sequence assembly using Macvector 16.0.10. The assembled sequence was blast using NCBI blast similarity search tool. The obtained COI gene sequence was submitted to NCBI to get the accession number. The similar sequence after NCBI blast was aligned using CLUSTALX2 (Thompson et al 1997). A neighbour-joining (NJ) tree (Saitou et al 1987) using similar COI sequences by Kimura 2 Parameter method (Kimura, 1980) was constructed using the MEGA 6 (Tamura et al 2013) and to verify the robustness of the internal nodes of NJ tree, bootstrap analysis (Felsenstein 1985) was carried out using 100 replications.

RESULTS AND DISCUSSION

In the invasive area, average number of ant population in the pre-monsoon season was more than 1000 meter^{-2}, whereas in the post-monsoon seasons it declined to an average of more than 450 meter^{-2}. The average number of native ants and other small crawling invertebrates in the invasive area was 0.12 meter^{-2} which include only one other species during pre-monsoon period, where as in the post-monsoon period the number was 0.5 meter^{-2} which include only one other species as well (Table 1). In the non-invasive adjacent area, average number of native species of ant and other small crawling invertebrates were 14.37 meter^{-2} which includes 10 native species in the pre-monsoon period, where as in the post-monsoon period the average number was 8 meter^{-2} which includes 7 native species (Table 2).

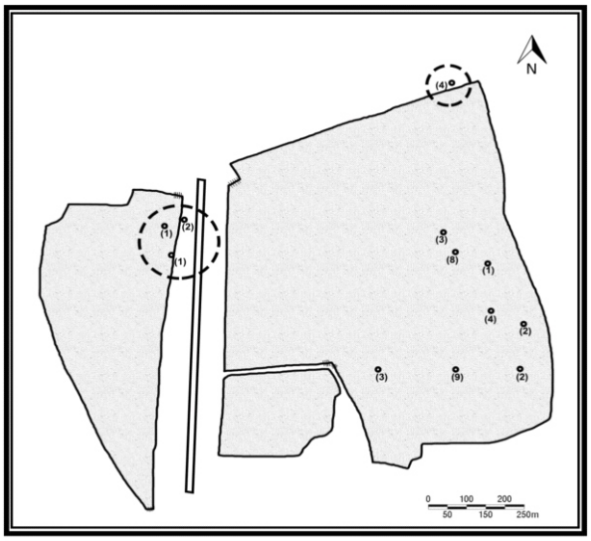

Fig. 1. Map of study site. The symbol "O" indicates the sample area and the number inside the symbol "( )" indicates number of traps at the rate of 1 trap per square meter and the non-invasive area are marked by dotted circle

The NCBI accession number of the submitted gene sequence is MK482686. This COI gene clearly belong the same cluster in NJ tree based on the COI genes sequence of different geographical regions with a bootstrap value ranging from 6 to 60 per cent (Fig. 2). The morphological and behavioural identification of the yellow crazy ant is supplemented by its COI gene sequence confirming the presence of this ant in the study area. The abundance at an average of more than 1000 per square meter reveals its invasiveness in this area. The very low number of other ants or crawling insects in the invasive area in comparison to the nearby non-invasive area indicates the displacement of native ant species. The prima facia evidence is indicating that this yellow ant are migrating at an average expanding rate of 50-100 meter per year to nearby area which is a serious and an alarming sign. The native range of this ant is unclear. Some authors speculated that the species originated either from Africa and Asia. In India it has been documented from Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Punjab, Sikkim, Tamil Nadu, Tripura, West Bengal (Bharti et al 2016). In Odisha, it is documented from Kuldiha Wildlife Sanctuary, Balasore, Odisha (Parui et al 2015). However, any outbreak/invasiveness of this ant from

Odisha, India was never been noticed earlier. Immediate steps must be initiated to check it spreads; otherwise it will pose severe environmental havoc like Christmas Island of Australia inside in this invasive area, in the nearby area and beyond (O'Dowd et al 2003, Csurhes et al 2012). The

Table 1. Average number of yellow crazy ant (YCA) and native ants/invertebrates per seasons per pit fall trap in the invasive area

Pit fall trap	Pre-monsoon period		Post-monsoon period	
	YCA	Native species	YCA	Native species
1	1345	0	212	0
2	1455	0	137	0
3	1532	0	131	0
4	1013	0	222	0
5	1196	0	387	0
6	1293	0	315	0
7	1344	0	107	0
8	1398	0	173	0
9	1079	0	435	0
10	1239	0	854	0
11	1109	0	115	0
12	1012	0	745	0
13	1256	1	1459	0
14	1143	2	773	0
15	1144	1	567	0
16	1232	0	618	2
17	1159	0	423	3
18	1018	0	187	0
19	988	0	316	0
20	1019	0	277	0
21	1177	0	193	0
22	976	0	77	0
23	755	0	328	1
24	1211	0	1282	0
25	1088	0	219	1
26	1013	0	534	1
27	1234	0	1093	0
28	1025	0	681	0
29	1198	0	485	1
30	954	0	547	1
31	1023	0	617	0
32	1168	0	211	6
Total	36796	4	14720	16
Average	1150	0.12 (1 native species)	460	0.50 (1 native species)

Table 2. Average number of yellow crazy ant (YCA) * and native ants/invertebrates per seasons per pit fall trap in the adjacent non- invasive area

Pit fall trap	Pre-monsoon	Post-monsoon
	Native species	Native Species
1	20 (15+2+3)	16
2	25	16 (11+2+3)
3	15 (10+2+3)	13
4	11 (8+2+1)	5 (1+4)
5	6	2
6	8	4 (2+2)
7	18 (14+3+1)	3 (2+1)
8	12	5 (3+2)
Total	115	64
Average	14.37 (10 native species)	8 (7 native species)

* Yellow crazy ant was not recorded in the pit fall trap

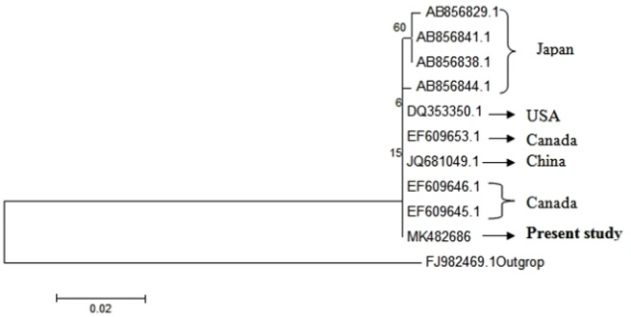

Fig. 2. Neighbour joining tree of yellow crazy ant *Anoplolepis gracilipes* based on COI gene sequences

negative impacts of the invasive alien species have already been documented from some parts of the Indian territory (Sarma et al 2015, Sinu et al 2017, Bishal et al 2019), therefore, it is high time to fasten our approach to address the alien species issues in order to fulfil the objective under Aichi Biodiversity Targets.

CONCLUSIONS

The work carried out during this study on the yellow crazy ants, its molecular phylogeny analysis and pit fall trap data clearly indicates the invasiveness of yellow crazy ants in the study area. These ants out numbered the other native ant species and small crawling invertebrates in the invasive area as compared to the nearby non-invasive area. This displacement of native ant species and small crawling invertebrates may pose serious ecological consequences like Christmas Island of Australia in near future; if not control immediately.

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Optimization of Compost Quantity for Fruit Body Yield in Button Mushroom (*Agaricus bisporus*)

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Abstract: The experiment was conducted to investigate the effect of substrate quantity on yield of button mushroom using plastic bags under controlled condition. No significant difference in morphological characteristics *viz*. pileus diameter, stipe length and average fruit body weight was observed, however, increase in mushroom yield was recorded with increase in compost quantity. Significant increase in yield was recorded upto 3 kg of compost. Biological efficiency did not exhibit any significant difference using different quantity of substrate. However, maximum biological efficiency of 10.13 was recorded with 3 kg of substrate and thereafter exhibited a consistent decrease with lowest being observed with 5 kg of substrate.

Keywords: Compost, Biological efficiency, Polythene bags

The button mushroom, *Agaricus bisporus* (Lange) Sing is the most widely cultivated and consumed mushroom throughout the world and contributes about 90 per cent of total country's production as against its global share of about 40 per cent (Mehta et al 2011). The button mushroom grows on composted substrates made from various materials (Delphina and Royse 2008). The quality and quantity of compost influences the yield of mushroom. Usually, a wide range of diverse cellulosic substrates are used for cultivating mushrooms. Among these, use of composted wheat straw has been the most widely used substrate for button mushroom cultivation (Uddin et al 2012). However, the Bastar plateau of Chhattisgarh has shown a reduction in the acreage of wheat production due to lack of irrigation and bunding on plots with higher slopes even though heavier soils predominate (Jain 2016) and requires an urgent need to optimize compost quantity that would result in maximum of mushroom production using minimum of substrate. Use of polypropylene bags has been used with varying degree of success for the production of button mushroom and offers opportunities to intensify mushroom production in Bastar plateau of Chhattisgarh. Therefore, the present investigation was planned with the objective to optimize the quantity of wheat straw as substrate that would maximize button mushroom production.

MATERIAL AND METHODS

Spawn preparation: The culture of *Agaricus bisporus* S-11 used in present experiment was procured from Indira Gandhi Agricultural University (IGKV), Raipur and was maintained on Potato Dextrose Agar (PDA) medium. Button mushroom's spawn was prepared using wheat grains. Wheat grains were boiled in water for 30 min (wheat grains: water, 1:2 w/v) so as to cook them soft enough to be pressed within the fingers. Extra water was sieved out, the grains were allowed to cool and then mixed with calcium carbonate and calcium sulphate powder @ 10g/kg of wheat grains respectively. Empty glucose bottles were filled with these grains @ 250 g per bottle, plugged with non-absorbent cotton, wrapped with paper and then autoclaved at 15 psi for 30 min. After cooling the autoclaved bottles overnight, these were shaken to restore transparent visibility of the glass and then inoculated aseptically with mycelial bits from the slant cultures. The bits were placed in such a manner that their mycelium touched the grains. These bottles were incubated at 22±1°C for 15- and saved at 4°C until use.

Compost preparation: The synthetic compost required for *Agaricus bisporus* was prepared by method of composting described by Garcha and Kiran (1981). Wheat straw was spread on cemented platform and wetted thoroughly for 48 hours while keeping it in the form of loose heap (=0.5m high) to attain 70-75 per cent moisture content. Considering stacking day as 0 day, first turning was done 3 days after stacking, urea @ 1.8 kg q^{-1} of straw was mixed with wet straw, again stacked into heap and covered with polythene. Subsequent turning was done at 3 days interval with a total of seven turns required for complete decomposition of compost. Wheat bran @ 2.5 kg q^{-1} of straw was mixed during 3rd turning, while gypsum was mixed during 6th turning @ 3.5 kg q^{-1} of straw. Light brown colored compost having no smell of ammonia was allowed to cool down before spawning.

Addition of spawn and filling of compost: Grain spawn was thoroughly mixed at the rate of 1.0 per cent of the total weight of compost. After spawning, different quantity of

compost was filled in polypropylene bags of different sizes (Table 1). The experiment was conducted in a completely randomized block design and each treatment was replicated 20 times. The spawned compost was then compressed, levelled and mouth of polythene bags were covered with a clean newspaper. Compost filled bags were then shifted to the growing room having a room temperature of 22±2°C and relative humidity 85-90 per cent until complete mycelia impregnation. Holes were made throughout the bag to allow aeration. Water was sprayed on top of the bags covered with newspaper, twice a day through out spawn running period.

Casing: Casing mixture consisted of coco- peat, soil and sand (3:2:1 v/v). All the ingredients were separately sterilized for 30 minute at 121°C at 15 psi before mixing. The sterilized casing mixture was used to cover spawn impregnated compost bags at uniform thickness of 3-4 cm following removal of newspaper. Case run was considered complete when mycelia covered the top of casing layer. Case run was done at a temperature of 21-23°C. After casing, the substrate surface was covered with newspapers and sprayed with water to avoid drying. When the mycelium reached the surface of the casing layer the newspaper was removed and temperature in the room reduced from 18°C to 16°C to provide shocking to induce fruit body formation. Time to pinhead formation was recorded. Mushroom yield was obtained from 2 flushes and mushrooms were harvested daily.

Harvesting: When the cap diameter of mushroom attained a size of 3-6 cm, these were harvested by twisting method and were collected in clean containers after cutting off the soil end parts of fruit bodies. During harvesting, the average weight of fruiting bodies, number of flushes, the diameter of stipe (stem), the diameter of pileus (cap), and length of stipe numbers were determined. The percentage of biological efficiency was calculated on wet basis using the following formula:

$$\text{Biological efficiency} = \frac{\text{Total weight of fresh mushroom}}{\text{Total wet weight of compost}} \times 100$$

RESULTS AND DISCUSSION

There was no effect of substrate quantity on pin head emergence and it started 2-3 days after removal of newspaper in all the treatments. The mushroom flushes came up in 5-7 days with a total of 4 flushes recorded for a period of 30 days. No significant difference in morphological characteristics *viz*. pileus diameter, stipe length and average fruit body weight was observed with increase in substrate quantity (Table 1). However, increase in mushroom yield was with increase in substrate quantity. The significant increase in yield was recorded upto 3 kg of compost, using 3.5 kg compost did not yield significant mushroom when compared to 3 kg. Moreover, yield from 4.5 kg of compost weight was not significantly different from either 4 kg or 5 kg compost. The decrease in mushroom yield using lower quantity of substrate may be attributable to earlier depletion of nutrients with limited substrate quantity as supported by Choi et al (2004). It is also apparent from the results that increasing substrate quantity above 3 kg did not result in significant increase in mushroom production and will be wasteful of time and labour. The size of plastic bags and spawn inoculation dosage used, 3 kg compost/ bag would allow optimum production of mushroom. With lesser wheat straw quantity, organic materials were limiting and resulted in lesser yield (Zireva et al 2007). In their study with oyster mushroom (*Pleurotus sajor-caju*), Zireva et al (2007) reported that mushroom yield increased with substrate quantity upto 6 kg of wheat straw and thereafter remained constant and lower substrate quantities of either 2 or 4 kg resulted in significantly lower yield compared to substrate quantities of 6, 8 or 10 Kg wheat straw per tray.

Biological efficiency, the quantity of fresh mushroom per

Table 1. Effect of different compost weight on morphological and yield parameters of button mushroom

Treatments (compost weight in Kg)	Size of polythene bag (Inch)	Total yield (gram bag^{-1})	Pileus diameter (cm)	Stipe length (cm)	Avg fruit body yield (g)	Biological efficiency (on wet basis)
1.0	9 x 15	95.08^{g}	2.93	2.80	16.66	9.51
1.5	9 x 15	144.45^{f}	3.13	3.03	20.33	9.63
2.0	12 x 18	189.01^{e}	3.50	3.00	17.66	9.45
2.5	12 x 18	247.08^{d}	3.23	2.86	19.00	9.88
3.0	12 x 18	303.80^{c}	3.26	3.56	21.00	10.13
3.5	12 x 18	326.15^{c}	3.33	3.00	19.00	9.32
4.0	18 x 22	365.27^{b}	3.16	3.50	21.66	9.13
4.5	18 x 22	384.43^{ab}	3.16	3.53	20.66	8.54
5.0	18 x 22	408.83^{a}	3.33	3.07	20.00	8.17
CD (p=0.05)		39.12	NS	NS	NS	NS

In the same column, significant differences at P<0.05 levels are indicated by different letters

unit quantity of wet compost, did not exhibit any significant difference using different quantity of substrate. However, maximum biological efficiency of 10.13 was with 3 kg of substrate and thereafter exhibited a consistent decrease with lowest being observed with 5 kg of substrate (Table 1). Increase in BE with increasing substrate quantity from 1 to 3 kg revealed more scrupulous utilization of substrate by mushrooms to produce mushroom fresh weight. Further increase in substrate quantity resulted in decreased substrate utilization either due to limiting space within the bags or higher humidity levels within the substrate mass at higher substrate levels.

CONCLUSION

The present study revealed that button mushroom cultivation using 12 X 18 inch polypropylene bags having 3 kg compost quantity resulted in optimum utilization of substrate to produce fresh mushroom yield. Optimization of substrate quantity would contribute to economical production of mushroom by saving labour, time and input. Further investigation on use of different substrates as composting material will help economize button mushroom production in Chhattisgarh in lieu of shortage in availability of wheat straw.

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Acute and Chronic Toxicity of Fluoroquinolone Antibiotics through Fresh Water cladoceron *Daphnia magna*

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Abstract: The 48 h acute toxicity test of antibiotics gemifloxacin and gatifloxacin on growth, survival and reproduction of *Daphnia magna* were conducted. The EC_{50} results obtained after 48 h acute test for gemifloxacin and gatifloxacin was 489.2 mg l^{-1} and 330.8 mg l^{-1} respectively. Adverse effect on reproducibility was observed on 21st day of exposure as a chronic toxicity test. The survival of *Daphnia magna* reduced to zero after exposure of 94.5 mg l^{-1} and 202.5 mg l^{-1} of gemifloxacin and gatifloxacin respectively.

Keywords: *Daphnia magna*, Gemifloxacin, Gatifloxacin, Non target organisms, Toxicity

Fluoroquinolone antibiotics is of particular environmental importance due to their extensive use in both human and veterinary medicine (Ebert et al 2011), which accounts for 17 percent of the global market share with a sale of 7.1 billion dollars in 2009 (Anupama et al 2010, Van et al 2014). They are excreted as parent compounds or as metabolites in pharmacologically active form, which can be found in municipal wastes, surface water and even ground water. Their removal from wastewater treatment plants is only partial and therefore, variable amounts of drugs are frequently released into the aquatic environment. In this context, FQs can be defined as emerging contaminants “pseudo- persistent" (Speltini et al 2015). The presence of these antibacterial contaminants in the receiving environment causes, disturbances to aquatic flora and fauna and risks to human health, possibly linked to the resistant bacteria (Sturini et al 2011, Tiwari et al 2016). These drugs affect the biological objects and are harmful to the environment (Tandon et al 2013), especially aquatic organisms and may affect the survival of the organism and future generation too. *Daphnia magna* are known as good toxicity model organism to predict the toxicity of pollutants to ecosystems because they are highly sensitive to environmental pollutants and are representative in food web chains as food and energy links between primary producers and secondary consumers (Kim et al 2017, Ahmad and Dutta 2018). This invertebrate has various characteristics that make it suitable for laboratory testing (Siciliano et al 2015). They are small, high fertility, short life cycle, parthenogenesis reproduction, easy laboratory handling and ubiquitous occurrence (Lv et al 2018). In this work, the toxicity of gemifloxacin and gatifloxacin were evaluated in laboratory using *Daphnia magna*.

MATERIAL AND METHODS

Chemicals: Gemifloxacin mesylate (CAS-210353-53-0) and gatifloxacin (CAS-112811-59-3) antibiotics were purchased from Yarrow Chemicals (India); purity ≥ 98 per cent. Standard stock solution of gemifloxacin and gatifloxacin antibiotics (500 mg l^{-1}) were prepared, from which test solutions have been prepared for each test with the appropriate dilution medium. The solution was stored in a dry and dark place, at above 18ºC for no longer than 2 days before use.

Test organism: *Daphnia magna* were maintained at temperature 20±1°C with photoperiod of 16L: 8D cycle according to the Organization for Economic Cooperation and Development (OECD) test guideline 211 (OECD, 2012) (Ribeiro et al 2018). The culture of *D. magna* was fed daily with yeast and algae, renewed water twice a week and similar size of *Daphnia magna* (< 24 hours) were used for this study (Ma et al 2015).

Acute toxicity test: For acute toxicity tests, the modified US, EPA 2002 standard procedures were used. The test concentration limit was selected based on range finding test and for each test concentrations (i.e. 12.34, 37.03, 111.11, 333.3 and 1000 mg l^{-1}), 5 individuals of *D. magna* were placed in a 100 mL glass beaker containing 50 mL solution. No additional food was added during the tests and the test solutions were not been renewed. The immobility of *D. magna* was recorded at 48 hrs. Individuals, which were unable to swim within 15s under gentle agitation were regarded as immobile. The concentration of gemifloxacin and gatifloxacin antibiotics causing 50 per cent immobility (EC50) was calculated after 48 hours of exposure.

Chronic exposure of *D. magna*: The OECD test guideline 211 (OECD, 2012) was followed for chronic toxicity tests.

Chronic exposure concentrations were selected based on 48 hrs $EC_{50}$from acute toxicity tests. During 21 days, test animals (< 24-h old neonates) were exposed to gemifloxacin (0, 3.5, 10.5, 31.5, 94.5, 283.5 mg l^{-1}) and gatifloxacin (0, 2.5, 7.5, 22.5, 67.5, 202.5 mg l^{-1}) with 10 replicates using ten individual replicates each. The chronic toxicity was mainly based on the reproduction test and the effect concentration was below the acute toxic level (EC_{50}). The endpoints analyzed during the test were the survival (%) number of young per female, first day of brood, number of young per brood.

Statistical analysis: A probit method (US, EPA Probit Analysis Program) was used to calculate the value of 48 EC_{50} (immobility). One way analysis of variance with Tukey's multiple comparisons was carried out to detect significant differences between groups using the SPSS software (Ver. 15.0)

RESULTS AND DISCUSSION

Toxicity of Gemifloxacin mesylate and Gatifloxacin to *D. magna*: To investigate the aquatic toxicity of gemifloxacin and gatifloxacin (Table 1) antibiotics, the modified US, EPA 2002 standard procedures were used to observe the immobility of *D. magna* under antibiotic exposure. The aquatic toxicity model predicts the effect concentration of a substance that causes adverse effects on 50% (EC_{50}) of the test population *Daphnia magna* within designated period. The EC_{50} showed that *D. magna* was more sensitive to gatifloxacin than gemfloxacin antibiotic in short period of exposure. The EC_{50} value for gemifloxacin after 48 hrs was 489.2 mg l^{-1} and for gatifloxacin was 330.8 mg l^{-1}.

The chronic invertebrate test according to OECD test guideline 211 (OECD 2012) was followed for chronic toxicity tests. Thereby, the most sensitive effect value from the endpoints reproduction was used. The chronic toxicity data for gemifloxacin and gatifloxacin antibiotics showed reproductive adverse effects during 21 days of daphnid exposure. The survival of *D. magna* was significantly reduced after 31.5 mg l^{-1} concentration of gemifloxacin. After 94.5 mg l^{-1} antibiotic concentrations survival of daphnid was observed to be zero (Fig. 1A). The first day of reproduction was statistically significant till 10.5 mg l^{-1} and after 31.5 mg l^{-1} no reproduction takes place because at higher concentration survival of dephnids also decreased (Fig. 1B). The average number of neonates per female was constantly decreasing with the increase in concentration (Fig. 1C). The effect of highest exposure could not be tested statistically since all daphnids died at this concentration. The number of young ones per brood decreased after 10.5 mg l^{-1} (Fig. 1D).

The survival of *D. magna* was significantly reduced after 22.5 mg l^{-1} of gatifloxacin antibiotic (Fig. 2A). At highest gatifloxacin antibiotic concentration i.e, 202.5 mg l^{-1} no survival was observed. The concentrations greater first day of reproduction have little effects at the initial concentrations of gatifloxacin and were markedly delayed after than 22.5 mg l^{-1} (Fig. 2B). After 67.5 mg l^{-1} gatifloxacin concentrations no reproduction of daphnia was observed. While comparing with control initial concentrations show no effects on average number of young per female and number of young ones per brood (Fig. 2C, D). Toxic effects were observed after 22.5 mg l^{-1} gatifloxacin concentrations was observed on average number of young per female and number of young ones per brood.

Table 1. Acute toxicity test results of gemifloxacin and gatifloxacin antibiotics on *Daphnia magna*

Concentration (mg l^{-1}) Exposure time (48 hrs)	Control	12.34	37.03 l	111.1	333.3	1000
Gemifloxacin						
A (a/d)	5/0	5/0	5/0	3/2	4/1	1/4
B (a/d)	4/1	4/1	2/3	4/1	¼	1/4
C (a/d)	5/0	4/1	4/1	5/0	2/3	4/1
D (a/d)	5/0	5/0	4/1	2/3	3/2	3/2
Per cent mortality	5	10	25	30	50	55
Gatifloxacin						
A (a/d)	4/1	5/0	4/1	4/1	5/0	0/5
B (a/d)	5/0	4/1	4/1	4/1	0/5	2/3
C (a/d)	5/0	5/0	4/1	3/2	2/3	3/2
D (a/d)	5/0	4/1	4/1	3/2	2/3	2/3
Per cent mortality	5	10	20	30	55	65

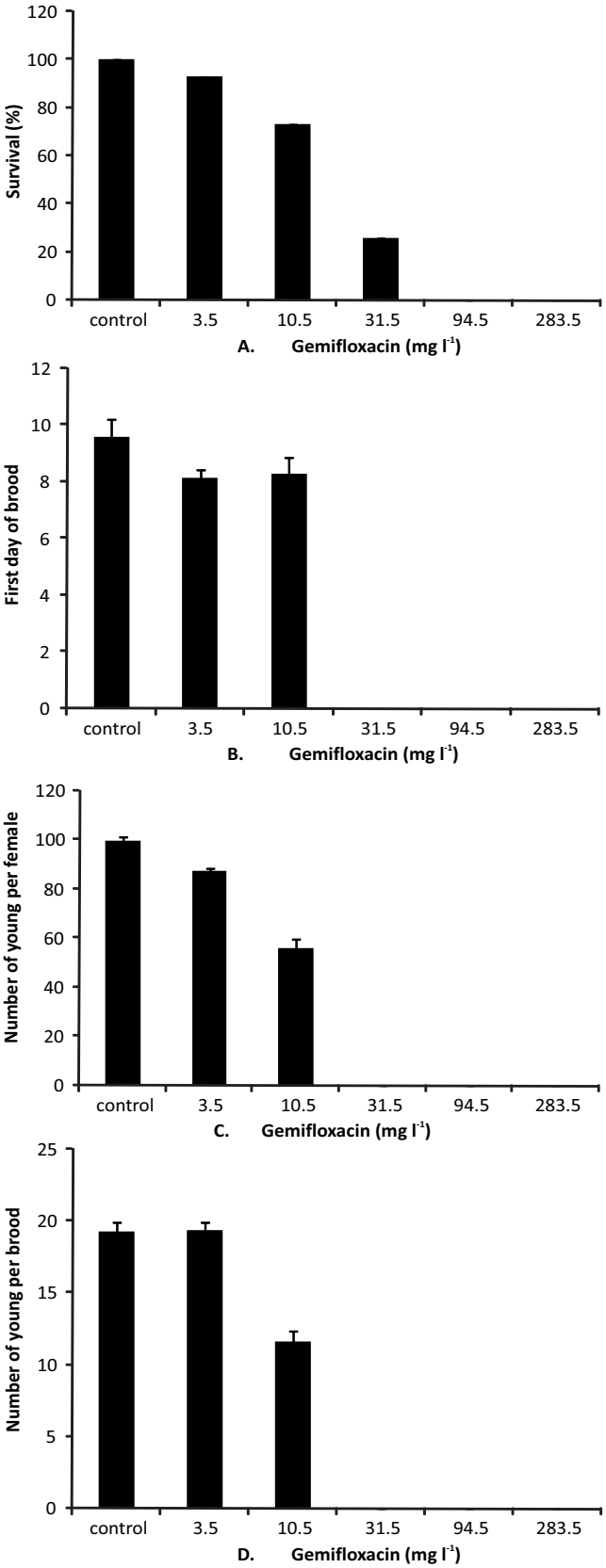
A, B, C, D is four different experimental groups; a/d indicates number of alive (a) and dead (d) animals in each group

Daphnia magna is a popular toxicity testing species. These invertebrates play an important role as consumers in aquatic ecosystems and are an important source of food for small fish (Lv et al 2018). Several environmental organizations, including the American Society Organization for Testing and Materials, the US Environmental Protection Agency, the International Organization for Standardization and the Organization for Economic Cooperation and Development have adopted standardized testing procedures using crustaceans (Ribeiro et al 2018). Most of toxicological studies with these crustaceans are based only on acute toxicity data for assessment of lethal concentrations (LC_{50}) for effective concentration (EC_{50}) for immobilization (Bownik 2017). Daphnids have become important model for system biology research for alternative testing and methodologies, prompting their use for prescreening tests before vertebrate testing, for both practical and ethical reasons (Siciliano et al 2015). Asian and Australian countries presently mainly use LC50s to express effects for acute *Daphnia* assays

(Ruebhart 2009). The standard test guidelines such as *Daphnia magna* Acute Immobilization Test (OECD 202) and Reproduction Test (OECD 211) promote the use and interactive comparison analysis of data from different research groups. The ecotoxicity test, immobility, reproduction, growth, and mortality of Daphnia are all well studied and are used as quantifiable parameters of its health; dose-response data can aid in predicting the consequences of exposure at other dose levels and life stages, in other species, or in susceptible individuals (Stollewerk 2010). Since antibiotics are designed to target particular pathways in humans or animals, when introduced into the environment they may affect the same or comparable pathways in mammals and invertebrates having the drug target homologies (Siciliano et al 2015).

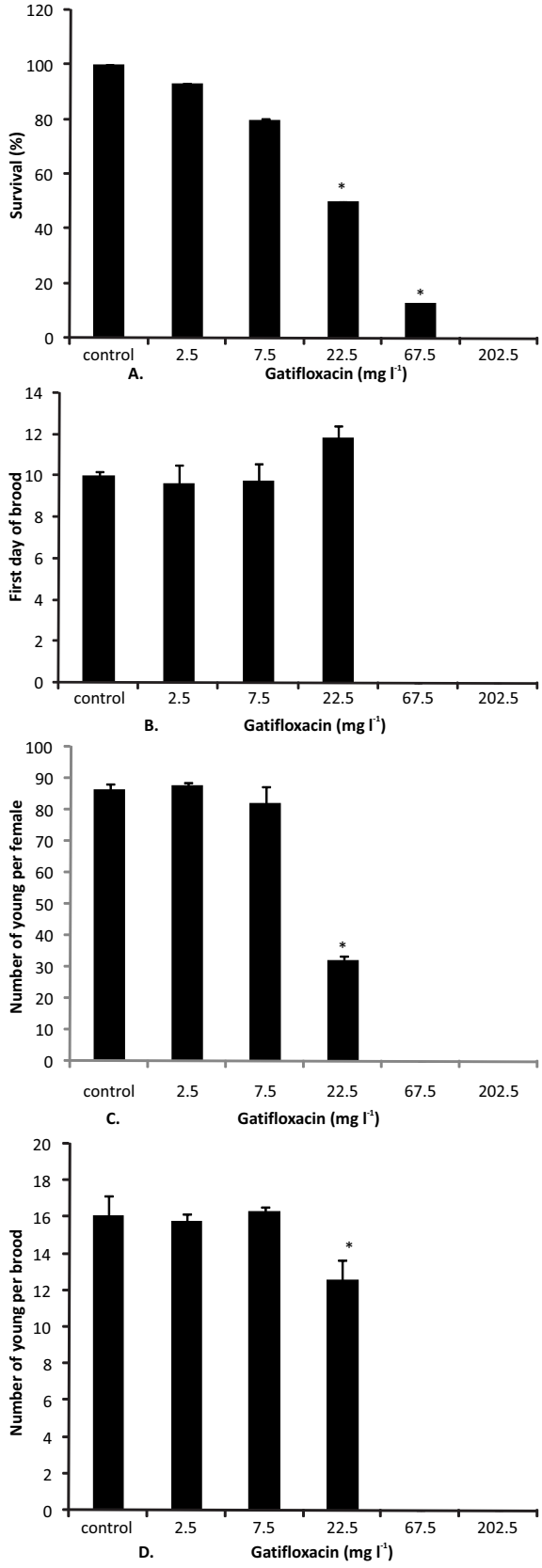
The results obtained in the acute toxicity tests, showing the calculated 48 h EC_{50} for the two antibiotic compounds tested. Acute toxicity evidence less toxic effects at the initial concentrations, as the mobility of daphnia was not that much affected by the presence of gemifloxacin and gatifloxacin antibiotics. However the immobility of daphnia increased with the increase in concentration. After 48 hrs, at concentration 1000 mg l^{-1} 55 per cent of daphnia became immobile in case of gemifloxacin (Table 1), whereas 65 per cent were observed to be immobile at the same concentration when treated with gatifloxacin . The immobility was observed to be 5 per cent in controls throughout the experiment. The data obtained for EC_{50} showed that *daphnia magna* was more sensitive to gatifloxacin than gemfloxacin antibiotic in short period of exposure. The EC_{50} value for gemifloxacin after 48 hrs was 489.2 mg l^{-1} and for gatifloxacin was 330.8 mg l^{-1}. In a study conducted by Andrieu et al 2015, they found that calculated EC_{50} value of enrofloxacin and ciprofloxacin were 111000 and 23000 µg l^{-1} for chlorella and 69000 and 71000 µg l^{-1} for *M. macrocopa*. Kim et al (2017), observed chronic effect on growth was at 83.0 mg l^{-1} of cefadroxil and 80.8 mg l^{-1} of cefadrine. The benzimidazole resulted in lower EC_{50} value in *Daphnia magna* showing higher sensitivity of fresh water macro invertebrates (Bundschuh et al 2016). *Daphnia magna* showed more sensitivity to cefotaxime, when compared to the cefixime antibiotic.

In chronic toxicity testing the survival of dephnids decreased with the increase in gemifloxacin antibiotic concentration, and after 94.5 mg l^{-1} no survival of organism was observed. The first day of reproduction was statistically significant till 10.5 mg l^{-1} and after 31.5 mg l^{-1} no reproduction recorded. The average number of neonates decreased with increase in concentration of gemifloxacin antibiotic, as organism survival rate was decreasing. The effect of highest exposure concentration on neonate number per female could



*=significant difference from control (Tukey test, $p < 0.05$)

Fig. 1. 21d chronic exposure to gemifloxacin in *D. magna* (Mean ± standard deviation)



*=significant difference from control (Tukey test, $p < 0.05$)

Fig. 2. 21 d chronic exposure to gatifloxacin in *D. magna* (Mean ± standard deviation)

not be tested statistically since survival rate was zero. The effect of higher concentrations on number of young per brood was observed and brood production was decreasing after 10.5 mg l^{-1} (Fig. 1). The survival of *D. magna* in case of gatifloxacin antibiotic was also observed to be decreasing with the increase in antibiotic concentrations. At highest gatifloxacin antibiotic concentration i.e. 202.5 mg l^{-1}, no *Daphnia magna* survival was observed. The first day of reproduction was significantly delayed at concentrations greater than 22.5 mg l^{-1}. The number of young per female was affected by higher concentrations of gatifloxacin antibiotic. The size of young ones per brood was observed to be significantly decreasing at concentration 22.5 mg l^{-1} in the chronic test (Fig. 2). The study was supported by Bernot et al (2005) they have shown that emidizolen based ionic liquid cause significant reduction in first brood neonates and average neonates and also studied that such reduction in reproduction output of populations could cascade through natural fresh water ecosystems. The cefotaxime antibiotic showed adverse effect than cefixime on reproduction after 21-days exposure. Cephalosporins, through photo transformation resulted in formation of byproduct which becomes more toxic. In a study conducted by Wang et al 2012 found that cephalexin, cefradine and cefotaxim becomes more toxic and less photoliable and becomes more persistent then parental drugs.

Acute toxicity tests showed rapid effects of drugs in the tested organisms in a short time to evaluate certain effects on the organism, such as mortality, luminescence inhibition and immobility of these organisms (Gueretz et al 2017). Acute toxicity study is better described as LC_{50}, LD_{50} and EC_{50} dose which kills 50 per cent of animals (Arome and Chinedu 2014). The acute test provides guidelines for which other testing program can be designed. Acute toxicity test is done to identify the target organ of toxicity, to provides safety measures and monitoring guideline for workers involved in the development and testing of test substances, to provide information needed for the dose selection in prolonged toxicity studies, to generate data containing the adverse effects of a substance on human, animal health and environment (US, EPA, 2002). Chronic assays evaluate an action of the possible pollutant over part or in the entire life cycle of the tested organism (Gueretz et al 2017). The chronic toxicity testing is used to characterize specific organs affected after repeated administration, to characterize dose-response relationships, to establish a no observable effect level. This test extends over a long period of time and it involves large groups of laboratory animals (OECD 2012).

CONCLUSION

For the acute toxicity the EC_{50} value for gemifloxacin and

gatifloxacin was found to be 489.2 mg l^{-1} and 330.8 mg l^{-1} respectively in *Daphnia magna* stating high toxic effect of the drugs in aquatic system when the animals get exposed. The comparative results define that the Daphnids exposed (Chronic exposure 21 days) to antibiotics showed more sensitive to gatifloxacin than gemifloxacin resulting in parental mortality, decrease in growth, number of broods and total offsprings. Further studies are needed to evaluate the ecotoxicity of pharmaceutical drugs and their metabolites in different species using many endpoints at both acute and chronic toxic levels, as different species can react differently to these antibiotics due to separate routes and mechanisms.

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Cell Growth and Carotenoids Production by Moroccan Strain of *Dunaliella Salina*

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Abstract: The cell growth and carotenoids production were studied in halophilic green algal, *Dunaliella salina* (Morocco-10) in the Sidi Abed salt lagoon using a batch system in order to determine optimal conditions (salinity, incubation temperature, pH, and cultivation time) for the highest production of carotenoids. The optimum cell growth (8.99 cells*10^6 ml^{-1}) was obtained in a salinity of 2.25mol l^{-1} at 30°C and pH 7.5 during 120 h of cultivation time. Maximum carotenoid accumulation (2.71 µg ml^{-1}) was obtained using the same salinity and cultivation time at 37°C and pH 7.5.

Keywords*:* Carotenoids, Cell growth, *Dunaliella salina,* Green algal, Moroccan strain, Optimal conditions

Microalgal culture is one of the modern concepts in biotechnology (Venkatesan et al 2013, Rasoul-Aminiet al 2014). Growing interest in carotenoid production by microalgae is due to increasingly important commercial applications of these natural compounds and to the market demand of carotenoids, especially for nutritional and pharmaceutical applications (Guedes et al 2011). *Dunaliella* species is characterized by an ovoid cell volume, lack a rigid polysaccharide, the cell is enclosed by a thin elastic plasma membrane covered by a mucous surface coat contain one large cup-shaped chloroplast, and it has an ability to move with two equally long flagellae (El Bakry et al 2004).This photosynthetic green microalga produces lipids, vitamins, carotenoids and glycerol has been widely used as a natural source for biomass and for β-carotene production (Ghasemi et al 2011, Borowitzka 2013). The species can accumulate a very high concentration (up to 14% of cell dry weight) of β-carotene when maintained under growth limiting conditions, namely high salinity, high temperature, high irradiance and/or nutrient deprivation. It is recognized as the most suitable biological source of this carotenoid (Lee 2001, Raja et al 2007).

Carotenoids are a class of hydrocarbons and their oxygenated derivatives (Britton 2008). They are one of the most important groups of natural pigments that are found in a wide range of natural sources plants and contain eight isoprenoid units. Natural carotenoids are high in demand in global markets owing to their widespread applications in nutrition, medicine, food coloring and in cosmetics, as well as in natural and health products for today's consumers (Ye 2008). They are notably used industrially as food additives including antioxidants, colorants and vitamins. Their protective capability against oxygen free radicals appears to be responsible for the therapeutic applications of carotenoids as anticancer agents, immune system stimulators and degenerative diseases preventatives according to several researchers (Salguero et al 2003). Other studies have indicated that consumption of carotenoid-rich vegetables and fruits could protect humans against cardiovascular disease, certain cancers and other degenerative diseases (Hu et al 2008). The main objective of this work was to study the effects of four environmental growth parameters such salinity, temperature, pH adjustment, and cultivation time and the interaction effects of these factors on cell growth and carotenoids production. The other aim is to select the optimum conditions for the production of β-carotene. This is an important step in the framework of large scale β-carotene production from microalgae for nutraceutical, food or pharmaceutical applications.

MATERIAL AND METHODS

Isolation, identification and maintenance of algae culture: *Dunaliella salina* (Morocco-10) was isolated from evaporating salt ponds in the Sidi Abed salt lagoon (33°02N, 08°42'w)El Jadida County in Sidi Abed Province, Morocco (Fig. 1). This strain was identified using a traditional taxonomy key (Borowitzka and Siva 2007) and confirmed with the Basic Alignment Search Tool (Blast) of NCBI (Sahnouni et al 2014) and phylogenetic analysis of Internal Transcribed Spacer 2 (ITS2) sequences as described by

Schultz & Wolf (2009) (Fig. 2). *Dunaliella salina* cells were cultivated in the Semenenko-Abdullaev culture medium (Semenenko and Abdullaev 1980). Composition of the growth medium used was NaCl, 58.44 g; $MgCl_2$ $6H_2O$, 1.5 g; KCl, 0.2 g; $CaCl_2$ $2H_2O$, 0.2 g; $NaNO_3$, 1.5 g ; KH_2PO_4, 0.035 g; Fe solution (Na_2EDTA), 189 mg l^{-1}; $FeCl_3$ $6H_2O$, 244 mg l^{-1} ,10 ml in 1l; and trace element solution (H_3BO_3,61.0 mg l^{-1}; (NH_4) Mo_7O_{24} $4H_2O$, 38.0 mg l^{-1}; $CuSO_4$ $5H_2O$, 6.0 mg l^{-1}; $CoCl_2$ $6H_2O$, 5.1 mg l^{-1}; $ZnCl_2$, 4.1 mg l^{-1}; $MnCl_2$ $4H_2O$, 4.1 mg l^{-1}, 10 ml in 1l. 5 g l^{-1} of sodium bicarbonate was used as carbon source (Kim et al 2017) to well support the growth of *Dunaliella salina.*

The medium was autoclaved for sterilization at 121°C for 20 min to avoid precipitation, phosphate was autoclaved separately (Hejazi and Wijffels 2003). All other essential equipment was also sterilized in the autoclave. All glassware was cleaned thoroughly with water, dried and sterilized in a hot air oven at 180 °C for 67 h prior to use. Inoculation of the culture was carried out in a vertical laminar flow cabinet under sterilized conditions to avoid bacterial and fungal contamination (Kirriola et al 2013).The Moroccan strain of

Fig. 1. Sidi Abed salt pond (left) showing red coloration in the precipitated salt layer caused by the presence of *Dunaliella salina* cells (right)

Dunaliella salina (Morocco-10) was inoculated with 50 ml of Semenenko-Abdullaev culture medium in a 150 ml Erlenmeyer flask under aseptic conditions. The culture was maintained at a light intensity of 180 µmol m^{-2} s^{-1} using cool-fluorescent tubes at 25±1 °C in a culture room and stirred using an air pump .To promote cell multiplication, periodically part of the culture was diluted with fresh Semenenko-Abdullaev medium to renew nutrient culture conditions.

Culture conditions: A growth experiment for optimizing cultivation conditions was carried out during the growth phase. The experiment was performed in 1l Erlenmeyer flasks incubated at 25°C in an orbital incubator shaker (Ivymen System shaking incubator) and agitated at 150 rpm for 8 days under the natural light intensity and under a 16:8-h light: dark cycle to obtain a final cell concentration of around 4×10^5 cell ml^{-1}. This culture was used as a standard inoculum for all the cultivation experiments in shake flasks. In each Erlenmeyer, 100 ml of the stock suspension was added to 150 ml culture medium (Fig.3). In order to assess the effects of the environmental parameters on cell growth and carotenoids production by *D. salina* (Morocco-10) , salinities used were varied from 1.50 to 3 mol l^{-1}, incubation temperatures were from 30 to 37°C, pH values were gradually adjusted from 7 to 8, and cultivation times were from 72 to 120 hours.

Analysis method: The total concentrations of carotenoids were determined by measuring the absorbance of the samples using a UV-1800 Spectrophotometer (Shimadzu, Japan) according to the method of Lichtenthaler 2005. One ml aliquots of algal culture were extracted with pure methanol. Total carotenoids concentrations were calculated using the following equation:

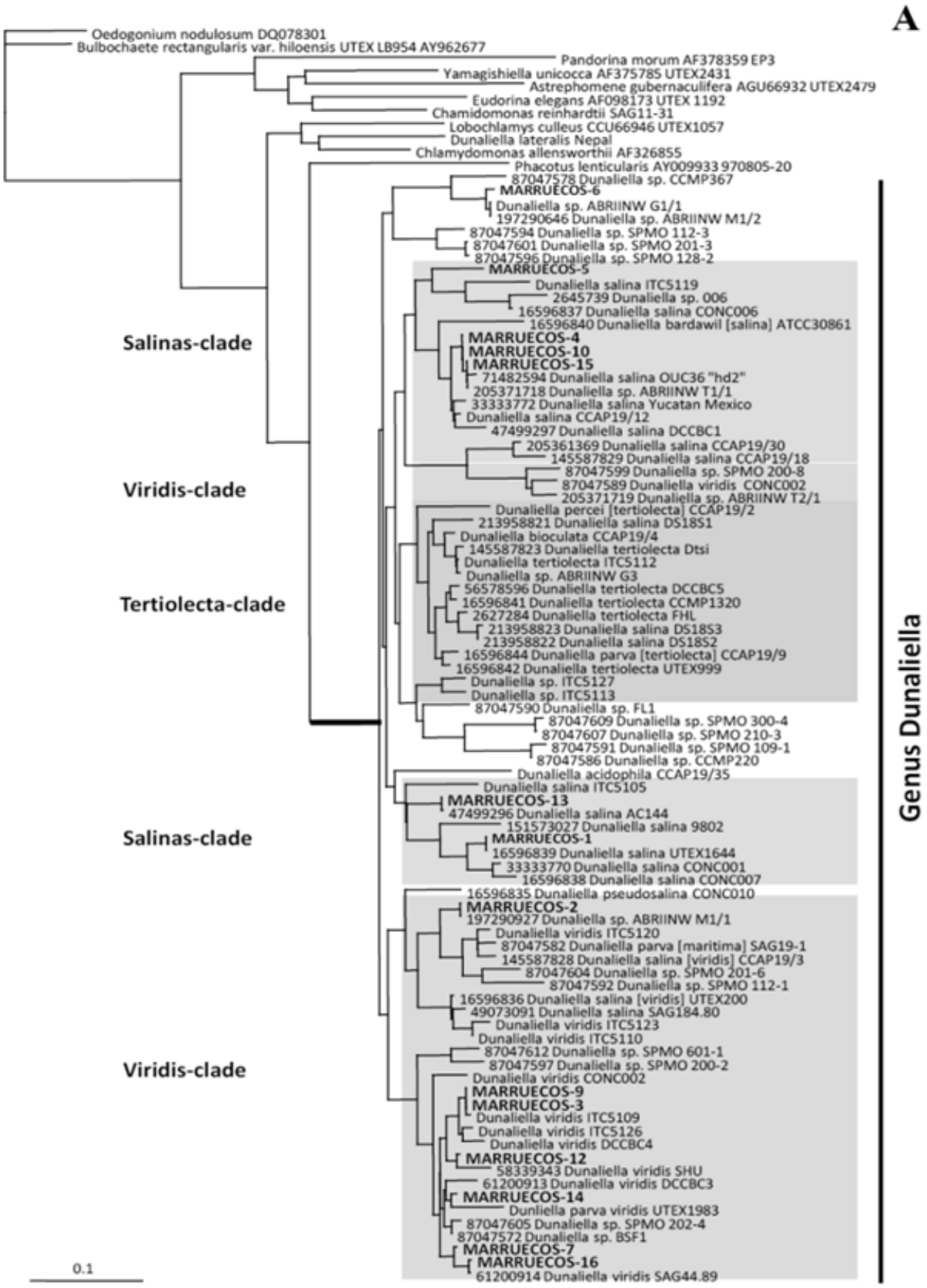
Total carotenoids (µg mL^{-1}) = [1.000 × A_{470} – (1.63 × 16.72 × $A_{665.2}$ – 9.16 × $A_{652.4}$) – (104.96 × 34.09 × $A_{652.4}$ – 15.28 × $A_{665.2}$)]/221 (Eq.1)

Where $A_{665.2}$, $A_{652.4}$, and A_{470} are optical concentration at 665.2, 652.4and 470 nm, respectively.

Measurement of cell growth: The number of microalgal cells were determined in a counting chamber (Malassez haemocytometer) using a light microscope, for a 1 ml of the cell suspension 2 drops of bleach is added to fix the cells. Number of cells was calculated as follows:

Number of cells ml^{-1} = Total counted cells × 10^6 × dilution factor

Experimental design and data analysis: In order to study the effects of environmental parameters on cell growth and carotenoids production by the Moroccan strain of *D. salina* (Morocco-10), the Box–Behnken design (Box & Behnken 1960) (BBD) and response surface methodology (RSM) were employed for random experimental design (Deepak et


A
Oedogonium nodulosum DQ078301
Bulbochaete rectangularis var. hiloensis UTEX LB954 AY962677
Pandorina morum AF378359 EP3
Yamagishiella unicocca AF375785 UTEX2431
Astrephomene gubernaculifera AGU66932 UTEX2479
Eudorina elegans AF098173 UTEX 1192
Chamidomonas reinhardtii SAG11-31
Lobochlamys culleus CCU66946 UTEX1057
Dunaliella lateralis Nepal
Chlamydomonas allensworthii AF326855
Phacotus lenticularis AY009933 970805-20
87047578 Dunaliella sp. CCMP367
MARRUECOS-6
Dunaliella sp. ABRIINW G1/1
197290646 Dunaliella sp. ABRIINW M1/2
87047594 Dunaliella sp. SPMO 112-3
87047601 Dunaliella sp. SPMO 201-3
87047596 Dunaliella sp. SPMO 128-2
MARRUECOS-5
Dunaliella salina ITC5119
2645739 Dunaliella sp. 006
16596837 Dunaliella salina CONC006
16596840 Dunaliella bardawil [salina] ATCC30861
Salinas-clade
MARRUECOS-4
MARRUECOS-10
MARRUECOS-15
71482594 Dunaliella salina OUC36 "hd2"
205371718 Dunaliella sp. ABRIINW T1/1
33333772 Dunaliella salina Yucatan Mexico
Dunaliella salina CCAP19/12
47499297 Dunaliella salina DCCBC1
205361369 Dunaliella salina CCAP19/30
145587829 Dunaliella salina CCAP19/18
Viridis-clade
87047599 Dunaliella sp. SPMO 200-8
87047589 Dunaliella viridis CONC002
205371719 Dunaliella sp. ABRIINW T2/1
Dunaliella percei [tertiolecta] CCAP19/2
213958821 Dunaliella salina DS18S1
Dunaliella bioculata CCAP19/4
145587823 Dunaliella tertiolecta Dtsi
Dunaliella tertiolecta ITC5112
Dunaliella sp. ABRIINW G3
Tertiolecta-clade
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16596841 Dunaliella tertiolecta CCMP1320
2627284 Dunaliella tertiolecta FHL
213958823 Dunaliella salina DS18S3
213958822 Dunaliella salina DS18S2
16596844 Dunaliella parva [tertiolecta] CCAP19/9
16596842 Dunaliella tertiolecta UTEX999
Dunaliella sp. ITC5127
Dunaliella sp. ITC5113
87047590 Dunaliella sp. FL1
87047609 Dunaliella sp. SPMO 300-4
87047607 Dunaliella sp. SPMO 210-3
87047591 Dunaliella sp. SPMO 109-1
87047586 Dunaliella sp. CCMP220
Dunaliella acidophila CCAP19/35
Dunaliella salina ITC5105
MARRUECOS-13
47499296 Dunaliella salina AC144
151573027 Dunaliella salina 9802
Salinas-clade
MARRUECOS-1
16596839 Dunaliella salina UTEX1644
33333770 Dunaliella salina CONC001
16596838 Dunaliella salina CONC007
16596835 Dunaliella pseudosalina CONC010
MARRUECOS-2
197290927 Dunaliella sp. ABRIINW M1/1
Dunaliella viridis ITC5120
87047582 Dunaliella parva [maritima] SAG19-1
145587828 Dunaliella salina [viridis] CCAP19/3
87047604 Dunaliella sp. SPMO 201-6
87047592 Dunaliella sp. SPMO 112-1
16596836 Dunaliella salina [viridis] UTEX200
49073091 Dunaliella salina SAG184.80
Dunaliella viridis ITC5123
Dunaliella viridis ITC5110
87047612 Dunaliella sp. SPMO 601-1
87047597 Dunaliella sp. SPMO 200-2
Viridis-clade
Dunaliella viridis CONC002
MARRUECOS-9
MARRUECOS-3
Dunaliella viridis ITC5109
Dunaliella viridis ITC5126
Dunaliella viridis DCCBC4
MARRUECOS-12
58339343 Dunaliella viridis SHU
61200913 Dunaliella viridis DCCBC3
MARRUECOS-14
Dunliella parva viridis UTEX1983
87047605 Dunaliella sp. SPMO 202-4
87047572 Dunaliella sp. BSF1
MARRUECOS-7
MARRUECOS-16
61200914 Dunaliella viridis SAG44.89
0.1
Genus Dunaliella

(B)

Sample	Source	Phylogenetic Analsis	Blast (Gen Bank)
Morocco-1	Lac Zima	*D. salina*	*D. salina*
Morocco-2	Sidi Abed	*D. viridis*	*D. viridis*
Morocco-3	Larache	*D. viridis*	*D. viridis*
Morocco-4	Sidi Abed	*D. salina*	*D. salina*
Morocco-5	Asilah	*D. salina*	*D. salina*
Morocco-6	Sidi Abed	*Dunaliella sp.*	*D. tertiolecta, D. viridis*
Morocco-7	Sidi Abed	*D. viridis*	*D. viridis*
Morocco-9	Asilah	*D. viridis*	*D. viridis*
*Morocco-10	Sidi Abed	*D. salina*	*D. salina*
Morocco-11	Sidi Abed	-	*Chlamydomonas sp.*
Morocco-12	Naila	*D. viridis*	*D. viridis*
Morocco-13	Naila	*D. salina*	*D. salina*
Morocco-14	Tislatin	*D. viridis*	*D. viridis*
Morocco-15	Tislatin	*D. salina*	*D. salina*
Morocco-16	El Aaiun	*D. viridis*	*D. viridis*

*Strain studied

Fig. 2. Sequence-structure Neighbor-Joining tree obtained by ProfDistS and supporting bootstrap values (100 replicates) of all the *Dunaliella* ITS2 sequences available in the ITS2 Database and the new Moroccan *Dunaliella* field strains (A). Table B shows the identification of *Dunaliella* strains obtained with the phylogenetic analysis of the ITS2 sequences (A) and the Basic Alignment Search Tool (Blast) of NCBI

al 2008). The total number of experiments for four variables was 27 ($2^k + 2k + n_0$), where k is the number of independent variables and n_0 is the number of experiment repetitions at the center point (Can et al 2006). A total of 24 experiments were augmented with 3 replications at the center values to evaluate the pure error.

The behavior of the system was determined by assuming a second order polynomial with linear, quadratic and interaction effects as shown by Eq. (2) (Khattar 2009):

$$Y = b0 + \sum_{i=1}^{n} biXi + \sum_{j=1}^{n} bjjXj^2 + \sum_{i<j}^{n} bijXiXj \quad Eq.2$$

Where Y is response; X_1, X_2, X_3 and X_4 are input variables; b_0 is constant; b_i is linear coefficient; b_{ij} is interaction coefficient; and b_{jj} is quadratic coefficient.

The ranges of four factors, salinity (X_1, mol L-1), incubation temperature (X_2, °C), pH adjustment (X_3) and cultivation time (X_4, h)were decided according to three different levels (Table 1). Coded levels and the experimental values of cell growth (Y_1) and carotenoids amount (Y_2) are shown in Table 2.

Estimation of regression coefficients and statistical tests were implemented in the MINITAB Version 16 (Minitab Inc., State College, PA, USA) statistical software based on the RSM. Analysis of variance (ANOVA) was conducted on the coded level of variables to identify the effects of individual variables. This software was used for regression analysis of the data obtained and to estimate the coefficient of regression equation. ANOVA (analysis of variance) which is statistical testing of the model in the form of linear term and interaction term was also utilized to test the significance of each term in the equation and goodness of fit of the regression model obtained. Effects and interactions were considered significant at $p<0.05$.

Table 1. Experimental ranges and values of the independent variables in the Box-Behnken design

Independent variables	Units	Symbol	Coded levels		
			-1	0	+1
Salinity	mol L^{-1}	X_1	1.5	2.25	3
Incubation temperature	°C	X_2	30	33.5	37
pH	___	X_3	7	7.5	8
Cultivation time	h	X_4	72	96	120

RESULTS AND DISCUSSION

The cell density and carotenoids production ranged from 4 to 9 cells*10^6mL^{-1} from 1 to 3 µg mL^{-1}, respectively, depending on the experimental conditions (Table 2).

Effect of environmental factors on cell growth of the Moroccan strain of *Dunaliella salina*: In order to study the effect of variation in factor levels on cell growth and to define the optimal level for each variable, three-dimensional response surface views were used to demonstrate the effects and the interaction of the independent variables on the response (Fig. 4). Maximum cell growth of *D. salina*

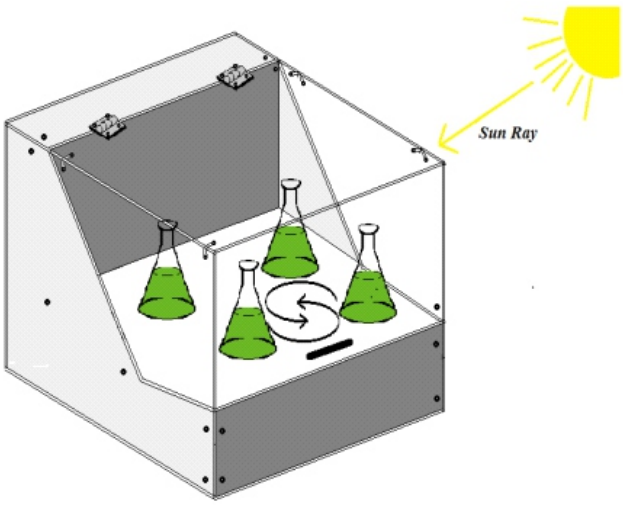

Fig. 3. Schematic of culture conditions

occurred when the salinity was at the minimum level (1.50 mol. L^{-1}) and temperature at the maximum level (37°C) (Fig. 4A). Effects of salinity (X_1) and pH adjustment (X_3) on cell growth (Fig. 4B) shows increasing salinity with pH, up to the optimal point, increased cell growth to the maximum level but a further increase in both variables decreased the cell growth. The effects of salinity (X_1) and cultivation time (X_4) on cell growth (Fig. 4C) shows increasing salinity with decreasing cultivation time gradually increased cell growth but at a higher salinity and cultivation time levels the trend was reversed. Maximum cell growth always occurred when salinity was at the lower level (1.50 mol L^{-1}). Zhou et al (2006) suggested that the optimal growth salinity of *D. salina* in the laboratory was 2.0 mol L^{-1} NaCl, but it was observed that *D. salina* grows in salinities >175 g L^{-1} (about 3 mol L^{-1} NaCl), which indicates that the alga can tolerate higher salinities than other species. This contrasting result can be explained by each strain having different optimum salinities. The interaction effect of the temperature (X_2) and pH adjustment (X_3) on cell growth of the Moroccan strain of *D. salina* (Fig. 4D) shows increasing temperature with pH adjustment up to the optimum point increased cell growth to the maximum, but higher elevation of pH had a negative impact on cell growth. The effects of incubation temperature (X_2) and cultivation time (X_4) on cell growth (Fig. 4E) shows increasing incubation temperature with decreasing the temperature increased cell growth a further increase both in the incubation temperature and the cultivation time decreased the cell growth. Temperature clearly affected cell growth and suggest that the optimal growth temperature of the Moroccan strain of *Dunaliella salina* in a laboratory was at 30°C ($7.32*10^6$ cells mL^{-1} Garcia et al (2007) observed optimal growth temperature for *D. salina* was 22°C ($3.06*10^6$ cells mL^{-1}) and 26 °C for *D. viridis* ($4.04*10^6$ cells mL^{-1}). The effects of pH and cultivation time on cell growth (Fig. 4F) shows increasing pH with cultivation time, up to the middle level, increased cell growth to the maximum level but a further increase in both decreased the cell growth. Thus the optimal growth pH of the Moroccan strain of *Dunaliella salina* was at pH 7.5. This accords with Çelekli and Dönmez (2006), who found that the maximum cell number was obtained at pH 7.5 ($4.2*10^6$cells mL^{-1}). The study also shows that cultivation time affects cell growth. Furthermore, increase cell growth started after the end of logarithmic growth phase then increased during the stationary phase to reach its maximum ($7.32*10^6$cells mL^{-1}) at 96 hr.

Effect of environmental factors on carotenoids production by the Moroccan strain of *Dunaliella salina*: A graphical representation can be introduced in order to visualize the significant relationship linking levels of variables

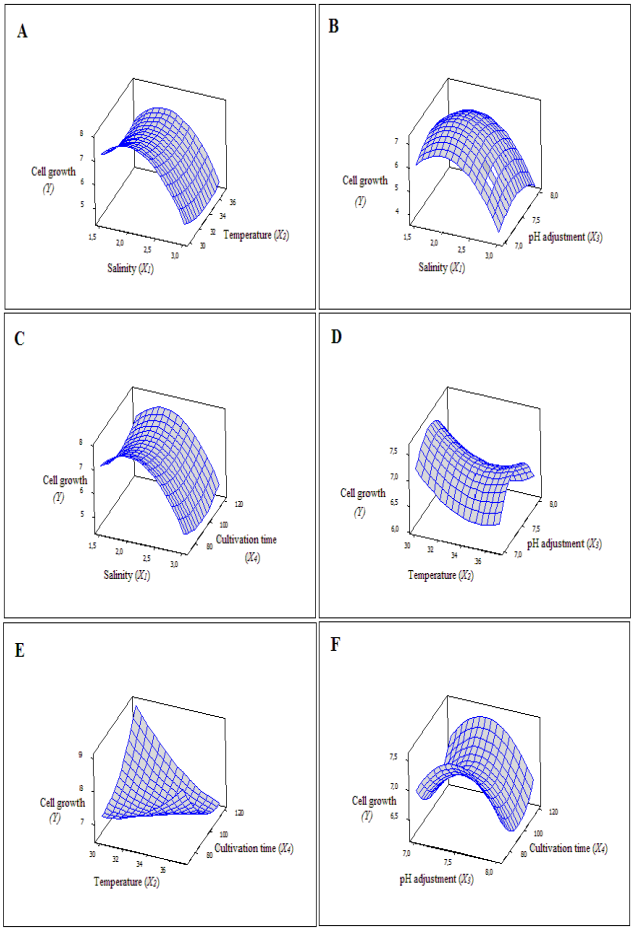

Fig. 4. Response surface plots (3D) showing the influence of four studied variables on cell growth

and response studied (Carotenoids production). The previously studies described by Borowitzka et al (1984), Fazeli et al (2006), Borowitzka and Siva (2007) showed that the environmental factors played most effective rules on the level of carotenoid production by *Dunaliella* sp. The Figure 5 depicts three-dimensional plots, each plot highlighting the response behavior function of two variables with the third variable fixed to its central point. Temperature and salinity are both important environmental factors for carotenoids production. Figure5A represents the response surface for interactive of salinity (X_1) and incubation temperature (X_2) on the response value (Y). Increased temperature and salinity, increased carotenoids production to the maximum level. The effects of salinity (X_1) and pH adjustment (X_3) on the carotenoids production (Fig. 5B) shows increasing salinity and pH causes an increase in carotenoid production. Carotenoids production (Fig. 5C) increased with an increase in salinity (X_1) and cultivation time (X_4). Maximum carotenoids production (2.50 µg mL^{-1}) for the Moroccan strain of *Dunaliella salina* (Morocco-10) occurred when salinity was at

the middle level (2.25 mol L^{-1}). A similar result was observed by Nezhed and Mansouri (2016)and observed that higher carotenoids concentration occurred at 2 mol L^{-1} NaCl concentration in *D. viridis*. Other results reported by Cifuentes et al (2001), Fazeli et al (2005) showed that total carotenoid production as well as cell productivity was affected by salinity. Maximum carotenoids production for the Moroccan strain of *D. salina* (Morocco-10) occurred when pH adjustment was at the middle level and the temperature was at the maximum (Fig.4D). The effects of temperature (X_2) and cultivation time (X_4) on carotenoids production (Fig. 4E) indicate that the optimal temperature for carotenoids production of the Moroccan strain of *D. salina* is 37°C. This result accords with Garcia et al (2007) who documented that highest carotenoid concentrations were obtained under suboptimal growing conditions (38°C), which confirms that induction and accumulation of high value products in *D. salina* are associated with stress conditions.

Carotenoids production of the studied microalgal strain was enhanced after increasing the temperature and the cultivation time. An increase in the cultivation time with pH (Fig. 4F) at the maximum increased carotenoids production to maximum level but a further decrease, both in the cultivation time (X_4) and the pH (X_3) decreased the carotenoids production. In this study, the optimal pH for carotenoids production of the Moroccan strain of *D. salina* was pH 7.5. This result is in accordance with Çelekli and Dönmez (2006), that maximum β-carotene accumulation and cell number were obtained at pH 7.5. Generally, formation of carotenoid in microorganisms is dependent on the strain, the culture medium and cultivation conditions .In present results, maximum carotenoids production was obtained at 96 hr. Similarly, another study maximum production of carotenoid by *R. glutinis* was obtained after 80 hr (Marova et al 2012).

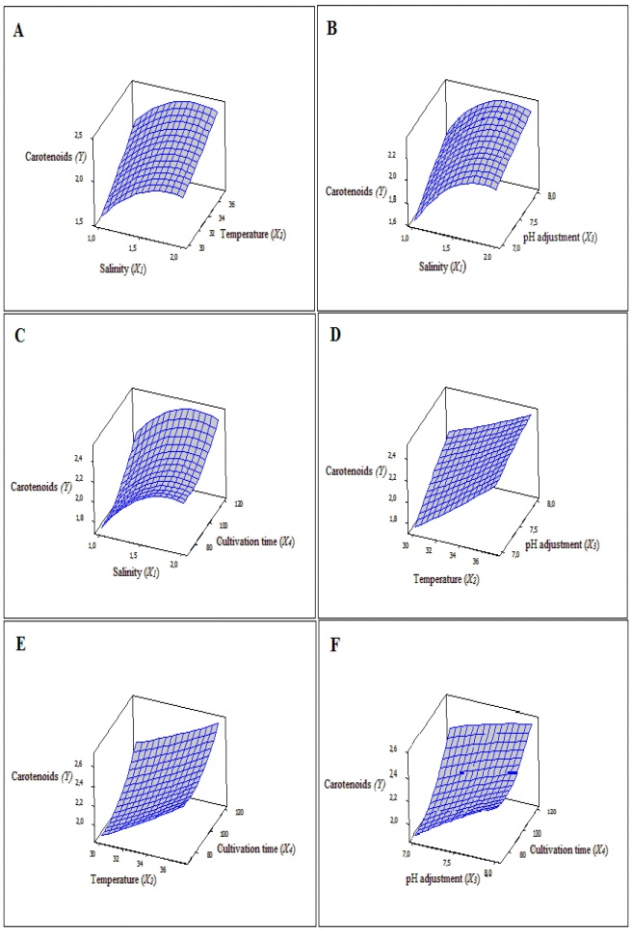

Fig. 5. Response surface plots (3D) showing the influence of four studied variables on carotenoids production

Fitting the models and adequacy of the refined models: Experimental design, the factor levels and the results of all 27 runs are illustrated in Table 1 and 2. The experimental data from these tables was used to analyze the effect of independent variables on cell growth (Y_1) through regression analysis and the functional relationship derived is shown below:

Cell growth (Y_1) = $-128.554+9.249\ X_1 - 1.352\ X_2 + 37.143X_3 + 0.256X_4 + 0.023X_1X_2 + 0.040X_1X_3 + 0.001X_1X_4 + 0.054X_2X_3 - 0.0111X_2X_4 - 0.007X_3X_4 - 2.606\ X_1^2 + 0.028X_2^2 - 2.578X_3^2 + 0.001X_4^2$

Where Y is the predicted response, i.e. cell growth (cells/mL), X_1, X_2, X_3 and $X_4$are the coded values of the test variables, salinity (mol L^{-1}), incubation temperature (°C), pH adjustment and cultivation time (h), respectively. Positive signs in front of the terms indicate synergistic effect while negative signs indicate antagonistic effects.

From the equations, the four process variables have linear and quadratic effects on cell growth. As shown in Table 3, the regression was highly significant (p <<0.05) and the lack of fit is significant ($p < 0.05$). These have been suggested that the design model adequately fits the experimental data. The R^2 value is always between 0 and 1. In this study, the value of the determination coefficient (R^2= 0.8503) indicated that 85.03 per cent of the variability in the response could be explained by the model.

The most important requirement in obtaining carotenoids from this *Dunaliella* species is to ensure optimum cultivation conditions. The empirical model in terms of coded factors for carotenoids production of the Moroccan strain of *D. salina* (Morocco-10) is as follows:

Carotenoids (Y_2) = $-20.583+4.185\ X_1+0.292\ X_2+ 2.960X_3 +0.015X_4 - 0.019X_1X_2 - 0.127X_1X_3 - 0.002X_1X_4 - 0.034X_2X_3 - 0.000X_2X_4 - 0.004X_3X_4 - 0.663\ X_1^2 + 0.001X_2^2 - 0.061X_3^2 + 0.000X_4^2$

where Y is the predicted response, i.e. carotenoids (µg ml^{-1}) ,X_1, X_2,X_3 and X_4 are the coded values of the test variables, salinity (mol l^{-1}), incubation temperature (°C), pH adjustment and cultivation time (h), respectively.

Statistical analysis for the response surface quadratic model for carotenoids production (Table 4) shows that salinity is the most effective variable for carotenoids production of the Moroccan strain of *D. salina*. The value of p for the model is less than 0.05, which indicates that the model significant and

Table 3. Analysis of variance of the model results for cells density of the Moroccan strain of *Dunaliella salina* (Morocco-10)

Source	Degree of Freedom (DF)	Sum of squares (SS)	Mean of squares (MS)	*p*-value
Model	14	38.2194	2.7300	0.005
Square	4	21.3754	5.3438	0.001
Interaction	6	3.6497	0.6083	0.424
Residual Error	12	6.7305	0.5609	-
Lack-fit	10	6.7039	0.6704	0.020
Total	26	44.9499	-	-

R^2= 0.8503

Table 2. Experimental design matrix and results of cells density and carotenoids production from the Moroccan strain of *Dunaliella salina* (Morocco-10)

Runs	Salinity mol L^{-1} (X1)	Temperature OC (X2)	pH time h (X3)	Cultivation (X4)	Cell density Number of cells* 10^6 mL^{-1}	Carotenoids (µg mL^{-1})
1	1.50	30.0	7.5	96	7.32	1.62
2	3.00	30.0	7.5	96	5.2	2.05
3	1.50	37.0	7.5	96	6.52	2.11
4	3.00	37.0	7.5	96	4.64	2.41
5	2.25	33.5	7.0	72	6.65	1.98
6	2.25	33.5	8.0	72	4.5	2.27
7	2.25	33.5	7.0	120	6.9	2.42
8	2.25	33.5	8.0	120	4.8	2.5
9	1.50	33.5	7.5	72	7.10	1.75
10	3.00	33.5	7. 5	72	5.06	2.13
11	1.50	33.5	7. 5	120	6.98	2.18
12	3.00	33.5	7.5	120	4.99	2.45
13	2.25	30.0	7.0	96	7.17	1.74
14	2.25	37.0	7.0	96	6.49	2.32
15	2.25	30.0	8.0	96	6.72	2.16
16	2.25	37.0	8.0	96	6.41	2.50
17	1.50	33.5	7.0	96	6.08	1.52
18	3.00	33.5	7.0	96	4.12	2.03
19	1.50	33.5	8.0	96	6.2	1.98
20	3.00	33.5	8.0	96	4.3	2.37
21	2.25	30.0	7.5	72	7.19	1.81
22	2.25	37.0	7.5	72	5.59	2.35
23	2.25	30.0	7.5	120	8.99	2.28
24	2.25	37.0	7.5	120	6.61	2.71
25	2.25	33.5	7.5	96	7.02	2.17
26	2.25	33.5	7.5	96	7.04	2.10
27	2.25	33.5	7.5	96	7.02	2.18

Table 4. Analysis of variance of the model results for carotenoids production by the Moroccan strain of *Dunaliella salina* (Morocco-10)

Source	Degree of Freedom (DF)	Sum of squares (SS)	Mean of squares (MS)	p-value
Model	14	2.104	0.150	0.000
X_1: Salinity1	1	0.428	0.048	0.003
X_2: Temperature1	1	0.618	0.008	0.155
X_3: pH of adjustment1	1	0.265	0.011	0.100
X_4:Cultivation time1	1	0.424	0.001	0.521
Square	4	0.327	0.081	0.000
Interaction	6	0.039	0.006	0.163
Residual Error	12	0.041	0.003	-
Lack-fit	10	0.041	0.041	0.002
Total	26	-	-	-

R^2=0.9805

representative. The *R*-squared value of the carotenoids production model was 0.9805 or 98.05 per cent of the total variation in the results can be attributed to the investigated independent variables.

CONCLUSIONS

A new Moroccan strain of halophilic microalgae, *Dunaliella salina* (Morocco-10), was isolated from evaporating salt ponds by using response surface methodology (RSM) to optimize the environmental factors. The results showed that the Box–Behnken design (BBD) can be successfully employed to reveal medium optimization conditions for *D. salina* in mixotrophic culture. Salinity showed the most significant effect on cell growth and carotenoids production. This study has shown that the Moroccan strain of *D. salina* (Morocco-10) is suitable for the producing large amounts of carotenoids on a commercial scale. Morocco is favored by possessing many salt marshes with an equitable climate for the growth of *D. salina* including strong sun light radiation to promote cell growth and carotenoids production. Aqua-culture of this alga offers a potentially viable option for carotenoids production in Morocco.

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Arthropod Diversity in Horticultural Ecosystems in Keelaiyur Block, Nagapattinam District, Tamil Nadu

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Abstract: Study was conducted to find the arthropod diversity in horticultural ecosystems especially in vegetable crops, fruit crops, and flower crops. Spiders were collected following standard techniques and identified. From the collection, eighteen species under eleven families were identified i.e., Salticidae: *Plexippus paykulli*, *P. chandraseharani, P. petersi, Telamonia dimidiata*; Oxyopidae: *Oxyopes birmanicus*, *O. salticus, O. shweta*; Sparassidae: *Palystes castaneus, Olios milleti*; Hersilidae: *Hersilia sp*., *H. savignyi;* Araneidae: *Neoscona rumpfi*; Erisidae: *Steogodyphus sarasinorum*; Lycosidae: *Pardosa pseudoannulata*; Theraphosidae: *Poecilotheria striata;* Thomisidae: *Oxytate virens*; Philodromidae: *Philodromus sp*; Pisauridae: *Dolomedes tenebrosus.* Shannon diversity index was maximum (1.18) in vegetables during April to July and minimum diversity was observed during May (1.04) in flowering crops.

***Keywords*:** Arthropod, Diversity, Fruit crops, Spiders

India is exceptionally rich in biodiversity with a very large species composition of 45,000 plant species and 81,000 animal species representing seven per cent of world's flora and 6.5 per cent of world's fauna, and is one of the 12 centres of mega diversity in the world. The natural forest litter ecosystem with its floral diversity and specialized micro niches supports a variety of macro and micro arthropods involving different trophic levels. Arthropod inventories can be good indicators of habitat biodiversity because arthropods respond quickly to environmental changes, since they are highly diverse in nature. Many amphibians, reptiles, birds, mammals and spiders are good indicators of environmental health. They play important roles in the dynamics of a specific habitat and are sensitive to habitat loss, climatic change and environmental upheavals. This study focuses on the influence of weather parameters on the changes in population and diversity of arthropods in bamboo plantations.

MATERIAL AND METHODS

Study area: The study was carried out at Keelaiyur block of Nagapattinam district in villages of Thirupoondi east, Vilunthamavadi, Thirupoondi west, Pudupalli,Valakarai, Karunkanni, Palakurichi, Cholavidyapuram. In these villages, observations were made for spiders in vegetable crops like brinjal, fruit crops and flower crops like jasmine.

Spider survey: The study was carried out during April to July 2018 in all the six villages and the specimens were collected by following standard techniques (Sutherland1996). Individual spider species were collected, identified and biodiversity of spiders was calculated using Shannon wiener index. The five standard sampling methods such as, Visual searching cum Hand picking, Net sweeping, Beating tray, Pitfall traps and Leaf litter traps. Visual searching cum hand picking and Net sweeping methods were employed for spider collection in this study. Collected arthropods were sorted out based on taxon. Soft bodied insects and spider species were preserved in 70 per cent ethyl alcohol in glass vials. Insects were identified by following Lefroy (1984), Comstock (1984), Reichard and Davis (1993) and Ayyar (1984) and with the help of spider taxonomists.

Shannon-Wiener Index of diversity: Shannon-Wiener index of diversity was used to examine the overall community characteristics comparing two or more distinct habitats. It is a measure of the possibility that the next individual will be the same spider species as the previous sample.

Shannon-Wiener Index of diversity was calculated (Batten 1976).

$$H' = - \Sigma pi. lnpi$$

Where, pi is the proportional abundance of the i^{th} species = (ni/N).

RESULTS AND DISCUSSION:

Spider diversity: Totally 342 number of individuals were collected during the period of survey, on an average 155 in fruit crops, 98 in vegetable crops and 89 in flower crops. Spiders collected comes under 11 families and 18 species. Similar to this, in another study in horticultural ecosystems in Kashmir, a total of 5774 individuals belonging to 40 species 23 genera under 11 families were recorded (Akthar Ali Khan 2009). Based on the observation dominant spider family falls under Salticidae and the species are viz., *Plexippus paykulli*, *P. chandraseharani, P. petersi, Telamonia dimidiate* followed

by Oxyopidae family viz., *Oxyopes birmanicus*, *O. salticus, O. shweta.* The lowest distribution of spider family falls under Araneidae: *Neoscona rumpfi;* Eresidae: *Stegodyphus sarasinorum;* Lycosidae: *Paradosa pseudoannulata;* Theraphosidae: *Poecilotheria striata;* Thomisidae: *Oxytate virens;* Philodromidae: *Philodromus* sp; Pisauridae: *Dolomedes tenebrosus* (Table 1). In April, Salticidae species of spider are dominant: *Telamonia dimidiata* and Oxyopidae: *Oxyopes shweta*. Comparatively lower level of surveillance spider species was observed in Araneidae family viz., *Neoscona rumpfi* (Table 2). During the May month the dominant spider species are in family Salticidae: *Telamonia dimidiate*; Oxyopidae: *Oxyopes salticus* and Sparassidae: *Olios milleti*. Low level presence of spider species surveillance was observed in Araneidae: *Neoscona rumpfi*. During the month of June, dominant spider species collected was Oxyopidae: *Oxyopes shweta*. Lower level of spider species observed was Araneidae: *Neoscona rumpfi*. In July, the dominant spider species observed belongs to the family Oxyopidae: *Oxyopes shweta* and lower level of spider species was observed as Araneidae: *Neoscona rumpfi*.

In this block, the major crops grown are vegetables, fruits and flowers. From the survey, it was observed that fruit crop has more number of spider individuals followed by vegetables and flowers. Shannon diversity index was maximum (1.18) in vegetables during April to July. Minimum diversity was observed during May (1.04) in flowering crops (Table 2).

In this study, major number of individuals was collected more in the fruit crops followed by vegetable crops and the flower crops. The major crops grown are vegetables, fruits and flowers. Shannon diversity index was maximum (1.18) in vegetables during April to July. Minimum diversity was during May (1.04) in flowering crops. Shunmugavelu *et al.,* (2011) reported 20 species of spiders in bhendi field of Chekkanoorani near Madurai representing eight families and 15 genera. The most frequently encountered species were *Argiope pulchella* (Thorell)*, Argiope lobata* (Pallas)*, Cyrtophora citricola* (Forskal), *Leucauge decorata* (Blackwall), *Neoscona crucifera* (Lucas), *Gasteracantha aciculata* (Pocock), *Cyclosa conica* (Pallas), *Hersilia savignyi* (Lucas), *Latrodectus hasselti* (Thorell), *Nephila pilipes* (Fabricius), *Peucetia viridana* (Stoliczka), *Peucetia graminea* (Pocock), *Oxyopes ratnae* (Tikader), *Stegodyphus sarasinorum* (Karsch), *Heteropoda phasma* (Simon), *Heteropoda venatoria (*Linnaeus), *Micrommata virescens* (Clerck), *Tetragnatha mandibulata* (Walckenaer), *Tetragnatha anguilla* (Thorell) and *Leucauge festiva* (Blackwall). Ganesan and Shunmugavelu (2012) recorded a faunal survey of 25 species of spiders belonging to 21 genera and 10 families in Perumalmalai forest area, Tamil Nadu. Climatic factors might influence the abundance and diversity of arthropods by affecting their habitat, movement and altering the suitability of food plants. In another study, it was found that soil arthropod communities were higher in dry season or early rainy season than in middle rainy season (Yang and Tang 2004) and manmade forest habitat in Menagesha holds the highest diversity of insects in both dry and wet seasons (Tamrat Aydagnhum 2007).

Table 1. List of spider species collected in different cropping systems in Keelaiyur block

Family	Scientific name
Salticidae	*Plexippus paykulli* *P. chandraseharani* *P. petersi* *Telamonia dimidiate*
Oxyopidae	*Oxyopes birmanicus* *O. salticus* *O. shweta*
Sparassidae	*Palystes castaneus* *Olios millet*
Hersilidae	*Hersilia* sp *H. savignyi*
Araneidae	*Neoscona rumpfi*
Eresidae	*Stegodyphus sarasinorum*
Lycosidae	*Paradosa pseudoannulata*
Theraphosidae	*Poecilotheria striata*
Thomisidae	*Oxytate virens*
Philodromidae	*Philodromus* sp
Pisauridae	*Dolomedes tenebrosus*

Table 2. Shannon diversity index of spider species collected during April to July

Month	Crop	H'
April	Vegetable crops	1.18
	Fruit crops	1.12
	Flower crops	1.01
May	Vegetable crops	1.12
	Fruit crops	1.20
	Flower crops	1.04
June	Vegetable crops	1.13
	Fruit crops	1.12
	Flower crops	0.93
July	Vegetable crops	1.18
	Fruit crops	1.12
	Flower crops	1.01

CONCLUSION

Spiders are the important predatory organisms in all

Plexippus paykulli *Telamonia dimidiate* *Pardosa pseudoannulata*

Oxyopes shweta *Olios milleti* *Hersilia savignyi*

Plate 1. Spider species collected from Keelaiyur block in different agro ecosystems

ecosystems which they inhibit, with a high prey finding ability and capacity to consume greater number of prey. They feed on variety of organisms. From the study it was observed that the diversity value was maximum in fruit crops during May month and minimum in flowering crops. This might be attributed to the prevailing environmental conditions like temperature, rainfall and other aspects, which favour more availability of prey and least occurrence of natural enemies like parasitic wasps, which favoured spider species. The spiders belonging to salticidae was maximum when compared to other families.

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Antropogenic Factors of Azov Sea Bioproductivity Transformation: Ecological History of Industrial Epoch

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Abstract: The problems of marine areas anthropogenic transformation are priorities of all coastal states. The Azov sea has the unique physical and geographical conditions that predetermine the peculiarities of marine resource usage. This is the smallest sea of the world ocean (37,800 km^2), the shallowest (depth is not more than 14 m), with insignificant salinity (about 13-14%), but it has very high biological productivity (up to 40 kg ha^{-1} of the water area) and biosphere value. The industrial era of Ukraine and Russia development in the Soviet Union, which began in the middle of the twentieth century, has led to a radical transformation of the physical and geographical conditions that affect the Azov sea resources formation. The changes that took place in the hydrological, and then in the biological processes of the Azov sea, far exceeded the limit of adaptation of a significant number of existing fish there, which led to a sharp reduction in their number and even death. As a result of the research, the interdependence of the hydrological and hydrochemical regimes of the Azov sea and the increasing role of anthropogenic factors in the functioning of the marine ecosystem, transformation of biological productivity and disturbance of its equilibrium have been established. It is proved that at the current level of urbanization, industrial and agricultural production in the Azov sea basin the reproduction of biological resources at the level of 30-50 ies of the twentieth century is impossible. The factors confirming this conclusion were substantiated: 1. Salinity is an important criterion, the existence and reproduction of certain ecological groups of fish depends on its level. The level of salinity is an integral indicator of the Azov sea water balance, the incoming part of which is almost completely controlled by water users of the Russian Federation, located in the basins of the Kuban and Don rivers. 2. Hydrotechnical structures with long service life (primarily Tsimlyanska HPP, Russian Federation) interfere with the normal spawning migration of valuable Azov fish. 3. Reduced river flow (especially in spring and summer), which formed in 95% on the Russian Federation territory and reduced almost three times the number of primary biomass and affect the maintenance of the food base of fish fauna of the sea significantly.

Keywords: Azov sea, Anthropogenic transformation, Bioproductivity, Hydrological regime, Fish resources

Problems of marine waters of coastal zones and regions development have become more urgent in the last period of society vital activity development. Sea of Azov and its coastal areas is the region of developed industrial, agrarian and marine ecosystem interaction. This leads to increased anthropogenic impact on the marine ecosystem and its significant transformation and complexity of environmental problems. The industrial era of Ukraine and Russia development in the Soviet Union, which began in the middle of the twentieth century, has led to a radical transformation of the physical and geographical conditions that affect the Azov sea resources formation and has led to its de-industrialization. The Azov sea (the most continental sea of the World Ocean) has been influenced by a variety of factors. The transformation of the hydrological functioning conditions has occurred, which has led to a change in the salt regime. Intensive catch cut fish resources. New living organisms' invasions have demonstrated the potential of a biological catastrophe. At the same time, the artificial settlement of other fish species allows maintaining the aquatorium productivity, although at a lower level.

The Azov sea has the unique physical and geographical conditions that predetermine the peculiarities of marine resource usage (Fig. 1). Firstly, it is the smallest sea in the world ocean: its area without the Gulf of Sivash and estuaries is 37.8 thousand km^2, and the volume of water mass (according to various estimates) from 256 to 320 km^3. Secondly, it is the shallowest sea - its largest depth does not exceed 14 m, the average is about 7-8 m and the water depths up to 5 m and occupies more than 50% of the total area of the sea (Bronfman 1972). Thirdly, despite the location in moderate latitudes (limited by parallels of 45°16' and 47°17' E Latitude and meridians of 33°36' and 39°21' E Length) and insignificant salinity (about 13-14%).

Note that the water regime of the Azov sea depends mainly on the following factors: a) the flow of fresh river water; b) the flow of moisture due to atmospheric precipitation; c) the arrival of salty waters from Sivash and the Black Sea; d) the flow of water from the Sea of Azov to evaporation and into the stream through the Kerch Strait in the Black Sea. The total area of the Basin (catchment) of the Azov sea is 593 thousand km^2. It is mainly located in a zone of insufficient and

unstable moisture, with a moisture deficit of about 400 mm year^{-1}. The water balance of the Azov sea reflects the Table 1.

As can be seen from Table 1, the volume of river water entering the sea is quite significant and amounts to about half of the total revenue, as well as almost 12 per cent of the total volume of the Azov sea (this is the highest of all the world's seas). Excessive inflow of river and atmospheric waters over evaporation from the surface of the sea would lead to its growing desalination and increase its level if there was no water exchange with the Black Sea. As a result of this water exchange in the Sea of Azov salinity, favorable for the existence of valuable industrial fish in it.

At the same time, the Azov sea basin is one of the most densely populated and involved in the economic activity of both territories - Ukraine and Russia, so the influence of man on river runoff is very ponderable. Among the most significant effects of anthropogenic impact on the Azov sea water regime, we note its violation as a result of the regulation of the Don and the Kuban runoff, the construction of rice irrigation systems in the Krasnodar territory, in connection with the increase in the cost of river water for settlements water supply and the satisfaction of industry needs.

MATERIAL AND METHODS

The factual basis of the study consisted of statistical materials from the Kherson, Donetsk, Zaporizhzhia regional statistics departments and Autonomous Republic of Crimea statistics departments, Council of Productive Forces of Ukraine NAS statistical materials, materials from the Institute of Geological Sciences, the Azov Scientific Research Institute of Fisheries (Rostov-on -Don), Southern Scientific Research Institute of Fisheries and Oceanology (Kerch). In terms of methodology, theoretical research was carried out in three major approaches: functional and sectoral, regional and environmental. The objectives of the study were solved using such a combination of methods: system-structural analysis, statistical analysis, zoning, mapping and comparative geographic methods.

RESULTS AND DISCUSSION

By the mid of the 20th century, but rather to 1951, the annual flow sampling of the Don and the Kuban was insignificant. The average annual sea salinity also changed slightly: in the 1932-1934, after the rich-weather period, the salinity was 96 per cent, in 1939 - after the low water period, it

Fig. 1. Geographical position of the Azov Sea

Table 1. Azov Sea water balance *

Source of water (inflow/outflow)	Total flow		Total out flow	
	Total flow (km^3)	Share in per cent of total inflow	Total out of flow (km^3)	Share in per cent of total outflow
River runoff including:	38, 8	46,1	-	-
Don river	26, 9			
Kuban river	10, 1			
Atmosphere	13,8 (atmospheric precipitation)	16,4	35,3 (evaporation)	42, 0
Black Sea (Kerch strait)	31, 2	37,1	47, 4	56, 4
Sivash (duct tonka)	0, 3	0, 1	1, 4	1, 6
Total	84, 1	100	84,1	100

* Calculated by authors (Altman 1972, Fedosov et al 1955, Tsurikova et al 1964)

was 12,1 per cent. The average salinity of Azov in the period from 1923 to 1951 was 10,9 per cent. The salinity of the Taganrog Gulf varied from 3,7 per cent in 1927 to 8 per cent in 1939. During the period of 1932-1951, the salinity was 6,2 per cent. In 1952 Tsimlyansk reservoir started to operate. As a result of the regulation of the Don river, the permanent irreversible removal of fresh water for the needs of other economy sectors, there were primarily significant changes in the regime of Azov sea salinity. In our time, the annual fresh water sampling in the sea is more than 30 per cent (in less water years, 42 km^3 of fresh water in the sea gets only 28-30 km^3), which leads to a over negative effects. It has been calculated (Makarov et al 1955) that the inflow of Azov sea fresh water has decreased by 18,3 km^3 at the present stage, which is almost double. This situation has led to a significant increase in the Azov sea water salinity, which in turn threatens the catastrophe for the reproduction of passable and semi-precious fish.

The chemical composition of Azov waters, it also has the features of the composition of the main salt-forming cells. As in the ocean, chlorides are predominant in the waters of the Azov sea. But unlike ocean water salinity of Azov is much lower and slightly disturbed typical for ocean sustainability ratio of basic salt-forming cells. Thus, in comparison with oceanic, in Azov waters the relative content of calcium, carbonates and sulphates is elevated, and chlorine, sodium and potassium are lower (Gorev et al 1995). With an average of Azov waters salinity 13-14 per cent in 1975, there are significant spatial differences in the distribution of salinity: the highest salinity is 17,5 per cent in the Kerch region of the Azov sea as a result of the salty Black sea waters flow; the central part of the sea is very homogeneous in terms of salinity, which is 12-12,5 per cent, and only a small region has a salinity of 13 per cent; in Taganrog Gulf salinity gradually decreases to the mouth of the Don to from 6.5 to 1.3 per cent. A special regime of salinity is the characteristic of Sivash (20-166 %), which is due to the insignificant inflow of fresh water in the conditions of the small depths of the bay (maximum depth is 3,5 m) (Marty et al 1976).

However, it should be noted that this mode of saltiness of the Azov sea is not natural, since it is due to the influence of anthropogenic factors, in particular, regulation of river flow. According to estimates carried out during the period 1920-1950-ies (that is, during the period of the conditional natural regime of the mainland runoff), the average perennial salinity of the Azov sea was 10.4 per cent, with fluctuations from 9.1 to 11.8 per cent (Review 1993).

According to Bronfman (1972), with increasing water content of the resultant effluent is still able to offset the negative environmental impacts of human intake of previous years and return the ecosystem of the sea to its natural state. First of all, it concerns the restoration of natural salinity and oxygen regime. Increase intake of fresh series of shallow flow in the years can cause negative transformation of Azov ecosystem to an irreversible condition.

Significant amounts of runoff to the Azov sea and its complicated water exchange with the Black sea affect the chemical composition of the present Azov waters, it reflects Figure 2.

In addition to these mineral substances, 17,1 thousand tons of phosphorus, 75,3 thousand tons of nitrogen and 119.7 thousand tons of silicon are sent to the Azov sea along with river waters and industrial wastewater. The wealth of the Azov sea with nutrients creates favorable conditions for the

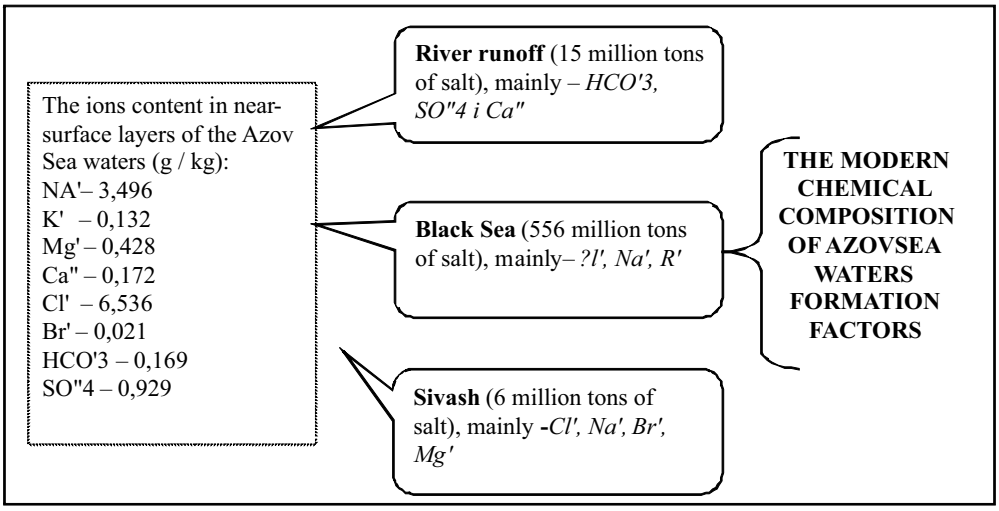

Fig. 2. Modern chemical composition of the Azov sea waters and the factors of its formation

development of life. Some of these substances is submitted to the Black sea, the part is removed from the sea with fishing, but most of it is accumulated in the soil at the bottom of the Azov sea. For example, phosphorus remains about 13 thousand tons or 76 per cent, nitrogen - about 31 thousand tons or 41 per cent, silicon - more than 82 thousand tons, or 69 per cent. It significantly changes the biotic regime of the sea and indicates the need for more modern technologies in industry and agriculture with the aim of wastewater treatment.

Shallow water, high biological productivity of the Azov sea, good mixing of water leads to the presence in its waters of large amounts of ammonia and oxygen. The content of dissolved oxygen reaches 7-8 cm^3 / liter. However, due to the summer slowdown vertical water circulation with no wind the aeration of lower horizons disturbed and a lack of oxygen is often observed (Gubanov et al 1998). Favorable conditions for the occurrence of oxygen deficiency also create the presence of silt deposits, rich in organic substances, the oxidation of which also requires a significant amount of this chemical compound. Lack of oxygen causes the phenomenon of so-called "fish death." The death of fish can also be caused by the development of blue-green algae, which by dying pollute the water with poisonous substances.

In addition to changing the hydrological regime, the chemical characteristics of water, an important feature of changing the physical and geographical conditions of the Azov sea is its shallowing. If 1906 was the largest sea depth was 16 m (Aksenov 1957), now the maximum depth is no more than 13,5-14 m. The process of the Azov sea shallowing is explained by the following factors:

- a large number of solid sediment runoff coming from the Don and Kuban;
- washed into rivers and the sea soil due to intensive land use and strengthening of water erosion;
- the effect of dust storms;
- deforestation in the rivers' valleys;
- accumulation of sedimentary material due to coast abrasion (about 8 million tons annually);
- accumulation of shells of plankton and benthic organisms.

The annual total amount of sediment in the Azov sea is about 41 million tons, which in terms of the area of the water area is about 2,5 mm per year.

Due to its small size, the Azov sea does not exert a great influence on the climate of the surrounding areas, except for coastal areas. On the contrary, large steppe areas of the southern part of Ukraine, Pre-Caucasus and Crimea, with their fairly dry climates, which surround the sea, are significantly influenced by the climate of the Azov sea. The temperature regime of the surface water layer is as follows: the lowest temperatures are observed in the northern and eastern parts of the Azov sea (winter temperatures for December-February range from 0 to +1°C, summer in July-August from +22 to + 25°C); higher temperatures in the western and southern coastal regions (in the winter from 0 to + 3°C, and in summer - up to + 26°C). The average annual water temperature in the Azov sea in the north is + 11°C, and in the south up to + 12°C. In the summer, the sea is very warm and near the shores the temperature of the water can reach + 30 + 32°C, and in the middle part + 24 + 25°C. In winter there is ice, which in some years lasts 4-4, 5 months, from December to March, with the ice capacity reaching 80-90 cm.

There is also a special regime of fluctuations of the level and flow for the Azov sea. The emergence of currents is primarily due to the influence of air circulation, as well as compensating phenomena and river runoff. These factors explain the presence of a circular current in the sea with the movement of water counter clockwise, and also the presence of a southwestern flow in the Taganrog Gulf (Kotovskiy 1991, Palienko et al 2001).

The sea level varies annually, during the year and even during the day due to changes in the size of the river runoff and the influence of winds, in particular, degradation phenomena. The sea level varies annually, during the year and even during the day due to changes in the size of the river runoff and the influence of winds, in particular, degradation phenomena. Acquisition of river waters in the sea of Azov has a well-defined annual course with a maximum in the spring and a minimum in winter, which, in fact, reflects the level of the sea of Azov. The amplitude of the fluctuations of the average lunar sea levels is small and is 25-50cm during the year. More sharply expressed short-term changes in the level caused by the wind, and these changes in the sea level in its various parts are "different by sign" near one shore the level decreases, near others - increases (Mamykina et al 1980).

Under the influence of storm winds of the north-eastern and eastern directions there is a strong formation of water from the estuaries and the sea along the eastern coast and the accumulation of water to the western coast, in particular the Gulf of Sivash. The maximum water level in the Taganrog area is more than 5km, here the maximum variation and between the water levels is 5.5m. In the central part of the sea, the level fluctuations are much lower. Wrecking phenomena are dangerous for navigation and recreation, but they promote the water exchange between the Azov and Black seas.

The biosphere value of the Azov sea is determined by one more of its peculiarity, related to physical and geographical conditions. It is known that through the northern

Azov sea, there is a path through which, during the spring and autumn periods, migrations of birds, nesting mainly in the north of Western Siberia, take place. During migration to the Molochny, Utlyuk, Obitochny estuaries (due to the large amounts of feed), there is a significant concentration of waterfowl flying birds. The following groups of birds are predominant: charadrii, larus, gavias, tadornatadorna, anseriformes, pelecaniformes, ciconiiformes, raptors and coracias.

Separate research and analysis of their properties requires biological resources that are the most valuable part of the Azov sea. It is these resources in the process of their reproduction are as vulnerable as possible, which is confirmed not only by the dynamics of catching Azov fish, but also by significant differences in the structure of catches at various stages. The structure and magnitude of the fishery resources of any reservoir are in close connection with their feed base. This requires their detailed study and evaluation to ensure the required balance.

In the Sea of Azov, the feed base for fish consists of several zoo and phyto groups: planktonic algae, macrophytes (higher aquatic plants), zooplankton, zoobenthos, detritus, phytoplankton. The main sources of fish in the Azov Sea include plankton, as well as benthos (for bottom fish species). It should be noted that the total mass of benthos at the present stage is 270-275 g m^{-2} and compared with the period before the regulation of the Don and the Kuban flow has decreased by 30-40 per cent.

Almost all types of pelagic fish use plankton algae as food. A large number of mineral substances entering the sea with rivers, causes a significant development of plankton algae. Their biomass sometimes reaches an incredible amount (200 g m^{-3}), primarily due to the massive development of diatom plankton algae in the spring and autumn. Sometimes, as in freshwater basins, there is a flowering of water caused by the massive development of blue-green algae, and in most cases the Taganrog Gulf is eutrophied.

The ichthyofauna of the Azov sea consists of 79 species of fish, 47 of which are marine, 7 passable, 12 semi- passable and 13 freshwater. By the time of the river regulation the biomass flow of industrial fish stocks, according to the estimation of 40-50-s of the XX century was determined at 600 thousand tons, and based on the data of "benthos throw" - 600-900 thousand tons of benthic fish. In 1956, on the basis of taking into account the main groups of the ihteoenosis, until the time of the regulation the biomass flow was estimated at 1300 thousand tons.

The Azov sea belongs to the most productive seas of the world (up to 40 kg ha^{-1} of the water area). From the history of Azov sea fish product complex development it is known that for a long time it was the most productive reservoir of the World Ocean. In the 30s of the XXth century, during the period of maximum catches, almost 160 thousand tons of fish were extracted annually: 10 thousand tons of *Acipenseridae*, 74 thousand tons of *Sander*, 13 thousand tons of *Gobiidae.* In the postwar years Azov sea accounted for almost half of all catches of fish in Ukraine. At the beginning of the 1990s catch volumes decreased more than 10 times, and the share of fish catches in the Azov sea amounted to 32,3% of the total catch in Ukrainian waters (Pylypenko 2005).

In the years of the Azov fishing heyday in the mid-1930s, one hectare of water in the sea of Azov was seized 7 times more than in the Caspian sea, 12 times more than in the Baltic Sea, and 35 times more than in the Black Sea. In recent years, fishing in the Azov sea varies in the range of 5-6 thousand tons and is determined by the number of *Engraulis encrasicolus* and *Clupeonella cultriventris*.

Azov fishes by genesis, distribution and biology are divided into 7 groups (Pylypenko 2005):

1. Mediterranean invaders

1.1. The naturalized invaders who spend all their lives in this sea - *Psetta maxima maeotica*, *Gobiidae*, etc.

1.2. The invaders which live in the Azov sea only part of the year, and then return to Black or even the Marmara sea - *Mugil*, *Mullusbarbatus*, *Engraulis encrasicolus*.

1.3. The invaders which irregularly enter the Azov sea - *Scomber*, *Thunnus thynnus*.

2. Relics - autochthons of the Pontic fauna ("Caspian")

2.1. Relic fish, which do not go beyond the Azov sea – *Percarina demidoffi.*

2.2. Passage forms - *Acipenser*, *Acipenser stellatus*.

2.3. Fish that spend part of life in the Azov sea, part - in the Black sea, and part - in the rivers - *Clupea*, *Alosa*, *Husohuso*.

3. Semi-migrating (fluvial anadromous) fish and migratory fish - *Sander*, *Abramisbrama*.

The value of the fishery resources of the Azov sea is definitely great, as the characteristics of its commercial fishing evidenced.

The Azov sea is the main water catchment area of the most valuable fish species - *Acipenseridae*. They are represented by *Acipenser*, *Acipenser stellatus* and *Acipenser nudiventris*. Meat and caviar of these fish are nutritious and tasteful, they are suitable for any culinary processing and have a high demand on the consumer market. However, these fish differ in a long period of life, late maturing and not annual spawning. Therefore, they are characterized by low productivity and increased environmental quality requirements. The study (Billard et al 2000) noted that the world catching of *Acipenseridae* in 1982

was almost 28,000 tons, and in 1999 - less than 2,000 tons. This decrease was caused by extremely important changes and degradation of the environment under the influence of anthropogenic factors

Valuable nutritional and taste qualities characterize the following species of fish - *Sander*. Because of its low fatness it is especially valuable in dietary nutrition. According to estimates, industrial stocks in the late 90's and early 2000's were 8,0-8,500 tons. Annual catch standards were set at 2,000 tons.

One of the commercial objects of fishing has become well acclimatized in Azov *Liza haematocheilus*. It also has a good taste, reaches considerable size (weight - 6 kg, length - 70-75 cm), differs unpretentious to the fodder base (even has a noncompetitive feed base), temperature and salinity changes. Approximately, its number is estimated at 20 million copies. Among other types of fish, *Psetta maxima maeotica* is in demand on the consumer market. It can be classified as medium-sized (length - 41 cm, weight - 2,0-2,6 kg). About 5,0 thousand tons of biomass reaches the *Abramisbrama*. Compared to the 80's, it has decreased by more than 3 times. Therefore, in the present conditions *Abramisbrama* fishing is limited to the level of 1,0-2,0 thousand tons.

The other traditional Azov fish have smaller size and somewhat poorer nutritional quality. This is *Rutilus heckelii* (length - 20 cm, weight - 400 g). Its population declined in comparison with the 80s by 7.4 times and is about 14 million copies. The catches fluctuate at the level of 10-20 tons. The *Vimba* and *Pelecus cultratus* have the similar characteristics (35-45 cm in length and 900 g in weight), but due to a sharp decrease in industrial stocks do not have the value.

In Azov the family of herring is represented by *Alosa*, Azov-Black Sea and Azov (Kerch) herring. These are valuable industrial fish, but their contemporary catch is insignificant as a result of previous years over catching.

The most mass species of Azov sea fish are the Azov *Engraulis encrasicolus* and *Clupeonella cultriventris*. Despite the small size, these fish species have an extremely favorable circs for fattening, and therefore have high fatness and good taste. It provides the largest volumes of their fishing and processing. Note that reducing of the plankton amount after runoff controlling negatively affects the nutrition of planktonphagus and among them there is a tense dietary relationship.

At the same time, in the 80's and 90's of the twentieth century. The catches of fish and fish products in the Azov sea declined sharply (Table 2). Most scientists (Aldakimova et al 1977, Bronfman 1985, Zhukov 1978, Serobaba 1998, Faschuk 1998, Faschuk et al 1999) explains this phenomenon by changing the physics and geographical conditions and hydrological regime of the sea under the influence of anthropogenic factors.

The analysis of available materials makes it possible to emphasize that the biological resources reproduction features occur as a result of an anthropogenic factors role increase in the functioning of the marine ecosystem and disturbance of its equilibrium. It should be noted that with high productivity, caused by high volumes of land drainage, shallowness, intensive mixing, warming, small volume of water, this fact makes the biological system of the Azov sea especially sharply reacting to environmental conditions changes.

The physical and geographical conditions affecting the formation of the Azov sea resources have changed over the past decades in such a way that it significantly affected the quantity and quality of its resources (Gan 1973, Doroshenko 1999). It is known that hydrobionts can adapt to pressure changes, a sharp change in the temperature of air and water, to the reduction of oxygen content and even some kinds of poisons, but, of course, there are always certain change limits. Each species of flora and fauna has its own range of limiting factors (depth, salinity, temperature, light, dissolved oxygen content, etc.) and has an ecological valency characteristic for each type, that is, the ability to live in a certain range of these factors quantities. For normal life, and even for the species survival, one factor, or one substance represented by the smallest weight of the necessary whole (the so-called Liebiah minimum law, which extends to physical and biological factors) can become the determinant. The changes that took place in the hydrological, and then in the biological processes of the Azov sea, far exceeded the limit of adaptation of a significant number of existing fish there, which led to a sharp reduction in their number and even death.

Analysis of hydrological and hydrochemical features regimes revealed their interdependence, since the salinity regime and qualitative composition of the Azov sea salts is almost entirely dependent on the water balance, in particular

Table 2. Azov sea fish catch dynamics*

Years	Catch volume, thousands of tons	Years	Catch volume, thousands of tons
1930	124,3	1975	153,6
1936	304,5	1980	132,2
1940	128,0	1985	159,8
1950	122,0	1990	8,6
1960	114,0	1995	14,4
1970	208,2	2000	15,6

* Calculated by the authors according to the Azov Scientific-Research Institute of Fisheries

the river flow, but in the last period, the flow of fresh water to the Azov sea has decreased by 18.3 km^3. The synoptic situation, which differs significantly from year to year and which causes changes in the size of runoff, precipitation, temperature, significantly affects the hydrological, chemical, biological regimes of the reservoir. It, in particular, more directly changes the timing and level of heating and cooling of the water, the intensity of their movement in the winds. From this the terms of the development and reproduction of marine organisms change, on larger or smaller scale, there occur the phenomena of frost in the bottom layer, which cause large or less devastation in biocenoses, and as a consequence, changes in the reproduction of fish resources.

It should be noted that the greatest decrease in catch volumes and changes in the structure, particularly of valuable fish, began in the late 1980s (Fig. 3). Thus, in recent years the role of migratory fish, has increased (instead of about 4 per cent in 1936 to almost 17 per cent in the structure of catch in 2000). At the same time, the group of marine and 5-6 per cent of the semi-migratory fish decreased by about 10 per cent. As a result of the collapse of the fish reproduction in the Azov sea, *Acipenseridae* virtually lost to industrial fishing (a total ban on fishing). Almost lost are Azov-Don herring, *Platichthys flesus*, *Silurus glanis*, *Gobiidae.*

After all, such an undesirable tendency as a decrease in the size and weight of individual specimens of industrial fish appeared, as can be seen from the example of one of the most important industrial fishes of the Azov sea – the *Sander* (Table 3).

Changes in salinity have led to a significant reduction in habitats of valuable fish species. Significant increase started with the regulation of the Don River runoff and complicated removal of significant amounts of water from the Kuban River for rice and dry period in the mid-1970s of the last century [Palienko et al 2001]. Percentage of salinity increase in the Azov sea is presented in Figure 4 (for main sea water area) and 5 (for the Taganrog Gulf).

These materials analysis allows us to conclude that the largest increase in salinity is observed in the Taganrog Gulf - the most important sea area in terms of reproduction of ichthyofauna resources. Increasing salinity caused a significant decrease in annual runoff, reduced the area of residence of fish of different ecological groups that are most important for freshwater and semi-passed. At the same time, an increase in the mineralization of water negatively affected the youth of a number of valuable industrial species of fish, which became the reason for the emergence of low-yielding generations and, as a consequence, a general fall in the craft volumes. The *Abramisbrama*, *Rutilusheckelii*, *Sander*, *Cyprinuscarpio* suffered the most. Their share in the catch shows a steady decline and the proportion of marine fish species, as the most resistant to increasing salinity and increased contrast. If in 1960 the semi - passable made 24.5 per cent of the general catch, and the marine 74,2 per cent, then in 1980 3,5 per cent and 95,6 per cent consequently. From 7 per cent to 1-2 per cent the share of migratory fishes in the structure of fishing has decreased.

A negative role in the Azov sea biological productivity was played the reduction of the forage base due to the massive input into the water of the *Mnemiopsis leidyi* crust - a direct feed competitor of the main industrial Azov fish. The reserches of the XXI century beginning (Shiganova et al 2001, Purcell et al 2001, Paavola et al 2005, Pylypenko 2005) demonstrate the significant effect of temperature and salinity changes on the growth of M. Leidyi populations and its subsequent impact on the industrial fish population in the Black and Azov sea. In 1983, the average river flow in the Azov sea decreased significantly and at the same time there was a steady tendency to increase the salinity of seawater,

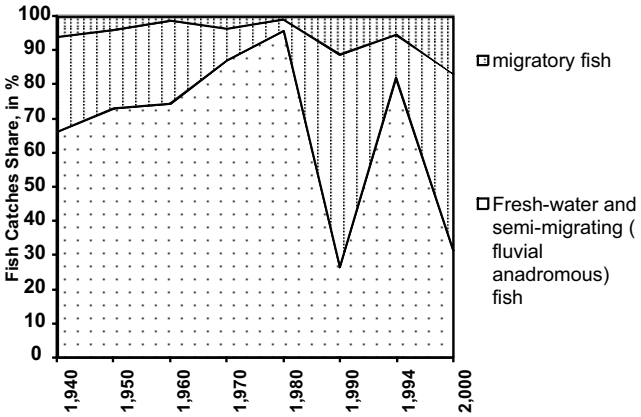

Fig. 3. Changes in the fish catches share of various ecological groups in the Azov sea (1940-2000)

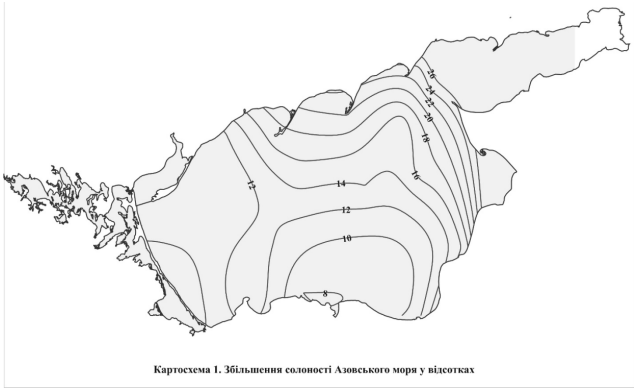

Fig. 4. Increase in the water salinity of the Azov sea in 2000 compared to 1951 (in %)

Table 3. Changes in the average weight of fish caught in the Azov sea basin *

1957	2000	Difference
2-years – 750 g	2- years – 477 g	-273 g
3- years – 1170 g	3- years – 780 g	-390 g
5- years – 2260 g	5- years – 1790 g	-470 g
7- years – 3140 g	7- years – 2680 g	-460 g

* Calculated by the authors according to the Azov Scientific-Research Institute of Fisheries

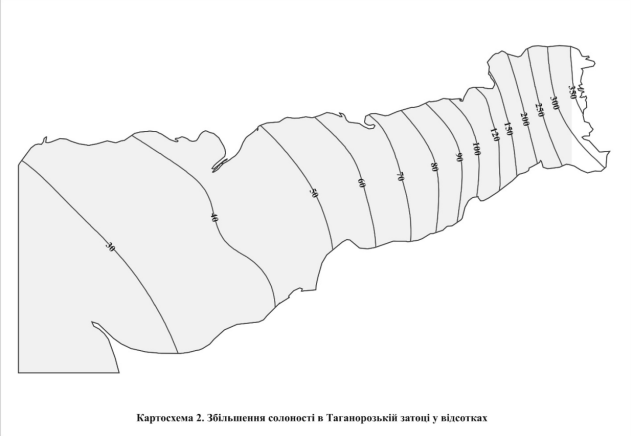

Fig. 5. Increase in the water salinity of the Taganrog Gulf in 2000 compared to 1951 (in %)

and anthropogenic pollution. Against this backdrop, in 1988, the invasion of the *Mnemiopsisleidyi* occurred. As a result, the already tense environmental situation in the Sea of Azov was further aggravated, primarily due to the insufficient amount of feed resources.

The main reasons for the deterioration of quantitative and qualitative indicators of catch (changes in structure and volumes) should be:

- excessive regulation of river runoff (first of all, the Don and the Kuban);
- progressive increase in mineralization and pollution of river runoff as a result of discharges of sewage from industrial enterprises and communal waste water from seaside cities (Mariupol, Berdyansk, Taganrog, Rostov-on-Don, Kerch, Genichesk);
- increase in salinity of the Azov sea, a sharp increase in the content of oil and heavy metals in sea water;
- pollution of coastal water areas of large and medium-sized cities on the coast of the Azov sea.
- in addition to the main environmental effects of economic activity, the negative effects of anthropogenic interference in the development and functioning of the Azov sea ecosystem can also be attributed to:
- silting the bottom during clearing and deepening of the fairway, expansion and deepening of ports water areas;
- dumping of soils in the coastal zone;
- pollution of the Azov sea area due to significant anthropogenic pressure on the coastal territories;
- pollution of the waters of the Kerch Strait by petroleum products as a result of intensive shipping.

For example, in 1989 an accident occurred in the city sewage system of Mariupol. As a result, the amount of nitric nitrogen in the waters of the Azov sea increased by 25 times, which led to a rapid increase in the number of cyanobacteria, which isolated alkaloids and peptides, reducing the oxygen content during the life cycle. This caused mass toxemia and death primarily of *Sander* i *Acipenseridae* (for example, more than 600 large *Acipenser* and 30 dolphins were found near the Achuevo village (Russia)). At the end of the twentieth century, due to the economic crisis in the CIS countries, there is an increase in fish catches in the Azov sea. In 1994, it amounted 32 thousand tons, during 9 months of 1999 enterprises of Ukraine (which provided data) caught 11,8 thousand tons.

CONCLUSIONS

At present the situation is complicated by the inability to significantly affect the formation and reproduction of some resources in the Ukraine, first of all - biological. This is due to the following factors:

1. Salinity is an important criterion, the existence and reproduction of certain ecological groups of fish depends on its level. The level of salinity is an integral indicator of the Azov sea water balance, the incoming part of which is almost completely controlled by water users of the Russian Federation, located in the basins of the Kuban and Don rivers.
2. Hydrotechnical structures with long service life (primarily Tsimlyanska HPP, Russian Federation) interfere with the normal spawning migration of valuable Azov fish such as *Acipenseridae* and some *Cyprinidae*.
3. Reduced river flow (especially in spring and summer), which formed in 95 per cent on the Russian Federation territory and reduced almost three times the number of primary biomass and affect the maintenance of the food base of fish fauna of the sea significantly.

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Influence of Elevated Zn on the Hematology, Serum Biochemistry and Productive Indicators in Laying Hens

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Abstract: Zinc is a common trace element and it plays a key role in living organisms. However, high zinc dose can be toxic. The aim of this study was to investigate the effect of high zinc doses on productive and biochemical parameters of laying hens and zinc accumulation patterns in various organs and tissues. The control group (group 1, n=30) and four experimental groups (10 animals each) were formed according to the random sample principle. For 30 days, the chickens of the experimental groups were administered 5 ml of an aqueous solution of zinc sulfate once a day. The total zinc dose to chickens with food and water was 250 mg $kg^{-1}$of feed (group 2), 500 mg kg^{-1} (group 3), 1000 mg kg^{-1} (group 4), and 1500 mg kg^{-1} (group 5). The living mass of chickens, egg production, hematologic and biochemical parameters of blood, zinc content in muscles, bones, feathers, liver, kidneys were determined. A dose of 1000 mg kg^{-1} and 1500 mg kg^{-1} zinc resulted in increased chick mortality, reduced body weight and egg production, as well as numerous pathological changes in organs and tissues. It was shown that zinc accumulation in the liver and kidneys was expressed to significantly greater degree than in muscle, bone and feather. In conclusion, a critical threshold zinc dose was set (1000 mg kg^{-1}) at which there is a sharp increase in its accumulation (10 times) in the poultry liver. The intake of elevated zinc doses decreased the total protein, bilirubin, creatinine as well as increased the concentration of hemoglobin and serum AST.

Keywords: Poultry, Zinc, Productivity, Blood biochemistry, Survivability, RODONIT cross

Zinc is one of the most common trace element in living organisms. This element plays a key role as a structural, catalytic and signal component in living systems. Zinc is a structural component of many transcription factors, such as protein modules of the "zinc fingers», in addition, zinc is a cofactor for many enzymes, such as oxidoreductases, transferases, hydrolases and others (Gamsjaeger et al 2007). Zinc can be signal mediator, since a change in the concentration of zinc ions in the cytoplasm of the cell can activate or inhibit a number of enzymes and thus it has an impact on vital activity. More than thirty proteins - zinc transporters, regulate zinc absorption in the intestine and zinc intake into a cell so an external zinc intake is strictly controlled and is determined by the organism needs. The organism is relatively resistant to the toxic effects of high doses of zinc (Kambe et al 2015), so zinc is regarded as relatively safe element, but when you receive it with food in very high concentrations it can still be toxic (Nielsen et al 2012). In humans, excess zinc intake can cause nausea, vomiting, diarrhea, lethargy and fatigue, disorders of respiratory function (especially when smoking), and increase the risk of prostate cancer. Excessive doses of zinc can cause decrease of copper intake and the associated functional impairment (Fosmire 1990, Plum et al 2010). Imbalance of zinc ions (Zn^{2+}) in the central nervous system plays an important role in the pathogenesis of several neurodegenerative diseases (Jellinger 2013).

Broiler chickens are considered relatively resistant to Zn intoxication, however, intake at concentrations exceeding the physiological mechanisms to compensate can result in a variety of pathological effects (Dean et al 1991). Due to the importance of zinc for life and its negative effects as a toxicant when excessive concentrations of this element are in the environment, studying the patterns of zinc accumulation in organs and tissues of farm animals, particularly poultry has become an urgent task. Currently, there are only a few works devoted to the study of toxic effects of high zinc concentrations in the body of chickens (Petukhov et al 2001). High doses of zinc intake from food in broiler chickens resulted in food input reduction, growth retardation and

multiple endocrine disorders (Dean et al 1991). Chicks zinc dietary intake of 100 mg kg^{-1} resulted in lower activity of pancreatic enzymes and changes in histological structure of pancreas tissues (Lu Combs 1988). However, the comprehensive work devoted to the high doses of zinc effects on the body of laying hens, as well as the trace elements patterns accumulation study in the chicken organs and tissues have not been conducted.

In Western Siberia regular monitoring of water, soil, plants and animals for the content of zinc and other trace elements was done (Miller et al 2013, Narozhnykh et al 2013, 2017, 2016, 2018, Petukhov et el 2016 a, b, Petukhova 2013). The aim of this study was to investigate the effect of high zinc concentrations in food on production and biological indicators of egg-laying hens, to determine the zinc accumulation level in various organs and tissues, and to explore the pathological changes in the chicken internal organs by intake of high zinc doses.

MATERIAL AND METHODS

A study conducted at the poultry farm number 1 on laying hens of Rodonit cross at the age of 180 days. This cross was obtained using the Lohmann Brown by Rodonit breeding poultry plant "Sverdlovsky" auto sexing quadric linear crosscourt line. The farm uses the cage method for keeping chickens (Fisinin 2013). In the soil, water and feed in the study area, there is no excess of the level of heavy metals (Syso 2017).The control group (group 1, n = 30) and four experimental groups (10 animals each) were formed according to the random sample principle. For 30 days, the chickens of the experimental groups drank 5 ml of an aqueous solution of zinc sulfate brand CHDA ($ZnSO_4 * 7H_2O$) by using the dispenser. The salt concentration in the water was calculated so that the total zinc dose to chickens with food and water daily, was 250 mg kg^{-1} (group 2), 500 mg kg^{-1} once (group 3), 1000 mg kg^{-1} (group 4), and 1500 mg kg^{-1} (group 5).

Eggs were collected twice a day before giving salt solutions to hens, and their number was taken into account by groups. Egg production was calculated as the number of eggs laid by one hen per day. After 30 days the live weight of laying hens was determined, then chickens of the control and experimental groups were slaughtered, blood, muscle, feathers, liver, bones and kidneys samples were taken. The content of erythrocytes was determined using the Goryaevcamera. Leucograms were counted visually using a hematological counter. Bloodserum content of total protein, bilirubin, hemoglobin, alanine aminotransferase (ALT), aspartate aminotransferase (AST) and creatinine were determined. Total protein content was assessed established according by refractometric method. The amount of hemoglobin was determined by hemoglobin cyanide method using spectrophotometer. The serum content of bilirubin in the blood serum was estimated by method of Jendrassik-Cleghorn and Grof (Poon 1981). The determination of creatinine was carried out by color reaction ofJaffe's, the content of transaminases (AST and ALT) were determined by the dinitrophenilhydrazine method. The De Ritiscoefficient, which represents the ratio of serum concentrations of AST to ALT was calculated (Bortos andSikaris2013). Determination of the mass zinc concentration in organs and tissues of chickens was carried out by the stripping voltammetry method (with analyser, TA2, in Research and Production Enterprise "Tekhnoanalit").

RESULTS AND DISCUSSION

Viability, live weight and egg productivity of chickens: In the control group, as well as with zinc exposure dose of 250 and 500 mg kg^{-1}, no chicken death was observed (Table 1). Only 90 and 60 per cent of birds remained alive respectively when zinc intake doses on the 30th experiment day were 1000 and 1500 mg kg^{-1}. Live weight of chickens was reduced as compared with that in the control group if zinc intake was 1000 and 1500 mg kg^{-1}. Zinc doses of 250 and 500 mg kg^{-1}had no effect on live weight of chickens. When zinc intake was 250 and 550 mg kg^{-1}, the egg production of hens was increased in comparison with the control group. The dose of zinc 1000 mg kg^{-1} had no effect on egg production. However, the intake of zinc in a dose of 1500 mg kg^{-1} led to a sharp decrease in egg production (Zinc content in organs and tissues of chickens*).* Data on the zinc content in organs and tissues of hens are presented in Table 2. When exposed to zinc at a dose of 250 mg kg^{-1}, the content of this element in the muscles did not differ from that in the control group, but the content of the metal in the kidneys and liver increased ($p < 0.01$). In the bones with a content of 250 mg kg^{-1}zinc was lower than in the control ($p < 0.01$).

Zinc intake at doses of 500, 1000, and 1500 mg kg^{-1}

Table 1. Zinc impact on viability, weight and egg productivity of chickens (Mean ±SE)

Group	Doses Zn, mg kg^{-1}	Weight (Kg)	Egg productivity, eggs day^{-1}	Survival (%)
1	Control	1.972±0.028	0.620±0.020	100
2	250	1.885±0.026*	0.780±0.030**	100
3	500	1.955±0.041	0.760±0.030**	100
4	1000	1.867±0.090	0.630±0.020	90
5	1500	1.667±0.117*	0.430±0.040**	60

*Here and further: significant differences with control group * - $p < 0.05$, ** - $p < 0.01$ (Student's t-test and the Mann-Whitney U test).

resulted in a progressive increase of zinc content in muscles, feather, kidneys and liver ($p < 0.01$). To the greatest extent, zinc was accumulated in the liver of hens at 1000 and 1500 mg kg^{-1}. Zinc content in this organ in the experimental groups of birds increased 28-30 times. Zinc level in the bones at an exposure at a dose of 1500 mg $kg^{-1}$was higher than in the bones of the control group, but when zinc doses were 500 and 1000 mg kg^{-1}, these differences were absent. The ranked number of organs and tissues according to the concentration of zinc in the control group had the following form: muscles <kidney = liver <bone <feather in the ratio 1: 1.6: 1.6: 3.8: 25.9. When the zinc entered the bird body at a dose of 250 mg kg^{-1}, the ranked series changed significantly: the muscles <bone <liver <kidney <feather in the ratio 1: 1.7: 1.8: 1.9: 26.2. When the zinc dose was1000 mg kg^{-1}, the order of the levels according to zinc concentration in the organs and tissues remained the same: the muscles <bone <liver <kidney <pen, but the ratio changed - 1: 2.0: 2.4: 15.0: 18.5. As hens got the highest zinc intake (1500 mg kg^{-1}), the ranked series were as follows: the muscles <kidney <bone <liver <feather in the ratio 1: 3.7: 5.6: 19.0: 24.9.

Earlier, we showed at the Rodonit Cross that at a dose of 100 mg kg-1 in water, a sharp weight loss occurs. At a dose of 1500 mg kg-1, chickens died within 2-14 days (Afonina et al 2003a). In the experimental group, the egg productivity decreased by 12 times at the same dose (Afonina et al 2003b). These data demonstrated that equal doses of Cu and Zn can cause different effects on laying hens. High doses of Cu have a significantly greater negative effect on the body.

Hematologic and biochemical parameters: The number of erythrocytes in the control group ($2.5\pm0.04 \times 10^{12} L^{-1}$) did not differ from the erythrocyte content in experimental groups. As zinc intake doses were 250, 500, 1000 and 1500 mg kg^{-1}, the number of erythrocytes in the blood was 2.7±0.06, 2.6±0.01, 2.70±0.08 and $2.40\pm0.141 \times 10^{12} L^{-1}$, respectively. This is slightly below normal values. The number of erythrocytes in hens in the norm ranges from 3 to $4 \times 10^{12} L^{-1}$. The biochemical composition of the blood is presented in control and experimental groups in Table 3. The hemoglobin content in blood of hens in the experimental groups was higher than hemoglobin in the control group ($p<0.01$), so hemoglobin levels increased with increasing zinc doses. When zinc dose was 250 mg kg^{-1}, the total protein content in the hen blood did not differ from this index in the control group hens. If intakes were 500, 1000 and 1500 mg kg^{-1}, the total protein content in hen blood was lower than in the blood of control birds ($p < 0.01$). If zinc doses were 500 and 1500 mg kg^{-1} the level of creatinine in hen serum decreased in comparison with the control ($p < 0.01$), however, when zinc doses were 250 and 1000 mg kg^{-1} there were no differences in this parameter from the control group. 1500 mg kg^{-1} zinc exposure led to decrease ($p < 0.01$) of bilirubin in hen blood serum compared with the control. When zinc doses were 250, 500 and 1000 mg kg^{-1}, the concentration of bilirubin in hen blood serum did not differ from the control. AST content in blood serum increased in comparison with the control when zinc intake doses were

Table 2. Zinc content in organs and tissues of hens (mg kg^{-1})(Mean ±SE)

Organ or tissue	Control	Dose Zn (mg kg^{-1})			
		250	500	1000	1500
Muscles	11.40±0.500	13.980±1.600	23.30±4.300**	33.60±5.800**	28.00±3.500**
Bones	43.20±4.100	24.2±1.900**	36.10±3.400	65.60±14.40	156.7±8.500**
Feather	295.0±22.00	364.00±28.00	541.0±6.800**	622.0±55.00**	696.0±70.10**
Liver	17.90±0.700	25.10±1.700**	48.90±6.500**	503.0±48.00**	532.0±84.00**
Kidneys	18.10±0.600	26.10±2.400**	37.30±6.400**	79.20±11.10**	103.70±10.00**

Table 3. Zinc effect on hen biochemical blood indices (Mean ±SE)

Indicator	Control	Dose of Zn (mg kg^{-1})			
		250	500	1000	1500
Crude protein (g L^{-1})	72.70±2.90	66.90±3.00	56.80±2.50**	55.30±1.70**	54.30±1.80**
Creatinin (mmol L^{-1})	46.50±1.50	44.70±2.10	35.40±2.80**	41.80±2.60	35.80±3.20**
Bilirubin (mmol L^{-1})	7.900±0.30	8.00±0.40	7.900±0.40	7.700±0.40	5.500±0.40**
AST (mmol $L^{-1}h^{-1}$)	3.700±0.30	4.300±0.10	3.900±0.10	5.800±0.20**	6.600±0.20**
ALT (mmol $L^{-1}h^{-1}$)	1.300±0.10	6.200±0.80**	5.500±0.60**	0.6200±0.05**	0.900±0.10*
De Ritis ratio	2.900±0.200	0.800±0.090**	0.800±0.100**	9.700±0.600**	7.300±1.600*
Hemoglobin (g L^{-1})	66.03±0.300	97.60±0.200**	102.6±0.190**	94.40±0.400**	131.0±2.280**

1000 and 1500 mg kg^{-1}. When zinc doses were 200 and 500 mg kg^{-1} ALT content in hen blood was significantly higher ($p < 0.01$), and De Ritis ratio was lower than in the control group. However, if zinc concentration doses were 1000 and 1500 mg kg^{-1}, the level of ALT in hen blood serum decreased, and the De Ritis ratio increased in comparison with the control ($p < 0.01$).

Pathological changes in organs and tissues: In birds of all experimental groups, in contrast to the birds of the control group, the pathological changes in internal organs were observed. As zinc admission dose was 250 mg kg^{-1}, an increase in the size of the kidneys was observed in 30 per cent of the birds, and in 30 per cent of the cases, foci of tissue necrosis were noted. When zinc dose was 500 mg kg^{-1}, the kidneys were increased in 40 per cent of the birds. Increased blood filling of the kidneys was noted in 60 per cent of cases. When zinc was given in a dose of 1000 mg kg^{-1}, in 70 per cent of the birds the kidneys were increased (i.e., 2-3 times more), and in 70 per cent of hens there was increased blood filling of this organ. As zinc exposure was 1500 mg kg^{-1}, kidneys in 70 per cent of birds were enlarged, and in 10 per cent of cases, necrosis foci were observed. In the same experimental group, 20 per cent of birds showed increased blood filling of the kidneys, and 10 per cent of cases showed flabbiness of the kidney tissue. 250 mg kg^{-1} zinc intake dose led to hemorrhage in the liver in 60 per cent of hens, and 20 per cent of hens had foci of necrosis in this organ. When zinc dose was 500 mg kg^{-1}, hemorrhages in the liver were observed in 20 per cent of hens, and foci of liver necrosis were observed in 60 per cent of hens. When the zinc dose was 1000 mg kg^{-1}, 10 per cent of the birds showed hemorrhages, and 30 per cent showed foci of necrosis in the liver. In addition, at this dose of zinc, 20 per cent of the birds showed flabby liver tissue. When zinc exposure was 1500 mg kg^{-1}, hemorrhages in the liver were noted in 20 per cent of birds, in 30 per cent of hens had foci of necrosis in the liver (i.e., 2.5 times more often), and 50 per cent of hens had laxity of the liver.

As a result of the study, it was found that the intake of elevated zinc doses was accompanied by an increase in the content of this element in all organs and tissues. In this case, zinc was accumulated mainly in the liver, liver and kidneys of experimental hens. When the dose was 1500 mg kg^{-1}, the zinc content in the liver and kidneys of hens exceeded the zinc content in the same organs in the control hens by 31.0 and 5.7 times, respectively. At the same time, when zinc was delivered at a dose of 1500 mg kg^{-1}, the zinc content in the muscles and bones of the test birds was higher than in the birds of the control group only 2.5 and 3.6 times, respectively. This pattern of zinc distribution in organs and tissues of hens differs from that in a man whose zinc, ingested with food, accumulates mainly in muscle tissue and bones (Kambe et al 2015). The1000 mg kg^{-1} zinc dose leads to a sharp increase in this element in the liver. Zinc concentration increased 10 times, and the subsequent increase in zinc dose to 1500 mg kg^{-1} practically did not change the level of this metal in the liver. It can be assumed that 1000 mg kg^{-1} zinc dose is a critical limit at which elemental homeostasis dramatically changes. For other organs and tissues, such critical points are not established. The zinc intake in the hen body at doses of 250 and 500 mg kg^{-1} did not lead to an increase in mortality, although it was accompanied by some decrease in body weight of birds. It can be assumed that, having these zinc concentrations, the physiological mechanisms for maintaining the homeostasis of this element are still able to compensate for the increased zinc intake in water. In addition, it is interesting to note that zinc intake in relatively small doses of 250 and 500 mg kg^{-1} even stimulated the egg production of hens. Earlier, we showed that 250 mg kg^{-1} copper intake also increased the egg production of hens (Petukhov et al 2016). On the other hand, additional zinc intake with food at a dose of 65 mg kg^{-1} did not result in an egg production increase (Gheisari et al 2011). 25-50 mg kg^{-1} zinc intake did not increase the number of eggs laid down by one laying hen a day, as well as the weight of eggs (Tabatabaie et al 2007), regardless of the form of intake of this element (in the form of organic compounds or in Sulfate form). The existing contradiction between our results and literature data is probably because in our study the doses of zinc were significantly higher (250-500 mg kg^{-1}). Thus, sufficiently high zinc doses that enter the body within 30 days may appear to have a temporary stimulating effect on the egg production of hens, which reflects the importance of this element for the processes of egg formation. In particular, zinc is a co-factor of carbonate-dehydratase, an enzyme that is critical for shell formation (Gheisari et al 2011).

The 1500 mg kg^{-1} zinc intake led to a significant decrease in hen egg production, as well as to body weight decrease and increased mortality. In addition, 1000 and 1500 mg kg^{-1} zinc intake led to changes in biochemical blood parameters - total protein and creatinine decrease, and a hemoglobin increase. In liver and kidneys, hemorrhages, foci of necrosis and flabbiness of the tissue were observed when zinc doses were increased. In present study, when zinc doses were 250 and 500 mg kg^{-1}, there was a sharp ALT content increase and the De Ritis ratio decrease, which may indicate liver dysfunction. Violation of the protein-synthesizing function of the liver is reflected in total protein level decrease in the blood serum of hens. The protein level decreases with increasing zinc dose, which reflects the development of mesenchymal inflammatory syndrome. Reduction of the total protein leads

to creatinine concentration decrease, which is a marker of catabolic processes, and, in our study, most likely, does not bear any definite independent value. Alanine aminotransferase is localized mainly in hepatocytes of the liver, as well as ALT in cells of liver, heart, and pancreas. When cell membranes of hepatocytes are damaged, a cytolytic syndrome develops, accompanied by the release of transaminases from liver cells. An increase in the activity of alanine aminotransferase from 1.3±0.1 to 5.5±0.6 mmol $L^{-1}h^{-1}$ occurred with an increase in zinc concentrations to 500 mg kg^{-1}, and then a sharp decrease was observed to 0.62 ± 0.05 mmol L^{-1} h^{-1}.1000 mg kg^{-1} zinc use reflects a change in cytolysis syndrome, a syndrome of hepatic-cell insufficiency, characterized by dystrophy and a significant reduction in the functional-active parenchyma of the liver due to cell necrosis.

When the zinc dosage was 1500 mg kg^{-1} there was an AST content increase, as well as ALT blood serum level decrease. The De Ritis ratio increased accordingly. ALT serum decrease is probably due to a decrease in the synthesis of this enzyme because of serious damage to hepatocytes. Activity increase of aspartate aminotransferase reflects necrotic changes in the liver, when not only the main cardiac but also the hepatic fraction of this enzyme enters the bloodstream. These biochemical changes correlate well with the established pathological changes in hen liver. Hen liver infection with heavy metal poisoning has also been noted in other studies (Petukhov et al 2016, Liu et al 2012). According to some authors, an increase in the AST content and a corresponding increase in the De Ritis ratio may reflect pathologies accompanied by hemolysis of red blood cells and damage to muscle tissue (Bortos and Sikaris 2013). However, in our studies we did not observe the development of such biochemical syndromes. On the contrary, in the group of hens receiving zinc in the maximum dose of 1500 mg kg^{-1}, the highest hemoglobin level was 131.0 ± 2.28 g L-1, 2 times higher than hemoglobin in the control group hens. In addition, the birds of this group were characterized by the lowest values of bilirubin and creatinine. This may be due to the different resistance of cells and tissues to zinc intoxication. The liver cells were the most sensitive, which correlates quite accurately with the predominant accumulation of zinc in the liver in these birds. Blood cells and muscle tissue were more resistant to zinc.

Thus in present study at relatively low doses and for a short time (250 and 500 mg kg^{-1}) resulted in liver damage, and at higher doses (1000 and 1500 mg kg^{-1}) the most pronounced morphological damage was observed in kidney tissue. Probably the main cause of these abnormalities at the cellular level is oxidative stress caused by excess doses zinc intake into cells. Oxidative stress is currently seen as a key mechanism in the pathogenesis of acute or chronic body poisoning with heavy metals (Valko et al 2005, Jan et al 2015, Wu et al 2016). The results of our studies, together with the analysis of literature data, suggest that the high doses zinc intake (250-1500 mg kg^{-1}) for a month in hens leads to the predominant accumulation of this element in liver. 250 and 500 mg kg^{-1}zinc accumulation in liver causes its toxic damage, probably because of violation of redox balance in hepatocytes. At higher zinc concentrations (1000 and 1500 mg kg^{-1}), an explosive character of elevated zinc concentrations in the liver is observed and its damage is aggravated. All this causes decrease of vitality decrease, egg production and live weight among laying hens.

CONCLUSIONS

1000-1500 mg kg^{-1}zinc dose lead to decreased viability, live weight and egg productivity of laying hens with severe pathological changes of the bird`s internal organs indicating a violation of the physiological mechanisms that ensure the homeostasis of zinc in the body. The differentiation of hen`s organs and tissues has been established according to the degree of zinc accumulation in them: zinc accumulation in liver, liver and kidneys is expressed to a greater extent than in muscles, bones and feather. 1,000 mg kg^{-1} zinc dose is a critical threshold at which the concentration of this element dramatically (in 10 times) increases. The further increase in zinc dose does not change its level in the liver. The toxic effect of high zinc doses was shown to reduce the content of total protein and bilirubin, increase in hemoglobin and AST level in serum, but did not affect the number of red blood cells.

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Incidence and Population Dynamics of Land Snails at Sharkia Governorate, Egypt

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Abstract: Incidence of the most common land snails infesting various crops at two districts at Zagazig and Fakous, Sharkia Governorate, Egypt and disclosed the existence of five species of order Stylommatophora were recorded in different area, namely: Sheeba, Banayous, and Banishebl, Zagazig district and Monshaat-El-Qady, Mayit-Elaz and El-Smanaa, Fakous district, all at Sharkia Governorate, Egypt. These species were the glassy clover snail; *Monacha cartusiana* (Müller), the brown grand snail; *Eobania vermiculata* (Müller), the conical snail; *Cochlicella acuta* (Müller) and two species of *Succinea*. The predominant one *M. cartusiana*, was present in all surveyed villages. *Succinea putris* has been appeared as the first recorded for the first time in Banayous village, Zagazig district foray the Egyptian clover severely. The lettuce, cabbage, and wheat were detected with moderate infestation while, rice and maize were detected with lowest infestation. The population dynamics of *M. cartusiana* infesting field of Egyptian clover was recorded in two villages, Banayous and Monshaat-El-Qady. The highest population densities of juvenile and adult were recorded in March and April, while the lowest population was observed during January and February for adult. The individuals of snail incrementally increasaed after the winter months to maximum during summer months.

Keywords: *Eobania vermiculata,* Incidence, Land snails, *Monacha cartusiana*, *Succinea putris*

Terrestrial mollusks have been increased greatly world wide showing economic importance. They cause regarded damage to field and horticultural crops around the world and there incidence is on increase. Lately, in Egypt, land snails have deemed a serious pest which of cereals, vegetables, fruit orchards and ornamental plants at the different growth stages causing a reduction in yields. In the last few years, many species were recorded in the Egyptian Governorates. In Sharkia Governorate, Egypt many authors reported a relatively high occurrence and population density of *Monacha* sp. on economic crops (Ismail et al 2011, Rady et al 2014, El-Sayed 2018). The main aim of this paper was to observe the incidence of land snail species on some major crops in Sharkia Governorate.

MATERIAL AND METHODS

Survey of land snails on different crops: Survey to study the distribution and population density of land snails at Zagazig and Fakous districts, they are towns in lower Egypt, situated in the eastern part of the Nile delta, Zagazig is the capital of the Sharkia Governorate with GPS coordinates of 30°34'35.5368" N and 31°30'14.6376" E, while Fakous with GPS coordinates of 30°43'45.3792"N and 31° 47' 52.008"E. The two district belonging to Sharkia Governorate, Egypt during the period from October 2016 to May 2017. The sites were chosen randomly were, Banishebl, Banayous and Sheeba villages at Zagazig district and Monshaat- El-Qady , Mayit-Elaz and El-Smanaa villages at Fakous district. The survey was conducted on Egyptian clover, *Trifolium alexandrium* L., wheat, *Triticum aestivum* L., maize, *Zea mays* L. and rice, *Oryza sativa* L., vegetable crops as cabbage, *Brassica oleracea* L., lettuce, *Lactuca sativa* L., garlic, *Allium sativum* L., onion, *Allium cepa* L., Pea, *Pisum sativum* L., broad bean *Vicia faba* L. and chicory, *Cichorium intybus* L., fruit trees as navel orange, *Citrus sinensis* L., lemon trees, *Citrus aurantiifolia* and the embellishment, sago palm (*Cycas revoluta*). Some individuals of snails were attacking mint, *Mentha viridis* L., samples were taken from each crop using the quadrate sample size 50x50 cm from each of 4200m^2. Snail individuals associated with each host plant in the different localities were transferred in plastic bags to the laboratory for identification according to the key given by Godan (1983) and El-Okda (1984).

Seasonal population fluctuation of juvenile and adult stages of *Monacha cartusiana*: The seasonal population fluctuation of the widespread glassy clover land snail, *Monacha cartusiana* heavily infesting Egyptian clover at Banayous village, Zagazig district and Monshaat- El-Qady village, Fakous district, Sharkia Governorate was evaluated during two successive growing seasons (2016/2017 and 2017/2018). All snail stages found on plants or demobilizing on the soil surface in the quadrate plot were counted and left in their initial places according to Baker and Vogelzang (1988).

Population dynamics of *Monacha cartusiana* (Müller 1774) infesting Egyptian clover: The population dynamics of *Monacha cartusiana* were studied in a field plowed with Egyptian clover at the two villages, Banayous and Monshaat-El-Qady, Sharkia Governorate during two successive growing seasons (2016/2017 and 2017/2018). In this respect, one feddan (4200m^2) was selected, five areas of 50x50 cm were randomly investigated at biweekly intervals during the growing seasons according to Staikou et al (1988). Snails were counted early morning before sunrise. Data regarding temperature and relative humidity during the period of study were getting from the meteorological station.

Statistical analysis: The data were subjected to statistical analysis using the relationship between the simple correlation coefficient of snail population and each of temperature and relative humidity (RH) was realized according to costat statistically computer program (2005).

RESULTS AND DISCUSSION

Survey of land snails on different crops: Five species of land snail were recorded, these species of the glassy clover snail, *Monacha cartusiana* (Müller), the amber snail *Succinea putris* (Linnaeus), the small amber snail *Succinea oblonga* (Draparnaud), palm snail *Cochlicella acuta* (Müller) (Table 1), and the brown garden snail *Eobania vermiculata* (Müller) (Figs. 1, 2). Abd El-Aal (2001) recorded five species of land snails at Sharkia Governorate. Ghareb (2007) had observed that, *M. cartusiana* was the only snail in 12 villages of Menia El-Kamh comparison with *S. putris* at El-Godaida village (Sharkia Governorate). The identified species varied in their incidence and level of infestation, according to the locality and host type. *M. cartusiana* was recorded in all

Fig.1. Map of study areas

Table 1. Incidence and infestation levels of land snails in Sharkia Governorate (October 2016 to May 2017)

Villages	Snail species	Host plants and levels of infestation
Zagazig district		
Banayous	*Monacha cartusiana*	Egyptian clover (+++), Rice (++), Wheat (++), Cabbage (++),Garlic (+), lettuce (++); maize (+).
	Succinea putris	Egyptian clover (+).
Banishebl	*M. cartusiana*	Egyptian clover (++), Cabbage (++), lettuce (++), Rice(+),Garlic(+),Wheat (+); Broad bean (+).
	Eobania vermiculata	sago palm (++).
Sheeba	*M. cartusiana*	Egyptian clover(+++), Wheat (+), Rice (++) lettuce (++);Cabbage (++).
Fakous district		
Monshaat-El- Qady	*Monacha cartusiana*	Egyptian clover (+++),Cabbage(+++), Lettuce (++),Garlic(++), Wheat(++) maize (+) , Rice (+),Peans(+), Mint(+); Citrus (+)
	Cochlicella acuta	Egyptian clover (++)
	Succinea putris *Succinea oblonga*	Egyptian clover (+)
Mayit – Elaz	*M.cartusiana*	Egyptian clover (+++), Cabbage (++) Garlic(++); Rice(+)
	C. acuta	Egyptian clover (+)
El-Smanaa	*M. cartusiana*	Egyptian clover(++), Wheat(+) , Rice (+) Broad bean (+); Onion (+)
	Eobania vermiculata	Citrus (++) ; Mango (+)

(+), (++), (+++)= Light,moderate and heavy infestation with less than (15 , 15 – 30 and more than 30 snail individuals in 50 × 50 cm)

surveyed localities as earlier observed by Shetaia et al (2009). Furthermore, the majority of the introspected plants were liable to be infested by that snail. The heavy infestation was on Egyptian clover followed by moderate on wheat, rice, lettuce, and cabbage while, garlic, and maize showed the light infestation. A similar trend was observed by Abou senna et al (2016). The chicory, *Cichorium intybus* Janch. had a heavy infestation with *M. cartusiana*.

The result indicated that *Succinea putris* snail was observed for the first time in Banayous village. *Succinea putris* and *Succinea oblonga* were noticed infesting the Egyptian clover. These results in agreement with Mohammed (2015) who also recorded *S. putris* and *S. oblonga.* It observed that, *Monacha cartusiana* was the most invasive species in the six villages as compared with *S. putris*, *C. acuta* and *E. vermiculata*. The results are in harmony with El-Sayed (2017), Ismail et al (2017) and El-Sayed (2018). *Cochlicella acuta* and *Eobania vermiculata* infested different host plants with few and moderate numbers in the villages.

Seasonal population fluctuation of juvenile and adult of *M. cartusiana*, land snail infesting Egyptian clover: The glassy clover snail, *M. cartusiana* was the prevalent species with high densely on major economic crops earlier. The intensity of *M. cartusiana* declined during October and November while, in the onset at April the intensity of increased at Banayous and Monshaat-El-Qady villages (Table 2). During October and November, population of adult and juveniles snail was low in both villages. The number of snails increased even at the end of outgrowth at both villages and the high population density of adult was in mid-April which recorded at Banayous village (32.20 and 36.60/ 0.25m^2), while at Monshaat-El-Qady were 25.40 and 26.60/ 0.25m^2 during two seasons of study, respectively. On the contrary, the infestation with juvenile snails was observed at the beginning of April, which increased to 32.80 and 34.80 / 0.25m^2 at Banayous village, but at Monshaat-El-Qady population was 33.80 and 35.60/0.25m^2.

Population dynamics of *M. cartusiana* on Egyptian clover: Population dynamics of *M. cartusiana* about temperature and relative humidity were studied on Egyptian clover. The population of snails decreased during October at Zagazig and Fakous districts, and then increased gradually and reached to the maximum number in mid-April at during

Table 2. Seasonal population fluctuation of juvenile and adult of *M. cartusiana*, land snail infesting Egyptian clover

Date of examination	Average number of snails							
	Zagazig district				Fakous district			
	Season 2016-2017		Season 2017-2018		Season 2016-2017		Season 2017-2018	
	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult
1 October	0	1.2	0	1.6	0	0.4	0	0.6
16 October	0	2.4	0	3.2	0	2.2	0	4
1 November	0	7.4	2.6	9.8	0.4	9.4	1	10.8
16 November	2.2	8.2	3.2	10.8	1.6	11.8	3.4	13.2
1 December	4.6	12.6	4.8	13.2	4.8	14	7.2	15.2
16 December	8.4	14.6	9.8	15.8	9.6	15.4	11.6	16.8
1 January	10.4	16.8	12	18.2	18.2	13.6	20.4	14
16 January	16.4	13.6	18.6	15.4	20.6	12.8	22.2	14.4
1 February	19.8	12.2	22.2	13.6	23	11	24.6	13.8
16 February	23.2	15.4	26.6	17.2	26	12.8	28.6	12.6
1 March	26.6	18.2	29.4	20.2	28.6	14	31	16.6
16 March	29.2	21	32.2	22.8	31	16.4	32.8	17.6
1 April	32.8	24.4	34.8	25.4	33.8	20.6	35.6	23
16 April	24.4	32.2	26.2	36.6	30.2	25.4	32.4	26.6
1 May	16.6	27	18.8	30.8	24.4	28.4	28.2	25.8
16 May	10.2	21.2	11.6	22.8	16.6	22	23.4	21.6
Total	224.8	248.4	252.8	277.4	268.8	230.2	302.4	246.6
Mean	14.05	15.53	15.8	17.34	16.8	14.39	18.9	15.41
CD (p=0.05)	7.88	15.91	8.65	5.75	9.98	6.94	9.99	10.48

-NS: not significant at p>0.05.

two seasons of study (Table 3). Earlier workers also this was in conformed this trend (Wen 1991, Perry and Arthur 1991, Alvarez and Willig 1993, Brook 1999) and observed that the population density increased during the spring and decreased during the winter. Finally, the results deduced that the population density of *M. cartusiana* was augmented during the spring months as compared with autumn and winter. Mortada (2002) observed that the initial infestation of the land snail, *Monacha cartusiana* inception in October 2001 on Egyptian clover and broad bean. However, on wheat, the infestation appeared at the beginning of November 2001. The population density of *M. cartusiana* increased during the spring as compared to low or moderate values during winter and autumn. The initial infestation of *M. cartusiana* was detected as the adult stage in all fields, while juvenile individuals were observed later. Furthermore, the Egyptian clover refuge the highest number of *M. cartusiana* followed by cabbage, lettuce, garlic, and wheat, Lokma (2007) observed that the Egyptian clover refuge the highest numbers of the snail, *M. cartusiana* followed by wheat, in contrast to the broad bean which was the lowest of the snail individuals. Population density values were higher through the second season 2017/2018 than those count in the first growing season 2016/2017 in both villages. The mean of population density were higher at Monshaat- El-Qady (31.19 and 34.31) than in Banayous village (29.58 and 33.11) during the two years of study, respectively. Ismail et al (2011) observed an increase in population density of *M. Cartusiana* at Abo-Kibeer district, Sharkia Governorate through spring seasons compared with other month (fall and winter). Heikal (2015) explained that the best period for control land snails are in autumn months where the population was very active. The nexus between the population dynamics and both temperature and relative humidity were exposed to statistical analysis (Table 4).The relative humidity showed a highly significant effect and negative impact on population density during both seasons at both districts, while the temperature showed a non-significant effect during the same seasons at both districts. Overall, data mentioned that the lower the relative humidity, the greater the density of the snails.

Table 3. Population dynamics of *M. cartusiana*, land snail infesting Egyptian clover

Date of examination	Zagazig						Fakous					
	Average number of snails/sample (50x50)		Temperature		R.H.%		Average number of snails/sample (50x50)		Temperature		R.H.%	
	2016-2017	2017-2018	2016-2017	2017-2018	2016-2017	2017-2018	2016-2017	2017-2018	2016-2017	2017-2018	2016-2017	2017-2018
1 October	1.2	1.6	27.43	28.32	42.22	46.03	0.4	0.6	28.23	29.76	45.23	45.67
16 October	2.4	3.2	25.76	22.53	47.56	49.34	2.2	4	26.35	26.53	48.37	49.03
1 November	7.4	12.4	22.7	19.61	49.32	58.16	9.8	11.8	21.63	20.87	56.76	57.37
16 November	10.4	14	21.43	23.06	59.03	53.67	13.4	16.6	20.19	21.38	54.36	53.26
1 December	17.2	18	13.43	15.47	61.34	57.79	18.8	22.4	14.32	13.79	59.73	58.37
16 December	23	25.6	14.32	15.24	60.34	58.44	25	28.4	13.73	14.73	61.13	59.71
1 January	27.2	30.2	12.72	12.03	60.35	61.45	31.8	34.4	12.25	13.6	59.75	51
16 January	30	34	13.65	12.99	54.65	55.76	33.4	36.6	13.89	14.33	55.63	54.88
1 February	32	35.8	14.23	15.37	53.04	53.67	34	38.4	14.99	13.65	54.03	53.75
16 February	38.6	43.8	15.68	13.56	46.89	50.54	38.8	41.2	17.47	16.73	52.8	51.53
1 March	44.8	49.6	16.54	17.56	45.65	43.33	42.6	47.6	19.47	20.73	47.93	44.85
16 March	50.2	55	16.29	15.56	40.89	42.65	47.4	50.4	21.37	20.67	46.53	43.64
1 April	57.2	60.2	22.37	24.69	35.61	32.56	54.4	58.6	23.93	24.56	39.13	43.09
16 April	56.6	62.8	25.46	25.89	36.79	30.43	55.6	59	28.56	26.73	33.07	33.05
1 May	43.6	49.6	26.56	26.85	34.36	33.89	52.8	54	28.93	29.87	34.68	35.6
16 May	31.4	34.4	30.73	31.23	30.64	29.93	38.6	45	30.37	31.15	36.64	38.36
Total	473.2	529.76					499	549				
Mean	29.58	33.11					31.19	34.31				
CD (p=0.05)	8.13	1.12***	19.08*	20.7**	48.53**	46.33	9.35	1.28***	22.87	26.92*	43.68*	44.77

- ns: not significant; *significant at p<0.05 ; **highly significant at p<0.05 and ***very high significant p <0.05.

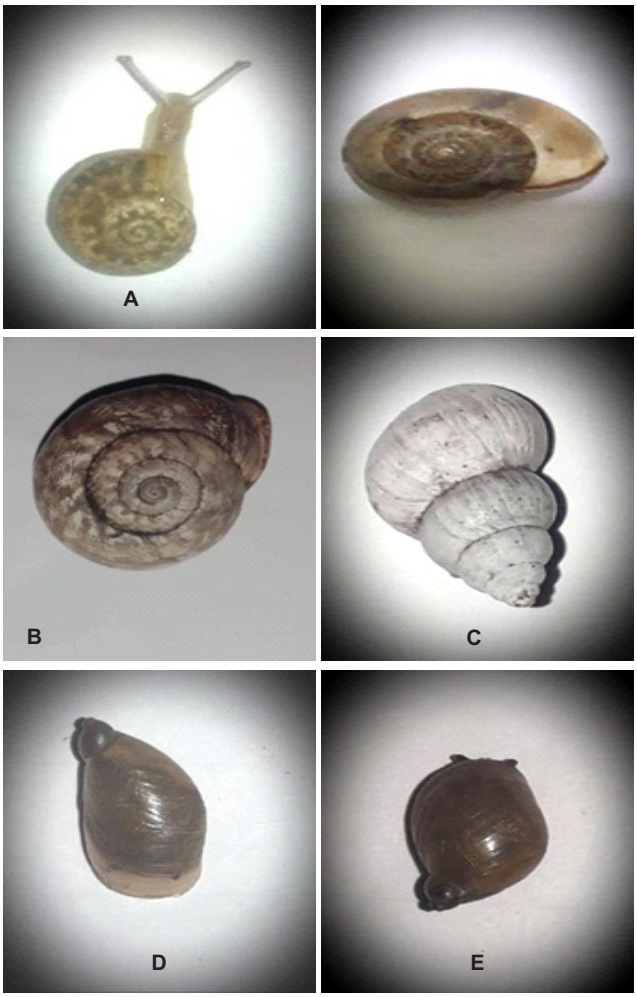

Fig. 2. Different species of land snail at Sharkia Governorate, A: *Monacha cartusiana* (Müller 1774), B: *Eobania vermiculata* (Müller 1774), C: *Cochlicella acuta* (Müller 1774), D: *Succinea putris* (Linnaeuus 1758) and E: *Succinea oblonga* (Draparnaud 1801)

Table 4. Correlation between temperature, relative humidity and population density of *M. cartusiana* infesting Egyptian clover

Climatic factors/ Districts	Temperature ºC		Relative humidity %	
	Season 2016-2017	Season 2017-2018	Season 2016-2017	Season 2017-2018
Zagazig	0.112	-0.047	-0.518***	-0.617***
Fakous	0.113	0.067	-0.508***	-0.562***

-Values represent correlation coefficient

CONCLUSIONS

The referred data uncovered five species of land snail at Sharkia Governorate, *Monacha cartusiana, Eobania vermiculata, Cochlicella acuta*, *Succinea putris* and *Succinea oblonga*. *M. cartusiana* is considered a conceivably intrusive snail species, though recorded at all reviewed territories swarming most overviewed plants and caused magnificent losses to them, the Egyptian clover was most plants refuge with *M. cartusiana* and their dispersal was contributed to different climate factors. In like manner, *S. putris* noticed for the first time in Banayous village, Zagazig district, Sharkia Governorate.

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Evaluation of Local Design Machine for Corn Threshing

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Abstract: The effect of local thresher machine on corn cultivars SYA-16 and R-106 was observed based on some technical indicators, under three revolutions of threshing cylinder (200,300 and 350rpm). The experiments were conducted in a factorial experiment under complete randomized design with three replications. The SYA-16 cultivar was significantly better than R-106 cultivar. For local thrashing machine, the machine productivity, power required, threshing efficiency, broken corn, grain cleaning, unshelled grains, loose grains a kernel outlet and grains damage were 1.226 t h^{-1}, 12.317 kW, 84.438; 6.128; 89.515; 1.908;1.938 and 1.993 per cent respectively. The revolution of threshing cylinder 200 rpm was significantly superior to the other two levels of 300 and 350 rpm in threshing efficiency, broken corn, grain cleaning, unshelled grains, loose grains a kernel outlet and grains damage. While the corn grain moisture content at range of 14% was significantly superior to the other ranges of 16 and18% in all parameters.

Keywords: Machines, Corn, Cylinder speeds, SYA-16 and R-106 cultivars, Sheller

Corn is an important cereal for the economic development of Iraq. At present, corn harvesting by farmers in Iraq differs from place to place. In some areas, attempts have been made by researchers in to improve the thresher so that their performance in corn shelling. The farm operations like harvesting, threshing and post-harvest operations require mechanization and demand the use of suitable and appropriate equipment to obtain higher operational efficiencies and productivity (Najim 2000). The development of a new power sheller must reduce grain damage and broken grains. Concave system was its effect without causing in any damage on maize grains during threshing process (Tastra 2009). Increasing the forward speed of thrashing machine increasing the machine productivity in which the velocity of speed of threshing cylinder machine is toward more controls. The operator is responsible for managing this important parameter (Humburg 2016). Grain above 30 per cent moisture can be difficult to remove from corn earand is easily cracked and damaged by over-threshing in the cylinder or rotor. Cylinder/rotor velocity and cylinder/concave clearance are the adjustments most critical to reduce grain damage and threshing losses (Chaudhary 2016). The lower energy consumption is associated with higher grain moisture content consequently dropping the threshing machine capacity. Abu Al - Khair et al (2005) reported that regulating of threshing machine operation has a direct effect on its productivity. With best adjusting of threshing machine, reducing the percentage of grain breaking then increasing machine efficiency that translate to ascending the machine productivity (El-Gayar 2005). The main goal of this research is to study the effect of local thrashing machine on corn SYA-16 and R-106 cultivars at different speeds of threshing cylinder and different ranges of grain moisture content

MATERIAL AND METHODS

This study was conducted in 2017 to evaluate local threshing machine performance with different speeds 250,300 and 350rpm because the machine gives the best performance and time, for thresher, power of Ac220v, Single - Phase required motor 5Hp, productivity 1500 kg h^{-1}, dimension 1026*471*990 mm, RPM 1800 r\m for local maize thresher. This machine, it can be operated using an internal combustion engine or electric motor (Fig. 1). The experiments was conducted at three levels of grain moisture contents 14, 16 and 18 per cent and three revolution number of threshing cylinder of 250, 300 and 350 rpm. The SYA-16 and R-106 cultivars were selected and the samples were taken by the probe which collected on the form of heap. The heaps number were six and mass of each heap was 250 kg. The random samples of corn that are taken from each heap were cleaned using sieves to remove all foreign matters, broken and immature grains. The initial moisture content of maize grain was determined by oven drying methods at 103°C for 48h (Sacilik et al 2003). The grains were kept in an oven at temperature of 43°C and monitored carefully for determining the moisture content of grain at 18%. The shelling production, power consumption, shelling efficiency, the breakage proportion, grain losses (unshelled grains percentage, loose grains at kernel outlet and grain damage)

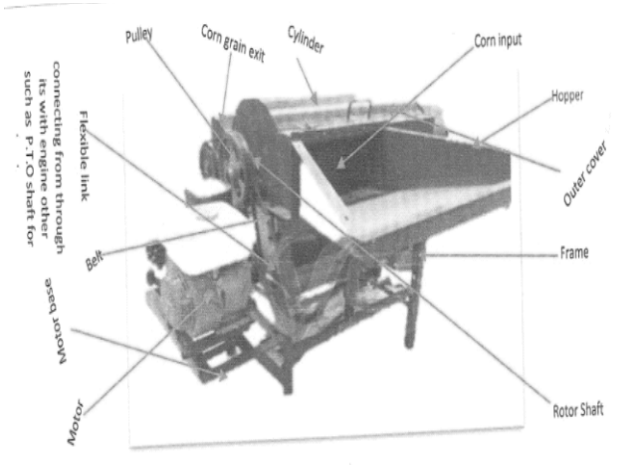

Fig. 1. Machine (type Local MTL) used for thresher maize

and percentage of grains cleanliness, were calculated for each running test.

Machine productivity: The machine was calculated as follow (Alsharifi et al 2018).

$$q = \frac{W \times 60}{T \times 1000}$$

Where, *q* is machine production(th^{-1}), *W* is output mass (g), and *T* is time (min).

Power required: Power required is the power, which is consumed by a machine to perform a specific job. The power required for this research is calculated as (Al Saadi and Al Ayoubi 2012).

$$P = \frac{\sqrt{3}}{1000}.v.I.\cos\varphi.E_{FE}$$

Where, *P:* Is power consumed (kW), *V*is voltage (V) and *I:* Is the electric current A, and cos (φ) is the angle between the current and voltage while (E_{FE}) is the efficiency of the motor (assuming as 90%).

Threshing efficiency: The threshing efficiency was determined as (Minaei et al 2007)

$$E_E = \frac{Ws - w_{mU}}{W_S} \times 100$$

Where: E_E: is the threshing efficiency (%): W_{mU}: is the mass unpeeled maize (g) and

W_S: is the mass of maize sample used. (g).

Corn grains breakage: There was calculated the percentage of the all grain damage and broken during threshing process (Gbabo and Ndagi 2014).

$$P_{Br} = \frac{w_{br}}{w_s} \times 100$$

Where: P_{Br}: Is the percentage of breakage (%), W_{br}: is the mass of breakage grain. (g) and W_s: Is the mass of maize sample used (g).

Grain cleanliness: After threshing process a randomized of 1000 g grains were taken to calculated the percentage of grains cleaning was calculated as (Ghonimy and Rostom 2004).

$$G_C = \frac{w_s - W_I}{w_s} \times 100$$

Where: G_C: Is the percentage of grain cleanliness (%), W_s: Is weight of sample (g) and W_i: Is weight of impurities (g).

Unsheller grains percentage: After shelling operation, the unshelled grains from the cobs were shelled manually and weighted then unshelled grains percentage was determined (Alsaidi 1983).

$$P_{LUN} = \frac{W_{UN}}{w_s} \times 100$$

Where: P_{LUN}: is the losses unshelled grains (%) W_{mU}: is the weight unsheller maize (g) and W_s: is the weight of maize sample used. (g).

Loose grains at kernel outlet: The loose grains which found with the residual of cobs (kernel) were weighted was determined

$$P_{LKO} = \frac{W_K}{W_s} \times 100$$

Where: P_{LKO}: is the losses grains at kernel outlet (%) W_{mU}: is the weight of grains with kernels (g) and W_s: is the weight of maize sample used. (g).

Grain damage: The grain damage with weight the split and cracked grains were weighted (Alsaidi 1983)

$$P_{GD} = \frac{W_{Sg}}{W_s} \times 100$$

Where: P_{GD}: is the grain damage W_{sg}: is the weight of split grains (g) and W_s: is the weight of maize sample used (g).

The results were analyzed statistically using the design complete randomized design (CRD) and the difference among treatments for each factor was tested according to the LSD test (Alsahoeke and Creama 1990).

RESULTS AND DISCUSSION

Machine productivity: The increase in the speed of threshing cylinder leads to increase the machine productivity. The low pressure on the grain in the threshing chamber increase machine production with increased speed of threshing cylinder. These results are consistent with the results of Abu Al - Khair et al (2005). The grain moisture of 14% indicated that the highest machine productivity of 1.273 th-1against 1.123 th^{-1} at grain moisture content of 18%. This is due to the fragility of the corn grains and increased pressure, which led to increase the machine production with decrease in maize grains moisture content. This is consistent

with Shepherd et al (2012). The machine productivity of the SYA-16 cultivar (1.226 th^{-1}) is significantly better than R-106 cultivar (1.165 th^{-1}). The interaction among SYA-16 cultivar, corn grains moisture content of 14% and the speed of threshing cylinder350 rpm provided productivity of 1.482 th^{-1}.

Power required : The speed of threshing cylinder of 350 rpm has the lowest power requirement (11.582 Kw) and rotational speed 200 rpm had the highest (13.438 Kw). Because the increase in speed of the machine leads to decreased machine disbursements and increased breakage percentage. These results are consistent with the results of (Humburg 2016). The power required of the SYA-16 cultivar (12.317Kw) is significantly lower than R-106 cultivar (12.686 Kw (Table 2). The increasing grain moisture led to increase in power required which was 11.414, 12.418 and 13.674 kw at 250, 300 and 350 rpm, respectively, This is due to the increased Damocles effort on grains during the threshing process hence increased capacity consumed with increasing corn grains moisture content. This is consistent with (Al Saadi and Al Ayoubi 2012) . The interaction among SYA-16 cultivar, corn grains moisture content of 14% and the speed of threshing cylinder350 rpm was best (10.352 Kw).

Shelling efficiency: The power required of the SYA-16 cultivar (84.438%) was significantly more than R-106 cultivar (Table 3). This is due to the thickness, length and type of the cultivar. At speed of threshing cylinder of 200 rpm had the highest thresher efficiency of 87.43%, and speed of threshing cylinder of 350 rpm had the lowest thresher efficiency of 81.74%. Attributed to that the characteristics design of engineering which characterized by local M.T.L machine type, depending on the type of cultivar .These results are consistent with the results that of Al Saadi and Al Ayoubi (2012). The increase in grain moisture led to decrease in thresher efficiency, which was 85.523, 84.390 and 82.299 % at different grains moisture contents. The increase in moisture content of grain also led to obstruct the thresher process thus decreased thresher efficiency (El-Gayar 2005). The interaction among SYA-16 cultivar, corn grains moisture content of 14% and the speed of threshing cylinder 200 rpm resulted in maximum efficiency of (89.416%).

Corn grains breakage: The corn grains breakage percentage was affected by the influence of cultivars, speed of threshing cylinder and corn grain moisture content which indicated that theSYA-16 cultivar was significantly better than the R-106 (Table 4). At speed of threshing cylinder of 200 rpm, the grains breakage was lowest of 5.511%. Because the increase in speed of the machine leads to increase in the number of multiplication times on the corn during threshing process as well as type and size grains. These results are consistent with the results of Chaudhary (2016). As for the increasing the grain moisture leads to increasing of the corn grains breakage (5.397, 6.446 and 7.361% at different grain

Table 1. Effect of cultivars, speed of threshing cylinder and grain moisture content on machine productivity (ton h^{-1})

Cultivar	Grain moisture (%)	Speed of threshing cylinder (rpm)			Interaction between cultivars and moisture
		250	300	350	
SYA-16	14	1.192	1.251	1.482	1.308
	16	1.104	1.168	1.368	1.213
	18	1.099	1.103	1.267	1.156
R-106	14	1.122	1.201	1.391	1.238
	16	1.076	1.196	1.233	1.168
	18	1.002	1.088	1.177	
CD (p=0.05)		0.092			N.S
Average of speed of threshing cylinder		1.099	1.168	1.32	
CD (p=0.05)		0.061			
Cultivars	Interaction cultivars and speed of threshing cylinder				Average of cultivars
SYA-16	1.132	1.174	1.372		1.226
R-106	1.067	1.162	1.267		1.165
CD (p=0.05)					0.031
Grain moisture (%)	Interaction grain moisture content and speed of threshing cylinder				Average of grain moisture
14	1.157	1.226	1.437		1.273
16	1.090	1.182	1.301		1.191
18	1.051	1.096	1.222		1.123
CD (p=0.05)		0.104			0.061

Table 2. Effect of cultivars, speed of threshing cylinder and maize grain moisture content on power required (Kw)

Cultivar	Grain moisture (%)	Speed of threshing cylinder (rpm)			Interaction between cultivars and moisture
		250	300	350	
SYA-16	14	12.123	11.071	10.352	11.182
	16	13.544	12.119	11.265	12.309
	18	14.021	13.672	12.688	13.460
R-106	14	12.348	11.778	10.812	11.646
	16	13.767	12.310	11.506	12.528
	18	14.824	13.966	12.869	13.886
CD (p=0.05)		0.191			0.1144
Average of speed of threshing cylinder		13.438	12.486	11.582	
CD (p=0.05)		0.133			
Cultivars	Interaction cultivars and speed of threshing cylinder				Average of cultivars
SYA-16	13.229	12.287	11.435		12.317
R-106	13.646	12.685	11.729		12.686
CD (p=0.05)					0.112
Grain moisture (%)	Interaction grain moisture content and speed of threshing cylinder				Average of grain moisture
14	12.236	11.425	10.582		11.414
16	13.656	12.214	11.386		12.418
18	14.423	13.819	12.779		13.674
CD (p=0.05)		0.212			0.061

Table 3. Effect of cultivars, speed of threshing cylinder and corn grain moisture content on the threshing efficiency (%)

Cultivar	Grain moisture (%)	Speed of threshing cylinder (rpm)			Interaction between cultivars and moisture
		250	300	350	
SYA-16	14	89.416	85.024	83.926	86.122
	16	88.041	83.718	82.559	84.773
	18	86.113	81.002	80.144	82.420
R-106	14	88.213	84.310	82.246	84.923
	16	87.146	83.211	81.665	84.007
	18	85.703	80.932	79.901	
CD (p=0.05)		0.203			0.040
Average of speed of threshing cylinder		84.439	83.033	81.740	
CD (p=0.05)		0.056			
Cultivars	Interaction cultivars and speed of threshing cylinder				Average of cultivars
SYA-16	87.857	83.248	82.210		84.438
R-106	87.021	82.818	81.271		83.703
CD (p=0.05)					0.041
Grain moisture (%)	Interaction grain moisture content and speed of threshing cylinder				Average of grain moisture
14	88.815	84.667	83.086		85.523
16	87.594	83.465	82.112		84.390
18	85.908	80.967	80.023		82.299
CD (p=0.05)		0.197			0.056

moisture). This is due to the fragility of the grain and easily breaking when increased moisture of grain during threshing (Gbabo and Ndagi 2014). The interaction among SYA-16 cultivar, corn grains moisture content of 14% and the speed of threshing cylinder 200 rpm resulted in lowest grain breakage (4.18%).

Corn grains cleanliness: The increase in speed of threshing cylinder leads to decrease in corn grain cleanliness being 89.772, 89.186 and 88.075% for different levels of speed of threshing cylinder. This is due to the removal of grain with impurities with increasing speed of threshing cylinder hence grain cleanliness decreased. These results are consistent with the results of El-Gayar (2005). The grains moisture content of 14% resulted in the highest grain cleanliness (89.992%) and at the corn grains moisture content of 18% indicated the lowest grain cleanliness (88.110%). This is due to increased straw with increasing grain moisture leading to decrease in maize grains cleanliness (Najim 2000). However the SYA-16 cultivar was significantly better than the R-106 cultivar. The interaction among SYA-16 cultivar, corn grains moisture content of 14% and the speed of threshing cylinder 200 rpm gave best result (91.561%).

Unshelled grains: The increase in the speed of threshing cylinder leads to increase the unshelled grains (1.632, 2.015 and 2.278 %, respectively). The low pressure on the grain in the threshing chamber decreased unshelled grains with increased speed of threshing cylinder. These results are consistent with the results of Tastra (2009). At the 14% moisture contents the grain resulted in lowest unshelled grains (1.736%). The highest unshelled grains of 2.303% were observed at moisture content of 18%. This is due to the fragility of the corn grains and increased the pressure, which led to increase in unshelled grains with corn grains moisture content increased (Shepherd et al 2012). It is indicated that the unshelled grains of the SYA-16 cultivar (1.908%) were significantly lower than R-106 cultivar (2.042%). SYA-16 cultivar, corn grains moisture content of 14% and the speed of threshing cylinder 350 rpm provided the best results (1.215%).

Loose grains at kernel outlet: The unshelled grains of the SYA-16 cultivar (1.938 %) were significantly lower than R-106 cultivar (2.268 %) (Table 7). This is due to the crop quality to withstand the effort on grain during shelled process. The results indicate that increasing the speed of threshing cylinder leads to increase in the loose grains at kernel outlet (1.799, 2.094 and 2.415%). The mismatch between rotational speed and grain size (cobs) led to increased percentage of loose grains at kernel outlet. The fragility of the corn grains and increased pressure, led to increase in loose

Table 4. Effect of cultivars, speed of threshing cylinder and corn grain moisture content on the maize grains breakage (%)

Cultivar	Grain moisture (%)	Speed of threshing cylinder (rpm)			Interaction between cultivars and moisture
		250	300	350	
SYA-16	14	4.188	5.117	6.011	5.105
	16	5.213	6.181	7.214	6.203
	18	6.139	7.090	8.003	7.077
R-106	14	4.835	5.591	6.641	5.689
	16	5.701	6.549	7.822	6.691
	18	6.991	7.815	8.129	7.645
CD (p=0.05)		0.126			00.11
Average of speed of threshing cylinder		5.511	6.391	7.303	
CD (p=0.05)		0.043			
Cultivars	Interaction cultivars and speed of threshing cylinder				Average of cultivars
SYA-16	5.180	6.129	7.076		6.128
R-106	5.842	6.652	7.531		6.675
CD (p=0.05)		0.011			0.052
Grain moisture (%)	Interaction grain moisture content and speed of threshing cylinder				Average of grain moisture
14	4.512	5.354	6.326		5.397
16	5.457	6.365	7.518		6.446
18	6.565	7.453	8.066		7.361
CD (p=0.05)		0.113			0.043

Table 5. Effect of cultivars, speed of threshing cylinder and corn grain moisture content on the corn grains cleanliness (%)

Cultivar	Grain moisture (%)	Speed of threshing cylinder (rpm)			Interaction between cultivars and moisture
		250	300	350	
SYA-16	14	91.561	90.124	90.001	90.562
	16	90.004	89.816	88.640	89.487
	18	89.281	88.703	87.509	88.498
R-106	14	90.136	89.911	88.215	89.421
	16	89.248	88.709	87.169	88.375
	18	88.401	87.855	86.913	87.723
CD (p=0.05)		0.291			0.163
Average of speed of threshing cylinder		89.772	89.186	88.075	
CD (p=0.05)		0.180			
Cultivars	Interaction cultivars and speed of threshing cylinder				Average of cultivars
SYA-16	90.282	89.548	88.716		89.515
R-106	89.262	88.825	87.432		88.506
CD (p=0.05)					0.084
Grain moisture (%)	Interaction grain moisture content and speed of threshing cylinder				Average of grain moisture
14	90.849	90.018	89.108		89.992
16	89.626	89.263	87.905		88.931
18	88.841	88.279	87.211		88.110
CD (p=0.05)		0.169			0.180

Table 6. Effect of cultivars, speed of threshing cylinder and corn grain moisture content on unshelled grains (%)

Cultivar	Grain moisture (%)	Speed of threshing cylinder (rpm)			Interaction between cultivars and moisture
		250	300	350	
SYA-16	14	1.215	1.820	1.987	1.674
	16	1.345	1.987	2.001	1.778
	18	2.001	2.103	2.713	2.272
R-106	14	1.430	1.961	2.001	1.797
	16	1.665	2.009	2.316	1.996
	18	2.138	2.211	2.648	2.332
CD (p=0.05)		0.066			NS
Average of speed of threshing cylinder		1.632	2.015	2.278	
CD (p=0.05)		0.044			
Cultivars	Interaction cultivars and speed of threshing cylinder				Average of cultivars
SYA-16	1.520	1.970	2.234		1.908
R-106	1.744	2.060	2.322		2.042
CD (p=0.05)					0.038
Grain moisture (%)	Interaction grain moisture content and speed of threshing cylinder				Average of grain moisture
14	1.323	1.891	1.994		1.736
16	1.505	1.998	2.159		1.887
18	2.070	2.157	2.681		2.303
CD (p=0.05)		0.065			0.044

Table 7. Effect of cultivars, speed of threshing cylinder and corn grain moisture content on loose grains at kernel outlet (%)

Cultivar	Grain moisture (%)	Speed of threshing cylinder (rpm)			Interaction between cultivars and moisture
		250	300	350	
SYA-16	14	1.218	1.609	2.001	1.609
	16	1.897	2.008	2.101	2.002
	18	2.011	2.139	2.459	2.203
R-106	14	1.492	1.910	2.115	1.839
	16	2.076	2.311	2.822	2.403
	18	2.104	2.588	2.997	2.563
CD (p=0.05)		0.122			NS
Average of speed of threshing cylinder		1.799	2.094	2.415	
CD (p=0.05)		0.081			
Cultivars	Interaction cultivars and speed of threshing cylinder				Average of cultivars
SYA-16	1.709	1.919	2.187		1.938
R-106	1.891	2.270	2.644		2.268
CD (p=0.05)		NS			0.029
Grain moisture (%)	Interaction grain moisture content and speed of threshing cylinder				Average of grain moisture
14	1.355	1.760	2.058		1.724
16	1.987	2.159	2.462		2.203
18	2.058	2.364	2.728		2.383
CD (p=0.05)		0.105			0.081

Table 8. Effect of cultivars, speed of threshing cylinder and corn grain moisture content on grains damage

Cultivar	Grain moisture (%)	Speed of threshing cylinder (rpm)			Interaction between cultivars and moisture
		250	300	350	
SYA-16	14	1.425	1.683	1.992	1.700
	16	1.988	2.009	2.111	2.036
	18	2.002	2.214	2.509	2.241
R-106	14	1.691	1.912	2.004	1.869
	16	2.010	2.188	2.519	2.239
	18	2.193	2.375	2.862	2.476
CD (p=0.05)		0.086			0.062
Average of speed of threshing cylinder		1.885	2.064	2.333	
CD (p=0.05)		0.081			
Cultivars	Interaction cultivars and speed of threshing cylinder				Average of cultivars
SYA-16	1.805	1.969	2.204		1.993
R-106	1.964	2.158	2.462		2.195
CD (p=0.05)		NS			0.067
Grain moisture (%)	Interaction grain moisture content and speed of threshing cylinder				Average of grain moisture
14	1.558	1.798	1.998		1.784
16	1.999	2.099	2.315		2.138
18	2.098	2.295	2.685		2.359
CD (p=0.05)		0.105			0.034

grains at kernel outlet with higher corn grains moisture content (Molenda and Stasiak 2002). The interaction among SYA-16 cultivar, corn grains moisture content of 14% and the speed of threshing cylinder 350 rpm resulted lowest loose grains.

Grains damage: The increase in speed of threshing cylinder led to increase the grains damage, and the results were 1.885, 2.064 and 2.333 per cent. There was not much impact of blows when rotational speed decreased hence decreased the grain damage percentage. The grains damage in the SYA-16 cultivar (1.993%) was significantly lower than R-106 cultivar (2.195%). This depends on grain size in shelling process and moisture contents the grain. The moisture of 14% resulted in the lowest grains damage of 1.784% and at the grain moisture content of 18% the damage was 2.359%. This is due to the fragility of the corn grains and increasing the pressure, this leads to increase the grains damage with increase in the moisture content. These results are consistent with the results of Alsharifi (2010). The interaction among SYA-16 cultivar, corn grains moisture content of 14% and the speed of threshing cylinder 350 rpm was the best treatment (1.425%).

CONCLUSIONS

The SYA-16 cultivar was significantly better than the R-106 cultivar. The corn grains moisture content 14% was superior significantly on the two levels 16%, 18% and the speed of threshing cylinder of 200 rpm was superior significantly on two speed of threshing cylinder in all studied properties. The overlap between the SYA-16 cultivar and corn grains moisture content 14% superior significantly. Also overlap between the SYR-16 cultivar and speed of threshing cylinder was 200 rpm, as compared the overlap of the R-106 cultivar with moisture content and speed of threshing cylinder in all studied properties. The best results have come from the triple overlap between SYA-16 cultivar, grain moisture 14%, and speed of threshing cylinder of 200 rpm in some studied properties i.e. broken corn, threshing efficiency, corn grains cleanliness, grains damage, unshelled grains and loose grains at kernel outlet, except for machine production and power required where best results were recorded with speed of threshing cylinder 350 rpm.

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An Investigation of Firewood Species used by Community of Gundani Village in Vhembe District, Limpopo Province, South Africa

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Abstract: The use of firewood by most rural communities in the Vhembe district has been a norm. This practice of using firewood for livelihood continues in those villages despite the presence of electricity. The purpose of this study was to investigate the utilization of plant species for firewood purpose. Thirty-four informants were interviewed on the use of firewood through a semi-structured interview. Forty-one firewood species were recorded at the study site. The most highly represented family is Fabaceae followed by Rubiaceae and Combretaceae. The three mostly used firewood species were *Vepris lanceolata*, *Parinari curatelifolia* and *Xylopia parviflora*. Preclusion of twenty plant species for firewood due to taboo and other reasons was also recorded. The prevalence in utilization of indigenous plants as firewood is an issue that needs immediate attention in terms of monitoring populations of species involved.

***Keywords*:** Vhembe district, Firewood, Preclusion, Plant species

Firewood is globally used for different purposes. In developing countries, it is used for cooking, light, warmth, firing clay pots and preparation of medicines (McElhinny et al 2005). Continued use of firewood is exacerbated by lack of electricity to 1.2 billion people around the world (Ketlhoilwe and Kanene 2018). There are many rural communities that rely on firewood for their sustenance (Cardoso et al 2017, Mashile et al 2019). However, unsustainable harvesting of firewood can lead to permanent forest degradation (Medeiros et al 2012). The extraction and collection of dead wood or branches can have an impact on the structure of the forest and biodiversity (Ndangalasi et al 2007). When cash is need, people begin to sell firewood, and this contributes to high collection value. In countries like Australia, firewood is purchased from merchants (Driscoll et al 2000). Some people collect firewood themselves and it is an affordable way of living since it minimises the use of electricity and other expensive fuels (Madubansi and Shackleton 2007). Heavy use of firewood exerts pressure on native forests, leading to loss of biomass, tree and shrub diversity (Martínez 2015).

Swemmer (2009) affirmed that in most rural communities within the bushveld regions of Africa and South Africa rely on firewood for their household energy needs. Reliance of tropical African rural communities on firewood for energy needs is influenced by fact that it is still regarded as a cheap source when compared to other alternative forms of energy (Uhunamure et al 2017). In South African rural communities, firewood is still regarded as traditional source of energy within the different energy mix. Limpopo Province of South Africa with a high population of rural communities has the highest consumption of fuelwood (Uhunamure 2017). Some traditions have precluded certain plant species for firewood because of cultural taboo and the poor quality of wood (Maroyi 2012). Some plant species are strictly prohibited, whereas some are partially avoided (Tabuti et al 2003). The aim of the study was to investigate the plant species that are preferred as firewood and those that are avoided. Identifying firewood species and monitoring the harvesting impact may assist in the maintenance of ecosystem. This becomes important because Swemmer (2009), suggests that global climate change is likely to damage the ecosystem that supply wood as a result of unprecedented heat waves and droughts.

MATERIAL AND METHODS

The study was conducted in the Musina local municipality (22˚19´5.099˝to 22˚ 19´17.839˝south latitudes and from 28˚ 57´53.895˝to 30˚36´55.821˝east longitudes) which falls within Vhembe District on the northern part of Limpopo Province of South Africa. Questionnaire was used to collect data through semi-structured interviews with local participants. The participants selected based on availability and willingness to participate in the study comprised of youth, middle age and elders. The interviews focused of plant names, availability and place of collection, prohibited species, reasons for species prohibition and reasons behind the choice of firewood as a source of fuel. Data from administered questionnaires was transferred into Microsoft Excel programme for descriptive statistical analysis.

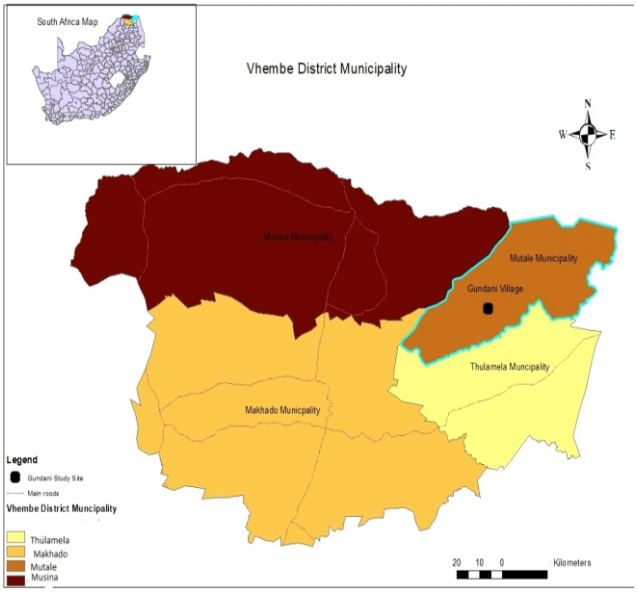

Fig. 1. Map of Vhembe District municipality and its local municipalities, Limpopo Province, South Africa. (Study area marked with a black dot)

RESULTS AND DISCUSSION

Informant profile: Interviews were conducted with 34 informants across different age, gender and educational status (Fig. 2). Females were by far the most represented gender amongst the informants. Voeks (2007) suggested that women are becoming the bearers of indigenous knowledge as a result of availability of labour jobs to their men. This also results in the process of acculturation experienced by men. The decline of ethnobotanical knowledge is therefore becoming gender specific when it comes to knowledge on firewood species.

Firewood species inventory: Traditional knowledge of species that are used for firewood has been transferred from generation to generation (Lev and Amar 2000). The current study has documented forty-one species used as firewood. Fabaceae family was identified as the main family representing firewood species amongst the 28 families recorded (Table 1). In a firewood study conducted in Uganda Fabaceae was also reported as the most dominant family (Tabuti et al 2003). However, in another ethnobotanical study on firewood done in Ogbomoso, Oyo state, Nigeria, Caesalpinioideae was reported as the most dominant family (Ogunkunle and Oladele 2004). Mashile et al (2019) also found Fabaceae dominating her documentation in a study conducted amongst the Mapulana of Mpumalanga Province in South Africa. Vegetation type in which firewood is collected do have an influence in the species documented.

Reasons for using firewood: The community of Gundani has different reasons for using firewood. Majority of the community members prefer to use firewood because it is free, affordable and readily available (Fig. 3). Firewood is also used because it is a quick and easy way of cooking. A few people make a business by selling firewood to earn some money. The high cost of electricity plays a role in making people go for firewood as an alternative source of fuel energy. As the standard of life increases, there is a shift in fuel utilization. Electricity and gas become the substitutes for firewood, although it will remain an option within the energy mix (Uhunamure et al 2017).

Most elders said they prefer firewood because it is what they have always been using since time immemorial. They also indicated that the use of firewood has always been part of their tradition (22%) and therefore they don't see a reason why they should change to other sources of fuel (Fig. 3). It has been noted that in Ethiopia urban and rural communities depend mainly on traditional sources of energy which include wood (Geremew et al 2014).

Plant species availability perceptions: Most of the plant species that are used as firewood in this village were perceived to be very highly available (60%), highly available (34%) and moderately available (6%).However, the perception of the ecologists and social ecologists is that most rural ecosystems are degraded. Swemmer (2009) has noted that most of the indigenous species that people utilize as firewood are resilient and can resprout even when cut every year.

Firewood prohibited species: There were many reasons associated with plant species avoided in relation to their utilisation as firewood. Twenty plant species belonging to 14 families dominated by Fabaceae were avoided as firewood (Table 2).

This study also concurred with the findings by Magwede et al (2018) who also reported some of the species avoided as firewood in their study on an inventory of Vhavenda useful

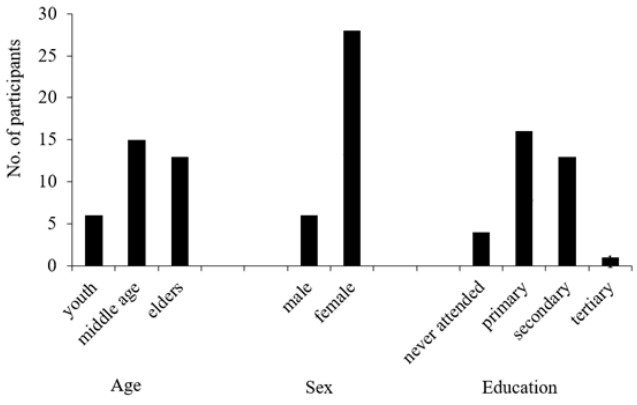

Fig. 2. Informants profile generated from data collected at Gundani village

Table 1. An inventory of plant species used as firewood by the community of Gundani village

Family	Scientific name	Vernacular name	Availability	Frequency
Annonaceae	*Xylopia parviflora* Spruce.	Muvhulavhusiku	Very high	20
Asteraceae	*Tarchonanthus camphoratus* L.	Muṱwari	Moderate	5
Burseraceae	*Commiphora tenuipetiolata* Engl.	Muṱahadzi	Very high	2
Celastraceae	*Cassine aethiopica* Thunb.	Mukwalikwali	Very high	1
Chrysobalanaceae	Parinari curatelifolia Planch. ex Benth.	Muvhula	Very high	23
Combretaceae	*Combretum collinum* Fresen	Muvuvha	High	8
Combretaceae	*Combretum imberbe* Wawra	Mudzwiri	High	2
Combretaceae	*Combretum molle* R. Br. exG. Don	Mugwiti	High	2
Combretaceae	*Terminalia sericea* Burch. ex DC	Mususu	Very high	7
Ebenaceae	*Diospyros mespiliformis* Hochst. ex A.DC.	Musuma	High	3
Fabaceae	*Senegalia ataxacantha* (DC.) Kyal. & Boatwr.	Muluwa	Very high	2
Fabaceae	*Afzelia quanzensis* Welw	Muṱokoṱa	High	2
Fabaceae	*Albizia adianthifolia* (Schum.) W. Wight	Muelela	Very high	1
Fabaceae	*Brachystegia spiciformis* Benth.	Mutsiwa	Moderate	12
Fabaceae	*Dichrostachys cinerea* (L.) Wight & Arn.	Murenzhe	Very high	10
Fabaceae	*Mundulea sericea* (Willd.) A. Chev.	Mukundaṋdou	Very high	8
Fabaceae	*Peltophorum africanum* Sond.	Musese	Very high	4
Fabaceae	*Philenoptera violacea* (Klotzsch) Schrire	Mufhanda	High	1
Fabaceae	*Pterocarpus angolensis* DC.	Mutondo	Very high	5
Fabaceae	*Pterocarpus rotundifolius* (Sond.) Druce	Muaṱaha	High	3
Fabaceae	*Vachellia tortilis* (Forssk.) Galasso & Banfi	Muswu	Very high	1
Loganiaceae	*Strychnos cocculoides* Baker	Mukudubu	Very high	2
Loganiaceae	*Strychnos madagascariensis* Poir	Mukwakwa	High	3
Malvaceae	*Grewia microthyrsa* K. Schu. Ex Burret	Mupfuka	Very high	12
Meliaceae	*Trichilia emetica* Vahl	Mutshikili	High	1
Myrtaceae	*Psidium guajava* L.	Mugwavha	Very high	1
Myrtaceae	*Syzygium cordatum* Hochst. ex DC	Muṱu	Very high	2
Ochnaceae	*Ochna pulchra* Hook	Tshiṱhoṱhonya	Very high	1
Phyllanthaceae	*Bridelia micrantha* (Hochst.) Baill.	Munzere	Very high	1
Phyllanthaceae	*Antidesma venosum* E. Mey.ex Tul.	Mukwakwala	Very high	1
Phyllanthaceae	*Pseudolachnostylis maprouneifolia* Pax	Muṱoṋḓowa	High	8
Picrodendraceae	*Androstachys johnsonii*Prain	Musimbiri	Very high	1
Rhamnaceae	*Berchemia discolor* (Klotzsch) Hemsl.	Munie	Very high	2
Rubiaceae	*Canthium mundianum* Cham. & Schltdl.	Mutomboti	Very high	4
Rubiaceae	*Gardenia resiniflua* Hiern	Tshidedede	Very high	4
Rubiaceae	*Psydrax livida* (Hiern) Bridson	Mukavhamahunguvhu	Very high	1
Rubiaceae	*Pavetta lanceolata* Eckl.	Tshiṱuku	Very high	1
Rubiaceae	*Rothmannia capensis* Thunb	Murathamapfene	Very high	3
Rutaceae	*Velpris lanceolata*G. Don	Muhondwa	Moderate	28
Rutaceae	*Zanthoxylum davyi* Waterm	Mununguu	High	2
Sapotaceae	*Englerophytum magalismontanum* (Sond.) T.D. Penn	Munombelo	High	1

Table 2. Inventory of plant species avoided as firewood by Gundani community

Family	Scientific name	Vernacular name	Reasons	Frequency
Anacardaceae	*Ozoroa paniculosa* (Sond.) R. Fern & A. Fern.	Mubandulakhali	Medicinal, taboo, bad smoke	14
Anacardaceae	*Sclerocarya birrea* (A. Rich.) Hochst.	Mufula	Edible fruits	1
Anacardaceae	*Mangifera indica* L.	Munngo	Edible fruits	1
Annonaceae	*Artabotrys brachypetalus* Benth.	Mudzidzi	Taboo, medicinal	4
Apocynaceae	*Tabernaemontana elegans* Stapf	Muhaṱu	Cooking soda	1
Combretaceae	*Terminalia sericea* Burch.ex DC.	Mususu	Poor coals	8
Euphorbiaceae	*Ricinus communis* L.	Mupfure	Taboo	1
Fabaceae	*Albizia adianthifolia* (Schumach.) W. Wight var. *adianthifolia*	Muelela	Taboo, poor coals	8
Fabaceae	*Burkea africana* Hook.	Mufhulu	Poor coals, other (edible worms)	8
Fabaceae	*Mundulea sericea* (Willd.) A. Chev	Mukundaṋou	Taboo	1
Fabaceae	*Peltophorum africanum* Sond.	Musese	Poor coals	2
Fabaceae	*Albizia versicolor* Welw.ex Oliv.	Muvhambangoma	Taboo	1
Lauraceae	*Persea americana* Mill	Muafukhada	Edible fruits	1
Moraceae	*Ficus sur* Forssk	Muhuyu	Taboo	1
Olacaceae	*Ximenia caffra* Sond	Muṯhanzwa	Edible fruits, taboo, medicinal	12
Phyllanthaceae	*Bridelia mollis* Hutch	Mukumbakumba	Poor coals	1
Picrodendraceae	*Androstachys johnsonii* Prain	Musimbiri	Bad smoke	1
Polygalaceae	*Securidaca longepedunculata* Fresen	Mpesu	Medicinal, taboo	7
Rubiaceae	*Gardenia volkensii* K. Schum.	Tshiralala	Taboo, medicinal	1
Santalaceae	*Osyris lanceolata* Hochst. & Steud	Mpeta	Taboo	2

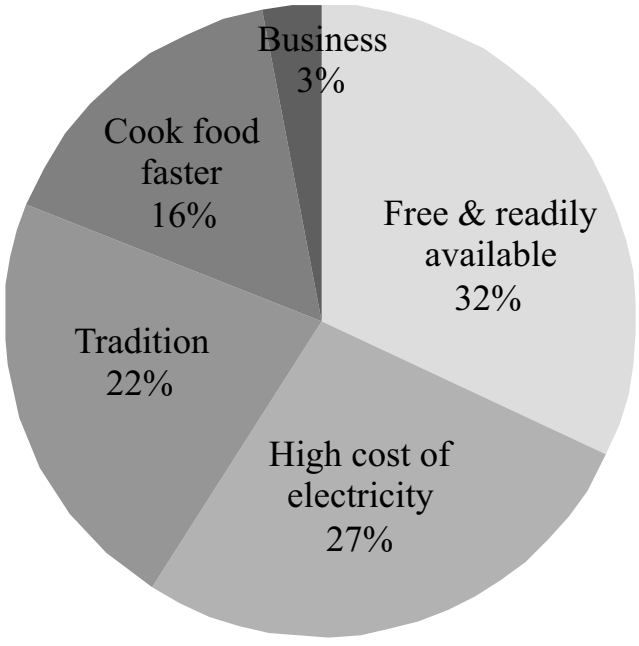

Fig. 3. Reasons behind the utilisation of firewood by the community of Gundani

plants. Plant species like *Securidaca longepedunculata*, *Artabotrys banchypetatus* and *Ozoroa paniculosa* are strictly not used because it is a taboo and they are also of medicinal importance. *Persea americana* and *Mangifera indica* are sometimes used as firewood when there is scarcity of preferred plant species. *Tabernaemontana elegans* is also avoided because of its use as cooking soda commonly known as 'mukango' in Tshivenda (Magwede et al 2018). In a study conducted on firewood in Uganda *Gardenia ternifolia* was reported to be avoided because is a tree species on which people commit suicide by hanging from it (Tabuti et al 2003). However, in this study a species from the same genus *Gardenia volkensii* is also avoided as a firewood species.

CONCLUSION

The community of Gundani village still use firewood as a source of fuel. The study was able to highlight different reasons of why people from the study area choose firewood as their main source of fuel. Plant species that are avoided as firewood were also identified. *Vepris lanceolata* is the most

harvested species, which may be endangered if harvested in an unsustainable manner. It is therefore recommended that populations of highly harvested species be monitored. The perceptions of local communities in terms of availability of firewood species should therefore be looked at when considering monitoring of such species. Collection of dry wood instead of live firewood should therefore be encouraged in order to maintain species diversity.

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Study on Work Pattern and Drudgery Experience of Hill Farm Women of Himachal

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Abstract: Sixty farm women performing farm and allied activities regularly were selected from three blocks from district Kangra, Himachal Pradesh. Work pattern and drudgery experienced by the farm women was assessed by personal interview method through a developed and pre-tested questionnaire. More than 50 per cent of the respondents had more than 20 years of experience in agriculture and livestock for which they spent an average time of 2-4 hours per day in these activities. Data on perceived exertion by the women highlighted that agricultural activities were experienced as moderately heavy to heavy types in exertion while activities in horticulture, livestock and poultry segments were observed as light to moderately heavy in exertion range. For Overall Discomfort Rating (ODR), studied by VAD scale, farm women experienced moderate to severe discomfort in agriculture activities. While doing activities of ploughing, harvesting and threshing, the women rated severe discomfort, while moderate uneasiness was felt for rest of the farm operations. Involvement in horticulture, dairy activities and household chores shared moderate and mild discomfort in their performance.

Keywords**:** Farm women, Himachal Pradesh, Overall discomfort rating, Perceived exertion, Work pattern

Agriculture is a primary unorganized sector that depends heavily on manual labour in which major contribution comes from farm women who performs the majority of the drudgery prone work (Nag and Nag 2004, Rani 2007, Mukherjee 2014). Women as farmer or farm workers, participate in several activities such as seeding, transplanting, weeding, fertilizer application, plant protection, thinning, harvesting, processing, selling, winnowing, storing, etc. (Sudharani and Raju 1991). But, women who play a significant and crucial role in agricultural development and allied fields, still remain as invisible workers. The physical strain of female farmers seems to be too high because of heavy work tasks of various activities done by them in agriculture and allied field **(**Singh and Vinay 2013). Women share abundant responsibilities to perform wide spectrum of duties both in the home and outside. Their activities typically include producing agricultural crops, tending animals, processing and preparing food, working for wages in agricultural or other rural enterprises, collecting fuel and water, engaging in trade and marketing, caring for family members and maintaining their homes. In agriculture, women are engaged in various agricultural activities like seeding, planting, weeding, irrigating, processing, harvesting and threshing operations. Women also have always emerged as the pillars of the rural economy due to their total involvement with agriculture, forest protection, cattle care and dairying. The male members of the family usually migrate to towns to earn a living for their families. Thus, women in villages become the heads of the family. Even where the men continue to reside in the villages, it is the women and girls who look after the agriculture and cattle.

Women are the major work force in Himachal Pradesh and play a significant role in agriculture and other allied activities. They are the veritable back-bone of subsistence agriculture because about 80% of the field work in agriculture, from sowing to harvesting, post-harvest management and dairy management is done by hill women farmers. These women participate in extremely tedious, time consuming and labour intensive agricultural operations, viz., land preparation, manuring, sowing, transplanting, weeding, hoeing, applying fertilizers, taking care of crops, harvesting, storage of food grains and so on (Kishtwaria et al 2009). The rural hill farm women are therefore involved in extensive work on fields and at household levels daily and also have to undergo a very hard life due to geo-physical conditions of the hilly region. Productivity in agriculture is always referred to the crop yield and the quality of inputs required. Human productivity and human performance, especially in women specific activities is the most neglected area in agriculture in developing and under developed countries. The work efficiency and productivity of women are directly related to the health and nutritional status and physical work capacity of women, which is especially true when they perform various activities manually in the field of agriculture (Patel et al 2015). While performing these activities, the women work continuously in awkward and difficult postures and

consequently they suffer from pain and discomfort in different parts of their body which lead to drudgery. Drudgery is generally conceived as physical and mental strain, agony, monotony and hardship experienced by farm women while performing these farm operations (Bhushan et al 2016). The drudgery prone condition leads to various health and mechanical hazards which creates physical exhaustion, fatigue and low productivity. Considering the multiple roles of agricultural women, the present study is an attempt to assess the status of hill farm women and to estimate the drudgery level involved in different farm operations.

MATERIAL AND METHODS

The survey was carried out in Kangra district of Himachal Pradesh. Sixty farm women who were performing agricultural and allied activities regularly were selected from three blocks viz. Panchrukhi, Baijnath and Bhawarna (twenty each) for the investigation. For assessing out the work pattern and drudgery level of hill farm women, a well-structured questionnaire containing aspects related to study was developed. Pre-testing of questionnaire was done to make it more functional for final study. An inventory of different activities performed by farm women in agriculture, horticulture, livestock, poultry, household chores and fish farming sectors was prepared. The activity profile of 60 farm women respondents selected from three different blocks was studied by subjective expression of their feelings towards the activity *i.e.* how easy or difficult the subject finds her activity. Overall discomfort rating (ODR) for each activity was measured by VAD scale- a 10-point scale based on adoption of technique developed by Corlett and Bishop (1976). It is used to determine the discomfort during the activity and doesn't attempt to measure the severity and intensity of the pain. It is a 10 point scale, 0 being the lowest point showing no discomfort and 10 being the uppermost point showing the extreme discomfort. The category scale constructed by Borg (1980) was used to assess the rate of perceived exertion of farm women in different agricultural activities. The data were collected personally regarding types of activities performed (household, farm and allied activities), frequency of performance, time spent on each activity and their perception regarding each activity performed by them i.e. exertion perceived and discomfort score to find the most drudgery prone task on hierarchy basis. Time spent in doing each of these activities was calculated on hours/day basis.

RESULTS AND DISCUSSION

Various research studies have reported that during various farm operations, agriculture workers suffer with high physical strain and fatigue. An assessment of health status of farm women was therefore done to evaluate if the respondents suffer from any health ailment or disease after years spent on performing various agriculture and allied activities. So, during the interview, the women were asked in detail about their health ailments, if any, Table 1 interprets the type of health hazards faced by the respondents during their life time. Further questioning about their status revealed that 83.33 per cent suffered from backache followed by headache (70%), breathlessness, tiredness and lethargy (61.66% each), pain in lower limbs (53.33%) and problems related to gastrointestinal system (55%). It was heartening to know that a very few percentage of 5 and 10 suffered from lifestyle disorders viz. diabetes and high blood pressure. In Himachal, most of farmers are small and marginal having terraced and fragmented land holding pattern. Due to the undulating topography of region, farmers/farm women are still using traditional modes of cultivating crops. The tasks are laborious and since the woman is unaware of the latest technical know-how, her output and productivity are low. So, lack of mechanisation adds burden on the shoulders of women thereby increases the drudgery level, affecting their nutritional status and health and reducing the productivity/output. Information on drudgery level involved in different farm and allied operations helps in assessing the risks associated to work of women in agriculture. Drudgery assessment of farm women in agriculture and allied activities was worked out by assessing perceived exertion and overall discomfort in different farm and household activities done by them. Before that, the data on their experience (year) and time spent (hours day^{-1}) in agriculture and allied activities was also taken into consideration.

For this survey, only the women who were involved in farm and allied activities were selected for the purpose of the study. Before going into details of drudgery perceived in agriculture and allied activities, the selected farm women were asked about their years of experience in respective fields of agriculture, horticulture, livestock, poultry, fish farming and household chores and average time spent on these sectoral activities. 51.66 per cent women had more than 20 years of experience in agriculture and livestock while 48.33% had 10-20 years of experience in reported sectors. Majority of the respondents had less than 10 years of experience in horticulture (98.33%) and poultry (90%). None of the respondents were rearing fish farming. An overall scenario of the Table 2 shows that main activities in the selected villages were agriculture and livestock. In district Kangra, mainly vegetables are grown on a large scale and very less emphasis is placed on horticulture which is more prevalent in the neighbouring districts of Mandi and Kullu. Only those plantation crops were reported which were in their

backyards and very less effort was placed on their part to plant new fruit varieties/species. An average time of 2-4 hours/day was spent in agriculture and livestock. In horticulture and poultry, less than 2 hours were spent on related activities during the day as there was less stuff to take care off. Household chores consumed more time as compared to other activities. 43.33 per cent farm women spent 5-7 hours while 28.33 per cent spent more than 7 hours daily on household activities. Overall scan of the Table 3 shows more working hours in household chores as compared to agriculture and livestock. This clearly suggests that these farm practices are steadily slowing down for various reasons. Most of the farmers are shirking agriculture because of unpredictable weather, increase in wild animals attack on crops and farmers and a less profitable venture. Most of the population in Himachal are in various public and private sectors and have less dependency on agriculture as a source of their income. A study on work participation and drudgery of hill women of Himachal Pradesh conducted by Thakur and Tiwari (1998) revealed a high work participation of women folk in all farm and household activities. On an average, nearly 5 hours were spent by farm women to undertake different household activities. More than 85 per cent of the total work related to livestock management was accomplished by female workers except marketing of milk and milk products.

Table 2. Experience (years) in agriculture and allied activities of selected farm women

Particulars	Blocks			
	Panchrukhi (n=20)	Baijnath (n=20)	Bhawarna (n=20)	Total (N=60)
Agriculture				
<10	-	-	-	-
10-20	9 (15.00)	14 (23.33)	6 (10.00)	29 (48.33)
>20	11 (18.33)	6 (10.00)	14 (23.33)	31 (51.66)
Horticulture				
<10	19 (31.66)	20 (33.33)	20 (33.33)	59 (98.33)
10-20	-	-	-	-
>20	1 (1.66)	-	-	1 (1.66)
Livestock				
<10	-	-	2 (3.33)	2 (3.33)
10-20	9 (15.00)	13 (21.66)	5 (8.33)	27 (45.00)
>20	11 (18.33)	7 (11.66)	13 (21.66)	31 (51.66)
Poultry				
<10	14 (23.33)	20 (33.33)	20 (33.33)	54 (90.00)
10-20	4 (6.66)	-	-	4 (6.66)
>20	2 (3.33)	-	-	2 (3.33)
Household chores				
<10	1 (1.66)	2 (3.33)	3 (5.00)	6 (10.00)
10-20	9 (15.00)	11 (18.33)	5 (8.33)	25 (41.66)
>20	10 (16.66)	7 (11.66)	12 (20.0)	29 (48.33)
Fish farming			--	

Figures in parentheses represents percentage

Table 1. Health ailment status of selected farm women

Particulars	Blocks			
	Panchrukhi (n=20)	Baijnath (n=20)	Bhawarna (n=20)	Total (N=60)
Backache	18 (30.00)	20 (33.33)	15 (25.00)	53 (83.33)
Joint pain	8 (13.33)	8 (13.33)	13 (21.66)	29 (48.33)
High BP	2 (3.33)	2 (3.33)	2 (3.33)	6 (10.00)
Diabetes	-	1 (1.66)	2 (3.33)	3 (5.00)
Skin infections	7 (11.66)	7 (11.66)	9 (15.00)	23 (38.33)
Headache	15 (25.00)	15 (25.00)	12 (20.00)	42 (70.00)
Arthritis	-	-	-	-
Respiratory problems	-	2 (3.33)	4 (6.66)	6 (10.00)
Heart burning	-	-	-	-
Repeated fever	-	1 (1.66)	3 (5.00)	4 (6.66)
Stomach problem	9 (15.00)	13 (21.66)	11 (18.33)	33 (55.00)
Allergy	-	3 (5.00)	4 (6.66)	7 (11.66)
Loss of appetite	7 (11.66)	8 (13.33)	7 (11.66)	22 (36.66)
Body ache	9 (15.00)	14 (23.33)	13 (21.66)	36 (60.00)
Tiredness/lethargy	12 (20.00)	11 (18.33)	14 (23.33)	37 (61.66)
Leg pain	10 (16.66)	10 (16.66)	12 (20.00)	32 (53.33)
Jaundice	-	1 (1.66)	-	1 (1.66)
Breathlessness	11 (18.33)	10 (16.66)	16 (26.66)	37 (61.66)

Figures in parentheses represent percentage

Data on perceived exertion by the women highlighted that agricultural activities were experienced as moderately heavy to heavy types in exertion. Main activities in horticultural crops category were harvesting/plucking, storage and post-harvest consumption which were light to moderately heavy in exertion range. Same level was calculated for livestock and poultry. For household chores, moderately heavy to heavy exertion was perceived by the selected respondents. Farm women experienced moderate to severe discomfort in agriculture activities as measured through 10-point scale. Involvement in horticulture and livestock shared moderate pain while in household chores mild to moderate discomfort was experienced. Data on perceived exertion by the women highlighted that agricultural activities were experienced as moderately heavy to heavy types in exertion. Activities viz. ploughing, sowing, irrigating the fields, weeding/interculture were perceived as of heavy exertion. Weeding is an important time consuming and drudgery prone task mainly performed by hill farm women for almost all crops grown. Weeding activity has been reported with a drudgery scale value of 2.01 followed by other agricultural operations as perceived by women (Gupta et al 2002). This directs for interventions in terms of improved technologies (weeder, kutla and hoe) to relieve women from high energy demands, time spent and associated drudgery particularly for weeding activity (Kishtwaria and Rana 2012). Levelling the fields, manuring/fertilization, spraying the standing crops against pests/insects, storage of harvested crop and watch and ward activities were reported moderately heavy and harvesting the crop was assessed as very heavy activity. During harvesting, the bending and squatting posture adopted for cutting the crop created various musculo-skeltal disorders and pain in affected areas.

Main activities in horticultural crops category were harvesting/plucking, storage and post-harvest utilization which were light to moderately heavy in exertion range. Since the horticulture crops reported by the respondents were mainly their backyard plantations so activities like basin preparation, manuring, grafting/budding, pruning/training required for maintaining healthy plants/trees were missing. Same level as for horticulture was calculated for livestock and poultry. For nearly all activities in livestock rearing i.e. fodder collection, grazing of animals, milking, collection of cow dung, maintenance of cowshed, preparation and marketing of milk and milk products moderately heavy exertion was perceived by the farm women. Feed making i.e. fodder chaffing, mixing with oilcakes was reported as light activity when compared to other doings.

For household chores, moderately heavy to heavy exertion was perceived by the selected respondents. Cleaning and maintenance of home and premises and fuel wood collection were experienced as heavy chores while cooking food, fetching water, washing of utensils and clothes and care of child or old/sick member were observed as moderately heavy activities. Knitting, stitching or other entrepreneurial activity like *papad* and *wadian* making were experienced as light chore. Overall discomfort rating (ODR) for different agriculture and allied activities by selected farm women was also studied by VAD scale. Farm women experienced moderate to severe discomfort in agriculture activities as measured through 10-point scale. While doing activities of ploughing, harvesting and threshing the women rated severe discomfort for them while moderate uneasiness was felt for rest of the farm operations. Involvement in horticulture activities shared moderate pain for harvesting

Table 3. Time spent (hrs day^{-1}) on different agriculture and allied activities by selected farm women

Particulars	Blocks			
	Panchrukhi (n=20)	Baijnath (n=20)	Bhawarna (n=20)	Total (N=60)
Agriculture				
<2	8(13.33)	4(6.66)	2(3.33)	14(23.33)
2-4	6(10.00)	11(18.33)	12(20.00)	29(48.33)
5-7	4(6.66)	5(8.33)	5(8.33)	14(23.33)
>7	2(3.33)	-	1(1.66)	3(5.00)
Horticulture				
<2	20(33.33)	20(33.33)	20(33.33)	60(100.00)
2-4	-	-	-	-
5-7	-	-	-	-
>7	-	-	-	-
Livestock				
<2	7(11.66)	4(6.66)	7(11.66)	18(30.00)
2-4	13(21.33)	16(26.66)	13(21.66)	42(70.00)
5-7	-	-	-	-
>7	-	-	-	-
Poultry				
<2	19(31.66)	20(33.33)	20(33.33)	59(98.33)
2-4	1(1.66)	-	-	1(1.66)
5-7	-	-	-	-
>7	-	-	-	-
Household chores				
<2	3(5.00)	1(1.66)	1(1.66)	5(8.33)
2-4	5(8.33)	3(5.00)	4(6.66)	12(20.00)
5-7	7(11.66)	10(16.00)	9(15.00)	26(43.33)
>7	5(8.33)	6(10.00)	6(10.00)	17(28.33)
Fish farming	--			

Figures in parentheses represent percentage

Table 4. Mean score of perceived exertion for different agriculture and allied activities by selected farm women

Activity	Blocks				Total (N=60)	
	Panchrukhi (n=20)	Baijnath (n=20)	Bhawarna (n=20)	Total (N=60)	Rank	Activity type
Agriculture						
Ploughing	2.00	2.21	3.11	2.44	II	Heavy
Levelling	3.00	3.21	4.11	3.44	III	Moderately heavy
Manuring/fertilization	3.80	3.02	2.41	3.08	III	Moderately heavy
Sowing	2.35	2.41	3.38	2.71	II	Heavy
Irrigation	2.60	2.32	3.46	2.79	II	Heavy
Weeding/interculture	2.40	2.04	3.22	2.55	II	Heavy
Plant protection (spraying)	4.70	3.43	3.07	3.73	III	Moderately heavy
Watch and ward	2.30	3.43	3.87	3.20	III	Moderately heavy
Harvesting	1.85	1.43	2.64	1.97	I	Very heavy
Threshing	1.70	1.67	2.69	2.02	II	Heavy
Winnowing	3.90	3.44	4.67	4.00	IV	Light
Storage	3.50	3.28	4.39	3.72	III	Moderately heavy
Horticulture crops						
Basin preparation	-	-	-	-	-	-
Manuring	-	-	-	-	-	-
Plantation	-	-	-	-	-	-
Grafting/budding	-	-	-	-	-	-
Pruning/training	-	-	-	-	-	-
Plant protection	-	-	-	-	-	-
Irrigation	-	-	-	-	-	-
Harvesting/plucking	4.60	4.33	4.47	4.47	IV	Light
Storage	4.10	4.21	4.06	4.12	IV	Light
Post-harvest	4.70	3.45	3.08	3.74	III	Moderately heavy
Livestock						
Fodder collection	3.00	3.43	4.22	3.55	III	Moderately heavy
Grazing of animals	3.05	3.45	3.05	3.18	III	Moderately heavy
Feed making (fodder chaffing, mixing with oilcakes etc.)	3.15	4.33	4.74	4.07	IV	Light
Milking	3.55	4.32	3.64	3.84	III	Moderately heavy
Cow dung collection	3.45	3.56	4.51	3.84	III	Moderately heavy
Cowshed maintenance	3.35	3.55	3.35	3.42	III	Moderately heavy
Preparation of milk products	2.35	3.89	3.42	3.22	III	Moderately heavy
Marketing of milk and milk products	3.05	3.00	3.23	3.09	III	Moderately heavy
Poultry						
Feed	4.11	4.23	4.27	4.20	IV	Light
Shed maintenance and hygiene	3.20	3.33	3.87	3.47	III	Moderately heavy
Hatching	-	-	-	-	-	-
Slaughtering	-	-	-	-	-	-
Household chores						
Cooking	3.45	4.03	3.54	3.67	III	Moderately heavy
Cleaning/ maintenance of home and premises	2.95	2.43	2.49	2.62	II	Heavy
Water fetching	3.05	3.92	3.69	3.55	III	Moderately heavy
Washing utensils	3.05	3.98	3.82	3.62	III	Moderately heavy
Fuel wood collection	2.30	2.04	2.97	2.44	II	Heavy
Child care	4.05	3.02	3.44	3.50	III	Moderately heavy
Care of old/sick member	2.45	3.65	3.35	3.15	III	Moderately heavy
Knitting/stitching/other entrepreneurial activity	3.50	4.82	4.36	4.23	IV	Light
Washing of clothes	3	3.89	3.25	3.38	III	Moderately heavy

Table 5. Overall discomfort rating (ODR) for different agriculture and allied activities by selected farm women

Activity	Blocks				Total (N=60)
	Panchrukhi (n=20)	Baijnath (n=20)	Bhawarna (n=20)	Total (N=60)	Pain type
Agriculture					
Ploughing	7.30	8.66	7.48	7.81	Severe
Levelling	4.85	5.43	5.04	5.11	Moderate
Manuring/fertilization	4.60	5.43	5.12	5.05	Moderate
Sowing	6.05	6.04	6.35	6.15	Moderate
Irrigation	4.25	3.04	3.45	3.58	Moderate
Weeding/interculture	6.00	7.43	6.62	6.68	Moderate
Plant protection (spraying)	3.60	4.93	4.37	4.30	Moderate
Watch and ward	3.50	4.73	4.22	4.15	Moderate
Harvesting	6.40	8.93	7.47	7.60	Severe
Threshing	6.85	7.84	7.25	7.31	Severe
Winnowing	5.30	4.33	4.62	4.75	Moderate
Storage	4.20	5.43	4.72	4.78	Moderate
Horticulture crops					
Basin preparation	-	-	-	-	-
Manuring	-	-	-	-	-
Plantation	-	-	-	-	-
Grafting/budding	-	-	-	-	-
Pruning/training	-	-	-	-	-
Plant protection	-	-	-	-	-
Irrigation	-	-	-	-	-
Harvesting/plucking	4.75	4.57	4.86	4.73	Moderate
Storage	-	-			
Post-harvest	4.45	5.43	4.94	4.94	Moderate
Livestock					
Fodder collection	4.45	4.34	5.00	4.60	Moderate
Grazing of animals	3.25	5.44	4.75	4.48	Moderate
Feed making (fodder chaffing, mixing with oilcakes etc.)	3.15	3.45	3.36	3.32	Moderate
Milking	2.65	2.34	2.49	2.49	Mild
Cowdung gathering	3.75	3.32	3.57	3.55	Moderate
Cowshed maintenance	3.35	3.96	3.63	3.65	Moderate
Preparation of milk products	1.50	1.21	1.46	1.39	Mild
Marketing of milk and milk products	1.15	1.32	1.45	1.31	Mild
Poultry					
Feed	0.45	1.34	1.00	0.93	No pain
Shed maintenance and hygiene	0.6	0.23	0.52	0.45	No pain
Hatching	-	-	-	-	-
Slaughtering	-	-	-	-	-
Household chores					
Cooking	3.43	4.32	3.58	3.78	Moderate
Cleaning/ maintenance of home and premises	2.85	2.43	2.44	2.57	Mild
Water fetching	1.98	2.32	2.65	2.32	Mild
Washing utensils	2.60	2.30	2.95	2.62	Mild
Fuel wood collection	3.70	3.01	3.76	3.82	Moderate
Child care	2.05	3.04	2.45	2.51	Mild
Care of old/sick member	1.20	2.06	1.63	1.63	Mild
Knitting/stitching/other entrepreneurial activity	3.20	2.09	2.87	2.72	Mild
Washing of clothes	3.00	3.09	3.75	3.28	Moderate

fruits and their post-harvest treatment. Milking of cattle, preparation and marketing of milk and milk products involved mild discomfort as oppose to rest of the activities reported as moderate under livestock head. In household chores, mild to moderate discomfort was experienced. Cooking, fuel wood collection from nearby forest and areas and washing of clothes by traditional methods were felt for moderate uneasiness while rest of household chores were experienced as mild.

CONCLUSION

During various farm operations, agriculture workers suffer with high physical strain and fatigue. In Himachal, due to small and fragmented land holdings, hilly terrain and terrace farming, crop cultivation at every step is accomplished mainly by age old traditional and cumbersome tools and manual methods which are tedious, tiresome and labour consuming and therefore involves lot of fatigue and drudgery and accelerate health related problems. The hill farm women are involved in extensive work on fields and at household levels daily and are hence exposed to all the risks of ill health, poor nutrition and inadequate care. The women also had to undergo a very hard life due to geo-physical conditions of the hilly region. This huge amount of work in the absence of proper nutrition and health care creates serious health repercussions. So, by promoting mechanization, the work and work environment can be improved, physiological workload can be reduced and efficiency/work output can be improved significantly. Various women friendly tools and equipment are available now that can alleviate the drudgery involved in performing variable agriculture activities. Farmers/farm women are not always aware of the improvements they could make by using scientific and technological knowledge. Thus, their attention should be directed towards these farm friendly technologies which would help them to improve their quality of life.

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Iron and Zinc Status of Adult Women from Low Income Rural Families of Punjab, India

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Abstract: Iron and zinc deficiency are widespread in malnourished poor women subsisting on cereal-based diets in developing countries. The study was aimed to determine iron and zinc status of women from low income rural households of Punjab, India. Thirty clusters (villages) from all 12 blocks of Ludhiana district were chosen randomly to select 312 women (15-45 yrs) from households of agricultural labourers and of small and marginal farmers. Serum zinc values were below optimal level in 31.41 per cent of the subjects, 50.64 per cent reference women had haemoglobin levels below normal and low serum iron was in 65.38 per cent of the subjects. Serum ferritin level showed that 54.17per cent of women had unsatisfactory ferritin levels. Wheat was the major contributor of energy, iron and zinc in the diets of women i.e. 43.5, 64.4 and 73 per cent. The iron intake was marginally inadequate among non-pregnant and non-lactating as well as lactating group, the per cent adequacy being 94.1 and 90.3 per cent, respectively. The percent adequacy of iron for pregnant women was 64.9per cent. Zinc intake distribution showed that 82 per cent of women had inadequate zinc intake. Wheat was a noteworthy source of energy, iron, and zinc in their diets.

Keywords: Iron, Zinc, Low income, Rural, Women

Iron and zinc are the two micronutrients that are deficient in the diet of the people of third world countries. A diverse diet *i.e*. consists of vegetables, fruits, dairy and meats is rich in micronutrients but is out of the reach of many of the world's poor being expensive. Resource-poor people rely primarily on a few starchy staples that are rich in energy, but not in micronutrients (Cakmak et al 2000). Zinc is an essential micronutrient for human growth, development and immune function. Severe acquired zinc deficiency has not been documented in India, but the existence of milder grade of zinc deficiency is likely in malnourished populations subsisting on cereal-based diets which could be quantitatively poor in meeting zinc requirements. Lack of suitable and simple parameters to assess zinc status also contributes to the paucity of information on the zinc status of the population. In India, sub-clinical zinc deficiency has been found in Northern population where per capita wheat consumption exceeds 400g per capita per day, mainly in whole wheat form. It is reported that 26 per cent of the Indian population have inadequate zinc intake. Due to universal nature of zinc metabolism in humans, there are special challenges in assessing human zinc status and thus in identifying individuals and populations who are at risk for zinc deficiency. In India, though the sub-clinical deficiency has been found in Northern population (Chakravarty and Sinha 2002), however, there is scanty information on the factors associated with zinc deficiency. Dietary factors such as intakes of zinc, calcium, phytates and non-dietary factors like socio-economic status and environmental conditions may be responsible for causing zinc deficiency. Another essential micronutrient is iron. Heme iron has high bioavailability and is well absorbed, whereas, absorbed amount of non-heme iron is highly variable and depends on iron status and other components of the diet which may interact with non-heme iron to either enhance or inhibit its bioavailability. The eventual consequence of iron deficiency is where the body's stores of iron have been depleted and the body is unable to maintain levels of haemoglobin in the blood. Children and pre-menopausal women are the groups most prone to the deficiency. As per NFHS 3 report, 56 per cent of Indian women are anemic (Arnold et al 2009). In Punjab, 38 per cent of women have anemia, including 26 per cent with mild anemia, 10 per cent with moderate anemia and 1 per cent with severe anemia (IIPS 2008). Several studies are available on prevalence of iron and dietary iron intake in different population groups, however scanty information is available related to deficiency of zinc as well as zinc consumption levels in India and particularly in Punjab.

MATERIAL AND METHODS

The study was conducted in the rural areas of Ludhiana district of Punjab. The sampling design of the study was three stage sampling. Ludhiana district is divided into 12 blocks with a rural population of 1339178 living in 918 villages. Thirty clusters (villages) from all blocks were chosen randomly to select 413 households of agricultural labourer and of small and marginal farmers to obtain a sample of 312 women (15-45 years). The number of clusters from each

block was proportional to the rural population of each block. This total sample size calculation was based on prevalence of zinc deficiency of 44 per cent, 95 per cent individual response, 90 per cent household response, 92 per cent confidence level, design effect of 2.0 and the percentage of the population composed by children 6-59 months of age (~13.5%) and household composition (~5.6 people per household). The study design was planned after discussion with a statistician and by following the guidelines for the Harvest Plus method (Gibson and Ferguson 2008) of 'Interactive 24h recall for assessing the adequacy of iron and zinc intakes in developing countries. The 24-hour recall survey based on the HarvestPlus method was carried out for each subject for one-day using a questionnaire. The daily food and nutrient intake were assessed by using HarvestPlus C.S. Dietary Software. Institutional Ethical Committee's approval has been obtained prior to start the study. Informed consent was taken from each participant in the study.

Dietary intake was assessed using 24-Hour Recall method. This method was chosen as a valid and feasible way to estimate the usual intakes of nutrients, where women subjects were asked to recall all foods and beverages, including amounts consumed, during a 24-hour period of the previous day. An interactive, multiple pass, 24-hour recall method was adopted; the interactive approach incorporates several tools to aid women's memories in recalling details of foods and beverages consumed, including preparation methods and portion sizes. The adequacy of nutrients namely energy, protein, calcium, iron, zinc, vitamin C, folate, vitamin B_{12}, thiamine, riboflavin, niacin and vitamin B_6 was determined by using the recommended dietary allowances (RDA) of Indian Council of Medical Research (2010). The mean intake was assessed separately for women who were non-pregnant and non-lactating (NPNL; n=171), pregnant (P; n=13) and lactating (L; n=129). The data of all women was also compared with estimated average requirements (EARs) of WHO/FAO (2005). The tabulated data for different foods was classified into eight groups namely wheat, maize, legumes, meat and poultry, nuts and oilseeds, vegetables and fruits, sugars and fat, milk and its products and others. The percent contribution of the above food groups to total energy, iron and zinc consumption was calculated.

The biochemical parameters were studied in Biochemical Analysis Laboratory of Dayanand Medical College and Hospital, Ludhiana. Zinc and iron in serum were estimated by Auto Analyzer. Serum ferritin was measured by chemiluminescent detection method using kit of Roche Diagnostics, Germany. Soluble transferrin receptor (sTfR) was tested using Roche methodology. The normal ranges mentioned in Standard Operating Procedures (SOP) of each biochemical parameter were taken for reference. Statistical analysis was carried out using CPCS 1 software.

RESULTS AND DISCUSSION

Zinc and iron blood parameters: The zinc and iron status of women subjects (Table 1). The mean value of serum zinc of the subjects was in the normal range of 66-120 µg dL^{-1}, however, 31.41 per cent of the subjects had zinc values below the optimum level. The average serum iron level was 52.24 µg dL^{-1} which was below the normal range of 60-180 µg dL^{-1}. The 50.64 per cent reference women had blood Hb levels below normal (≥12.0 g dl^{-1}) given by WHO (2011) and low serum iron values were found in 65.38 per cent of the subjects. Serum ferritin level, a most reliable indicator of iron deficiency in the absence of infections showed that 54.17 per cent of women had unsatisfactory ferritin levels. The values of STfR revealed the deficiency of iron among the subjects was 16.35 per cent. The categorization of women on the basis of degree of anemia as per WHO classification showed that 26.0, 22.4 and 2.2 per cent of women were mildly, moderately and severely anemic.

The reported values for low serum zinc was found in approximately one third of the studied group. Overall 25 per cent of the world's population is at risk of zinc deficiency (Maret and Sandstead 2006). On the other hand, the estimated population at risk of low zinc intake in Asia was reported to be 61 per cent (Brown and Wuehler 2000). Data from five states of India namely, Uttar Pradesh, Karnataka, Orissa, Gujarat and Madhya Pradesh revealed the prevalence of zinc deficiency in its adult population being 43.8 per cent (Kapil and Jain 2011). The zinc deficiency based on serum zinc levels in the present study was lower than the value of reported study. In another study by Agte et al (2005), 45.7 per cent women had their RBCNZn (indicator of Zn deficiency) below the cut-off indicating Zn deficiency in apparently healthy Indian women. The findings confirm that zinc deficiency is fairly prevalent in Indian women. The raised levels of STfR indicates poor iron status and is unaffected by infection status of the subjects. The serum ferritin and STfR

Table 1. Zinc and iron status of reference women (15-45 yrs)
n = 312

Blood parameters	Normal range	Mean ± SE	Number (%) (below the normal range)
Serum Zn (µg dL^{-1})	66-120 µg dL^{-1}	87.30 ± 1.95	98 (31.41)
Hb. (g dL^{-1})	11.5-16.5 g dL^{-1}	11.70 ± 0.08	158 (50.64)
Serum Iron (µg dL^{-1})	60 -180 µg dL^{-1}	52.24 ± 1.88	204 (65.38)
Serum Ferritin (µg dL^{-1})	13-150 µg L^{-1}	16.9 ± 1.1	169 (54.17)
Soluble transferrin receptors (mg l^{-1})	1.9-4.5 mg l^{-1}	5.43 ± .18	51 (16.35)

values observed in this study indicated that the actual deficiency prevalence was less, however, higher values of serum ferritin could be due to the presence of sub-clinical infection among good number of subjects.

The data on anemia prevalence depicts a dismal picture of iron status of the women in the present study. About half of the women subjects were found to be anemic (50.6%), however, majority of anemic women had mild (26.0%) to moderate (22.4%) degree of anemia while severe anemia was only among 2.2 per cent of the subjects. NNMB (2006) data indicated that 75.1% of Indian women were anemic, out of which 30.3 and 2.9 per cent were moderately and severely anemic. Despite supplementation programs being operated for decades, there has been no perceptible decrease in the prevalence of anaemia.

Dietary sources of energy iron and zinc: Wheat is the major contributor of energy in the diets of women i.e. 43.5 per cent. The second major contributor to energy in case of women, after wheat, was sugar and fats followed by milk and milk products. The contribution of nuts and oil seeds was negligible. Contribution of milk and milk products to energy intake in the studied population was satisfactory because a good number of households had their own cattle for milk supply to their family members. Wheat contributes 64.4 per cent of iron to the diets of women. Vegetables and fruits as well as legumes also contributed fairly to the iron intake of women. The consumption of meat and poultry was negligible among women mainly because of cultural and religious reasons. Seventy three percent of zinc in the daily diets of women was contributed by wheat while maize flour and legumes provided only 5 and 6 per cent to the total daily zinc intake (Fig. 1).

The data on dietary sources of iron and zinc revealed that wheat is not only extensively grown in Punjab state but also consumed by its population in the amounts so that it becomes a noteworthy source of these two minerals in the diets of the women. The results on daily nutrient intake by the women showed that nutrient density of their diets was poor. Mann and Bakhetia (2007) surveyed 500 adult women from five villages of Ludhiana for their dietary intake. The adequacy of energy was found to be 70 per cent of the recommended levels. Sadana et al (2007) observed that cereals contributed high percentage of energy, protein and iron to the diets of rural Punjabi women when compared with other states of India, per capita energy intake was comparable to that in rural areas of Gujarat, Uttar Pradesh, Tamil Naidu, Maharashtra, Madhya Pradesh and Kerala, whereas, the intake of protein, calcium, iron, beta carotene, ascorbic acid and thiamine was higher than their counterparts in other states of India. The NFHS-2 and NFHS-3 data indicated that the intakes of all the foods except vegetables were lower than the suggested levels among rural women from 9 states of India. There was inadequate intake of micronutrients. The prevalence of chronic energy deficiency was found in 36 per cent of rural women (Narasinga Rao 2010).

Nutrient intake: The dietary intake of energy for three groups of women i.e. NPNL, P and L was lower than the RDA, however adequacy was least in L group (61.3%) followed by NPNL (75.4%) and P (86.2%) group (Table 2, Fig. 2). Similarly, protein intake was also lower than the

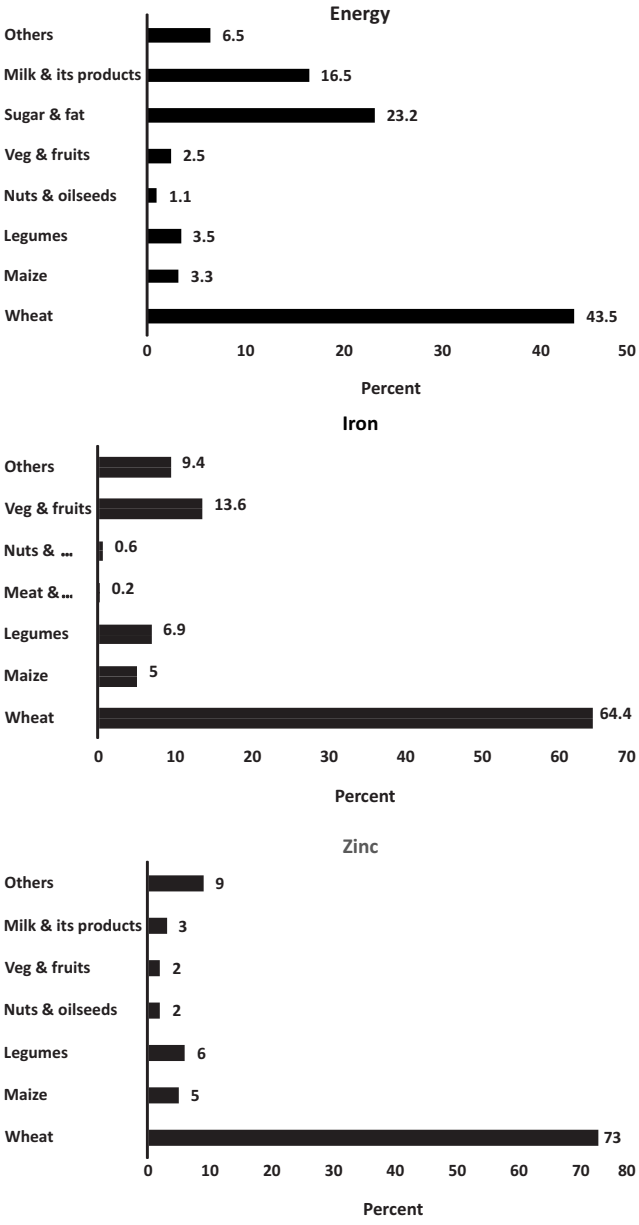

Fig. 1. Sources of energy, iron and zinc in the diets of adult women (15-45 yrs old)

Table 2. Daily nutrient intake of Non pregnant non lactating (NPNL), pregnant (P) and lactating (L) women (15-45y)

n=312

Nutrients	NPNL		Pregnant		Lactating	
	Mean ± SE (n=171)	RDA	Mean ± SE (n=13)	RDA[a]	Mean ± SE (n=129)	RDA[a]
Energy (kcal)	1681 ± 33.6	2230	2223 ± 53.5	2580	1711 ± 35.2	2790
Protein (g)	48.6 ± 1.0	55	63.6 ±1.9	82.2	49.9 ±0.9	74.1
Calcium (mg)	903.49 ± 28.27	600	1098 ± 25	1200	1041 ±34	1200
Iron (mg)	19.76 ± 0.73	21	22.70 ± 0.83	35	22.58 ± 0.83	25
Zinc (mg)	5.98 ± 0.13	10	8.51 ± 0.24	12	5.83 ± 0.11	12
Vit C (mg)	24.50 ± 1.44	40	47.31 ± 3.04	60	22.43 ± 0.85	80
Folate (µg)	72.27 ± 2.63	200	118.31 ± 3.63	500	71.78 ± 3.11	300
Vit B_{12} (µg)	0.42 ± 0.03	1	0.56 ± 0.03	1.2	0.37 ± 0.02	1.5
Thiamin (mg)	1.30 ± 0.03	1.1	1.70 ± 0.05	1.3	1.29 ± 0.02	1.4[b]/1.3[c]
Riboflavin (mg)	0.83 ± 0.02	1.3	1.06 ± 0.02	1.6	0.82 ± 0.02	1.7[b]/1.6[c]
Niacin (mg)	11.49 ± 0.32	14	19.25 ± 1.20	18	11.26 ± 0.21	18[b]/17[c]
Vit B_6 (mg)	0.32 ± 0.01	2	0.51 ± 0.02	2.5	0.30 ± 0.01	2.5

[a]RDA: Recommended Dietary Allowances by ICMR (2010)
[b]RDA for Lactating women (0-6 months), [c]RDA for lactating women (6-12 months)

recommended levels in all the three groups. The calcium intake was also lower than the RDA in pregnant and lactating women, however NPNL group had adequate calcium intake. The iron intake was marginally inadequate among NPNL and L group, the percent adequacy being 94.1 and 90.3 per cent, respectively. The percent adequacy of iron for pregnant women was 64.9%. On the other hand, a gross zinc inadequacy was found in all the three groups, the maximum being in L group followed by NPNL and P groups. For all the groups, the intake of other nutrients namely vitamin C, folate, vitamin B_{12}, riboflavin, niacin and vitamin B_6 were inadequate against the RDAs, however intake of thiamine was found to be adequate. The percent contribution of carbohydrates, protein and fats to total energy intake was ranged between 62.2-65.5 for carbohydrates, 11.4-11.6 for proteins and 22.8-26.4 for fats in the three groups.

. The median intake of calcium was inadequate, the percent adequacy being 89.4 per cent of the EAR (Table 3). Similarly, the iron intake was also adequate, the percent adequacy was only 56.4 per cent on the basis of low iron bioavailability of cereal based and vegetarian Indian diets. Zinc intake was also low, the adequacy among women being 69.5 per cent when compared to EAR given by WHO/FAO. On comparison with recommendations given by IZiNCG (2004) the adequacy was 81.4 per cent. Women usual zinc intake distribution showed that 82 per cent of women had inadequate zinc intake. All other nutrients were also inadequate against the EARs except for thiamine.

Table 3. Daily energy and nutrient intake by all reference women

Nutrient	EAR[1]	Median (25^{th}, 75^{th} percentile)
Energy, kcal	-	1920 (1466, 2401)
Protein, g	-	48 (38, 60)
Carbohydrates, g		317 (249, 397)
Fibers, g		11 (8, 15)
Fat, g	-	51 (33, 78)
Calcium, mg	1000	894 (570, 12623)
Iron, mg	low: 29.1 mod: 14.5	16.4 (12.1, 26.5)
Zinc, mg	WHO: 8.2 IZiNCG: 7	5.7 (4.4, 7.2)
Vitamin C, mg	60	20 (11, 31)
Thiamin, mg	0.9	1.27 (1.00, 1.59)
Riboflavin, mg	0.9	0.75 (0.55, 1.05)
Niacin, mg	11	10.7 (8.4, 13.8)
Vitamin B_6, mg	-	0.29 (0.14, 0.45)
Folate µg DFE[2]	320	68 (40, 102)
Vitamin B_{12}, µg	2.0	0.25 (0.07, 0.55)
Vitamin A, µg RAE[2]	500	21 (6, 174)

[a]EARs are shown for non-pregnant/non-lactating women 15-45 years of age for comparison to dietary intakes. For iron, EARs are given for low (5%) and moderate (10%) iron bioavailability. For zinc, EARs are given for WHO/FAO (2005) and for IZiNCG (2004) corresponding to low bioavailability
[b]Folate DFE, Dietary Folate Equivalents; Vitamin A RAE, Retinol Activity Equivalents

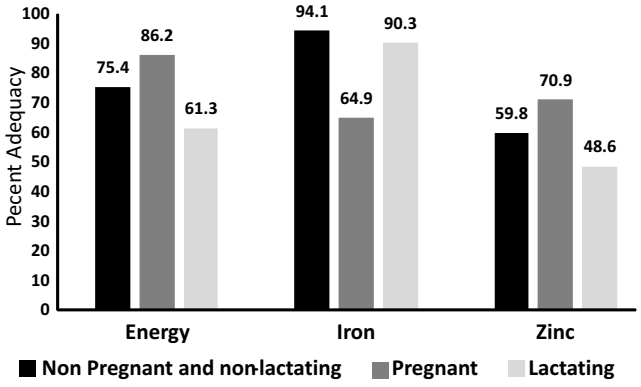

Fig. 2. Percent adequacy of energy, iron and zinc among reference women

CONCLUSION

The study highlighted that a significant size of studied group showed inadequate blood levels of both iron and zinc. Wheat was noteworthy source of energy, iron, and zinc in their diets. The diets of these women were deficient in both iron and zinc however, dietary inadequacy of zinc was more pronounced than the iron inadequacy. The information regarding appropriate dietary approaches to curb the two deficiencies needs to be assimilated to the target groups through educational interventions. Bio-fortification of wheat with iron and zinc can also prove sustainable approach to overcome the problem of iron and zinc deficiency.

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Impact of Mid-Himalayan Watershed Development Project on Employment, Income Generation and Problems Faced by Farmer's in Himachal Pradesh

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Abstract: Mid-Himalayan watershed development project was integrated multi-sectoral watershed development project that aims to achieve green growth and sustainable development by establishing the watershed ecosystem. The beneficiary farms labour employed on agriculture was maximum (172man-days) followed by, horticulture, forestry, and non- beneficiary farmers also maximum was on agriculture (97 man-days). Thus, the farm size increased the employment of labour (mandays family^{-1} year^{-1}) also increased 80 mandays. Under overall farm situation the number of labour employed on agriculture, horticulture, forestry, livestock and off-farm was 77.32, 16.67, 26.92, 29.69 per cent and 37.04 per cent higher on beneficiary farms as compared to non-beneficiary farms. Net farm income from agriculture, forestry and livestock has significantly increased by 76.59, 14.35 and 14.05 per cent respectively, whereas in horticulture the net farm income has been decreased by 8.60 per cent. The major problems coming in the way of watershed development areas by using Garrett's ranking technique were price fluctuations in perishable crops (76.80 %) followed by lack of credit facilities stray/wild animal menace, the inadequate training of the farmers about the use of watersheds. All the problems have not equally affected the beneficiary farms.

Keywords: Beneficiary, Constraints, Employment, Watershed, Income, Non-beneficiary

Water is a prime resource like most other natural resources, water does not have a substitute can be used frugally, but cannot be replaced. Water problem is one of the most pressing issues facing the critical question of how to provide stable supply of water for drinking and food production for an estimated population of about 8 billion people in 2025. Agriculture is facing a number of problems in food production mainly non availability of water. Watershed management is an integrated approach, considering holistic development for all users of the watershed. Therefore a combination of few approaches is required to be adopted in given watershed. In India, most watershed projects are implemented with the twin objectives of soil and water conservation and enhancing the livelihoods of the rural poor (Sharma and Scott 2005). Integrated watershed management of the all resources with people's participations is a well-accepted concept for the management of natural resources. The state of Himachal Pradesh characterized by undulating, highly erodible and degrading tracts, has about 80 per cent of cultivated land as rainfed (Anonymous 2017) hence, the watershed approach is the most suitable approach for development of hilly areas and necessary to protect, conserve and improve the land resource for efficient and sustained production. The study was conducted to observe the impact on employment and income of the beneficiary households and the problems associated with the implementation of watershed development project in district Kullu Himachal Pradesh.

MATERIAL AND METHODS

Himachal Pradeshmid himalayan watershed development project (HPMHWDP) was implemented on 30th September 2005 in 42 developmental blocks of Himachal Pradesh. The project was operative in 10 districts of the state covering 272 micro-watersheds spread over 710 selected panchayats. Purposive sampling has been adopted to select Ani tehsil of Kullu district in Himachal Pradesh, which lies between 31^0 21' 45" to 31^0 25' 62" N and 77^0 23' latitude 15" to 77^0 28' 15" longitude. The simple random sampling design was used for the selection of 30 respondents (beneficiary and non-beneficiary) from the project sites for assessing the impact of project. An interview schedule was prepared on the basis of pilot study, personnel of agriculture, forest department, MHWDP offices and available literature. Both primary as well as secondary data were collected in order to fulfill the requirement of specific objectives of the study.

Per cent change in selected parameters: The labour use, costs and returns etc. associated with different farm enterprises have been estimated both for project beneficiaries and non-beneficiaries.

$$\text{Per cent change} = \frac{X_1 - X_2}{X_2} \times 100$$

where, X_1, X_2= value of parameter under project and non-beneficiaries beneficiaries

Chi-square: The chi-square test has been one of the most widely used non-parametric tests in the statistical work:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

where, O refers to the observed frequencies and E refers to the expected frequencies.

Garrett's ranking technique: The problems encountered by beneficiaries have been analyzed using Garrett's ranking technique. The ranks given by respondents have been converted into per cent position

$$\text{Per cent position} = \frac{100 \times (R_{ij} - 0.5)}{N_j}$$

where, R_{ij} = Rank given to i^{th} problem by the j^{th} individual and

N_j = Number of problems ranked by j^{th} individual.

The estimated per cent positions have been converted into scores using Garrett's table. The mean score values estimated for each factor have been arranged in the descending order. The constraint with the highest mean value has been considered as the most important one and the other followed that order (Karthick et al 2013).

RESULTS AND DISCUSSION

Changes in employment levels: The beneficiary farms labour employed varied from 28 to 190 mandays, with a total of 460 mandays for different activities in a year. Similarly, for non-beneficiary farmers maximum (146.5) and minimum (24) were livestock and horticulture, activities in a year. In case of beneficiary farms marginal farmer's maximum (154) and minimum (17) were livestock and horticulture activities, with a total of 360.5 mandays for different activities in a year. Per year total labour employed on small farms was 498.15 mandays of which maximum were for livestock (196 mandays) followed by agriculture (187), forestry (39), horticulture (38.5) and off farm activities (37.5). Likewise the beneficiary semi medium farmers employed 210 mandays on agriculture, 28.5 mandays on horticulture, 35 mandays on forestry, 220 mandays on livestock and 27.50 mandays on off farm activities during the year. Per year total labour employment generated by different activities was 521 mandays on semi medium farms. Thus, as the farm size increased the employment of labour (mandays farm^{-1} year^{-1}) also increased. Similar trend was observed by Naik et al (2009). The overall farm situation indicate the number of labour employed on agriculture was 77.32 per cent higher on beneficiary farms as compared to non-beneficiary farms. In case of horticulture, a beneficiary farms estimated 16.67 per cent higher mandays than that of non-beneficiary farmers. In case of forestry, livestock and off farm, the number of labour employed on beneficiary was 26.92, 29.69 and 37.04 per cent higher than the non-beneficiary farms.

Seasonality of labour use: In June, July and August more labour in beneficiary farms more labour was required than non-beneficiary farms because of more crops grown by beneficiary farms. The labour demand in May, November and December was more for horticulture crops in beneficiary and non-beneficiary farms. The labour used for collection of fuel wood, small timber and stacking material has been included in the forestry sector on beneficiary and non-beneficiary farms. The labour requirements for livestock remains by and large equally distributed throughout whole year. Labour needs in livestock include grazing and tending of animals both beneficiary and non-beneficiary farms used labour for these purposes in the months of November and December.

Net farm Income: In beneficiaries agriculture (Rs. 791421) has maximum share in the net farm income followed by horticulture (Rs. 56870), livestock (Rs. 33606) and forestry (Rs. 2727) enterprise respectively (Table 2). Similar trend was observed in case of non-beneficiary farms by Desai et al (2007) and Biradar et al (2012). The net farm income from agriculture, forestry and livestock increased significantly by 76.59, 14.35 and 14.05 per cent respectively, whereas, in case of horticulture the net farm income decreased by 8.60 per cent. The change in net income from horticulture was

Table 1. Source wise labour employed on beneficiary and non-beneficiary farms

Mandays farm^{-1} year^{-1}

Source of employment	Beneficiaries				Non-beneficiaries	Change (%)
	Marginal	Small	Semi medium	Overall		
Agriculture	119	187	210	172	97	77.32
Horticulture	17	38.5	28.5	28	24	16.67
Forestry	25	39	35	33	26	26.92
Pasture and Livestock	154	196	220	190	146.5	29.69
Off-farm	45.5	37.50	27.50	37	27	37.04
Total	360.5	498	521	460	320.5	43.53

negative because of the fact that due to availability of irrigation facility project beneficiaries have diverted the area from fruits to vegetables crops to some extent and also non-beneficiary farms has larger area under fruits than the beneficiary farms. Similar results were documented by Bhattacharyya et al (2008). The watershed helped farmers to bring more area under vegetables (*rabi* season) as well as higher availability of water resulted in diversification of cropping pattern with the substation of more profitable crops.

Problems encountered by beneficiaries: The most significant production problem was lack of credit facilities (73.33%) followed by stray/ wild animal menace (72.40 %) and inadequate training of the farmers about the use of watershed (70.00%). Although, different project interventions

Table 2. Composition of net farm income of beneficiaries and non- beneficiaries in the study area

Rupees farm^{-1}

Particulars	Beneficiaries				Non-beneficiaries	Change (%)
	Marginal	Small	Semi medium	Overall	Overall	
Agriculture	684082	854652	1057580	791421	448179	76.59
Horticulture	43861	54833	88791	56870	62219	-8.60
Forestry	1646	3875	2964	2727	2384	14.35
Livestock	27468	33396	47283	33606	29466	14.05

Table 3. Problems faced by the farmers in effective use of watershed in the study area

(Per cent)

Problems	Farm Size				
	Marginal	Small	Semi-medium	Overall	Rank
Production problem					
Lack of knowledge about seed treatment	61.54	63.64	50.00	63.33	VI
Stray/ wild animal menace	71.20	73.25	74.63	72.38	III
Fragmented holding	45.65	52.36	76.29	53.61	XI
Untimely availability and insufficient amount of irrigation water	38.50	45.50	50.00	43.30	XXI
Theft of irrigation water by non-beneficiary farmers	30.77	27.27	50.00	33.33	XXII
Lack of knowledge regarding recommended practices for crops and livestock	61.54	54.54	50.00	56.81	VIII
Unavailability of recommended variety seeds	46.15	45.45	50.00	46.65	XIX
Lack of knowledge about the management of common properties resources	61.54	54.55	50.00	56.67	IX
Inadequate agricultural technology for the watershed areas	61.54	54.55	66.67	60.00	VII
Inadequate training of the farmers about the use of watershed	69.23	72.73	66.67	70.00	IV
Problem related to kuhl irrigation system	53.85	54.55	50.00	53.33	XII
Drinking water (shortage of)	61.54	54.55	50.00	56.60	X
Lack of coordination among the beneficiaries	53.85	45.45	50.00	50.25	XV
Lack of credit facilities	76.92	72.73	66.67	73.33	II
Lack of outside field visits for successful implementation of watershed areas	53.85	54.54	33.33	50.90	XIII
Marketing problem					
Inadequate post-harvest technologies	47.30	50.36	48.86	48.31	XVII
Unfavorable climatic conditions	53.85	45.45	50.00	50.30	XIV
Lack of market facilities for farm output	61.54	63.64	66.67	63.39	V
Lack of transport facilities	46.15	54.54	50.00	50.00	XVI
High marketing cost	28.24	24.78	19.52	25.63	XXIII
Price fluctuations in perishable crops	71.36	80.32	87.46	76.80	I
Financial problem					
Ineffectiveness of Gram panchayat	46.15	45.45	50.00	46.67	XVIII
Approach road to the village	23.08	18.18	16.67	20.00	XXIV
Weak advisory and extension services	45.63	46.45	47.99	46.31	XX
Chi square value	83.82*	98.91*	111.81*	84.26*	

*p<0.05

have been done in irrigation but problem related to kuhl irrigation system has been perceived as production problem by 53.33 per cent of beneficiary farms. Karthick et al (2013) also observed that the water scarcity as one of the production problem encountered by 39.60 per cent of sampled households. The major marketing problems viz. price fluctuations in perishable crops (76.80%), Lack of market facilities for farm output (63.39 %) and lack of transport facilities (50.00%) were faced by beneficiary farms. Ineffectiveness of gram panchayats in supplying inputs including credit facility and weak advisory and extension services have been reported as financial problem by 46.67 and 46.30 per cent respectively, of the beneficiary farms. Among different farm categories, major production problems varied between 66.67 to 76.92, 71.20 to 74.63 and 66.67 to 72.64 per cent for lack of credit facilities, stray/ wild animal menace and inadequate training of the farmers about the use of watershed, respectively. Similar results were obtained by Anand (2000). Marketing problems among different categories varied between 71.36 to 87.46, 61.54 to 66.67 and 45.45 to 53.85 per cent for price fluctuations in perishable crops, lack of market facilities for farm output and unfavorable climatic conditions, respectively and financial problems viz. ineffectiveness of gram panchayat and weak advisory and extension services has varied between 45.45 to 50.00 and 45.63 to 47.99 per cent, respectively. Similar results were documented by earlier workers (Ramanna and Chandrakanth 2000, Sisodia et al 2007, Thomas et al 2009, Kushwaha et al 2010). Chi square value for all farm categories were significant which shows that all these problems have not equally affected the beneficiary farms. The most severe problems were price fluctuations in perishable crops followed by lack of credit facilities (stray/ wild animal in the study area. Whereas chi square value for

Table 4. Problems faced by the farmers in effective use of watershed in the study area

(Per cent)

Problems	Farm Size				Chi square value
	Marginal	Small	Semi-medium	Overall	
Production problem					
Lack of knowledge about seed treatment	61.54	63.64	50.00	63.33	2.86
Stray/ wild animal menace	71.20	73.25	74.63	72.38	0.10
Fragmented holding	45.65	52.36	76.29	53.61	10.81*
Untimely availability and insufficient amount of irrigation water	38.50	45.50	50.00	43.30	1.68
Theft of irrigation water by non-beneficiary farmers	30.77	27.27	50.00	33.33	9.64*
Lack of knowledge regarding recommended practices for crops and livestock	61.54	54.54	50.00	56.67	1.28
Unavailability of recommended variety seeds	46.15	45.45	50.00	46.67	0.28
Lack of knowledge about the management of common properties resources	61.54	54.55	50.00	56.67	1.28
Inadequate agricultural technology for the watershed areas	61.54	54.55	66.67	60.00	1.28
Inadequate training of the farmers about the use of watershed	69.23	72.73	66.67	70.00	0.27
Problem related to kuhl irrigation system	53.85	54.55	50.00	53.33	0.24
Drinking water (shortage of)	61.54	54.55	50.00	56.67	1.28
Lack of coordination among the beneficiaries	53.85	45.45	50.00	50.00	0.71
Lack of credit facilities	76.92	72.73	66.67	73.33	0.79
Lack of outside field visits for successful implementation of watershed areas	53.85	54.54	33.33	50.00	6.27*
Inadequate post-harvest technologies	47.30	50.36	48.86	48.31	0.11
Marketing problem					
Unfavorable climatic conditions	53.85	45.45	50.00	50.00	0.71
Lack of market facilities for farm output	61.54	63.64	66.67	63.33	0.23
Lack of transport facilities	46.15	54.54	50.00	50.00	0.71
High marketing cost	28.24	24.78	19.52	25.63	1.75
Price fluctuations in perishable crops	71.36	80.32	87.46	76.75	2.04
Financial problem					
Ineffectiveness of Gram panchayat	46.15	45.45	50.00	46.67	0.28
Approach road to the village	23.08	18.18	16.67	20.00	1.19
Weak advisory and extension services	45.63	46.45	47.99	46.31	0.07

*p<0.05

all problems were non-significant (Table 4) which shows that all these problems have equally affected the beneficiary farms except fragmented holding, theft of irrigation water by non-beneficiary farmers and lack of outside fields visits for successful implementation of watershed areas.

CONCLUSIONS

The low level of involvement of beneficiaries was in pre-project stage activities. Due to project interventions i.e. availability of irrigation facility and land development activities project beneficiaries have diverted the area from cereals or fruits to vegetables/cash crops for enhancing the income and employment of the beneficiary farmers'. Thus, study can be concluded that as the farm size increased the employment of labour (mandays farm^{-1} year^{-1}) also increased. The most significant problems faced by beneficiary farmer's were price fluctuations in perishable crops followed by lack of credit facility and Stray/ wild animal menace. The necessary action is required so as to facilitate timely supervision and valid guidance to the project beneficiaries. The increase cold storage facility to frame policy for wild animal menace specially monkey and to provide good extension is required. Watershed technology has helped to increase the returns from dry land crop production as well as other subsidiary activities.

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Effectiveness of Nutritional Intervention on Food and Nutrient Intake and Hemoglobin Level of Moderately Anemic Adolescent Girls

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Abstract: **:** The present study was carried out to know the effectiveness of nutrition education and dietary intervention on food and nutrient intake and hemoglobin level of moderately anemic (8-10.9 mg dl^{-1}) adolescent girls (10-18 yrs). Three hundred adolescent girls were screened for their hemoglobin level of which 90 moderately anemic girls were selected divided into three groups for a period of four months intervention. Group-I was imparted diet as well as nutrition counselling, group-II received only nutrition counselling and group-III formed the control group i.e. no intervention of any type was provided to them. Diet survey was carried out by 24 hr recall method for three consecutive days.The nutrition intervention had positive impact on dietary habits. Significant increase was observed after intervention in intake of cereals and millets, pulses, milk and milk products in group-I and group-II. After receiving intervention, in group-I, 13.33 per cent were not anemic while 76.66 per cent from group-I and 13.33 per cent of group-II were mild anemic and 10 per cent of group-I, 86.66 per cent of group-II and 100 per cent of control group remained in the same category of moderately anemic. Dietary intervention with nutrition education is an effective tool in enhancing food and nutrients intake as well as in increasing the level of hemoglobin status among moderately anemic girls who are future mothers and who are responsible for health of their family members.

Keywords: Adolescent girls, Dietary intervention, Nutrition education intervention, Food and nutrient intake, Hemoglobin level

Adolescence is a transitional growth period, with increased demands for energy and nutrients. This period is marked by rapid physical growth, reproductive maturation and cognitive transformations. Good nutrition is needed to support the growth and developmental changes of adolescence. Total nutrient needs are higher during adolescence than any other time in the lifecycle (Kamalaja et al 2016). Nutrition and physical growth are integrally related and optimal nutrition is a requisite for achieving full growth potential. According to NNMB report (2003) 70 per cent and according WHO (2011) report 56 to 90 per cent of the Indian adolescent girls are anemic. In India, poor nutrition, early bearing and reproductive health complications compound the difficulties of physical development in adolescent girls (Manford and Picciano 2000). Adolescent girls are more vulnerable to the effects of malnutrition, stunting, anemia etc, because of frequent erratic eating pattern, lack of nutritional knowledge and poor dietary habits (Gaikwad et al 2013). Nutrition education with diet intervention is an effective gauge to improve healthy dietary habits and food choices. In India, reproductive health of adolescent girls is very poor and they suffer from nutritional deficiencies (Parimalavalli 2007). So, nutritional intervention is required to improve the intake of vitamins and minerals which are very important nutrients. Hence with this background the present study was taken up to assess the effectiveness of diet and nutrition education based intervention on nutrient and diet intake as well as on hemoglobin level of moderately anemic adolescent girls.

MATERIAL AND METHODS

Locale and selection of subjects: The study was conducted in selected Government Senior Secondary Schools of three blocks of Kangra district viz Baijnath, Panchrukhi and Bhawarna. Total 300 subjects were assessed for hemoglobin level and out of them 90 moderately anemic subjects (Hb-8–10.9 gm dl^{-1}) were purposively selected to study the impact of nutrition intervention (spread over a period of 4 months) on their hemoglobin profile. These subjects were divided into three groups. The group 1 received iron rich garden cress products group 2 were imparted nutrition education and group 3 (n=30) were the control group no nutrition intervention in any form was provided to this group.

Development of educational package: The information obtained from knowledge score of the subjects during pre-intervention was utilized for preparing the educational package. Combined package of audio-visual aids including posters/ leaflets/ flip card/ power point presentation in Hindi was prepared for conveying message and information regarding nutrition education to the selected respondents

covering various aspects of food and nutrition science such as food and nutrients, balanced diet, nutrients preservation, right ways to cook food, anemia, iron rich foods, junk food, sanitation and hygiene.

Educational intervention: Subjects were imparted nutrition education through lectures-cum-discussion using audio-visual aids viz. posters/ leaflets/ flip card/ power point presentation. The lectures were delivered to n=30 (Group-1 and 2) for period of 120 days at weekly interval on selected topics. The pamphlets or leaflets were distributed to the subjects.

Dietary intervention: Three iron enriched variants each of sweet and savoury recipes viz. *ladoo, mathri*, *shakkarpare* and biscuits were prepared. The first recipe of each product was control i.e. garden cress was not incorporated and was developed for comparison. Variant-1 was incorporated with un- processed (whole seed powder) garden cress seeds. Variant-2 was subjected to incorporation of processed (soaked+roasted+ dried) garden cress seeds. Dietary intervention was carried out with one sweet *laddoo* (amaranth flour-10g wheat flour-10g jaggery-40g fat- 10g garden cress powder-10g sesame seeds-15g grated coconut-5g raisin-5g) and one savoury preparations *mathri* (refined flour-30g amaranth flour-20g garden cress powder -10g sesame-16g dry fenugreek leaves-2g fat -20g black pepper-2g salt-1.50g fat for frying)which were highly acceptable and had highest analysed iron content among developed recipes were used for dietary intervention to n=30 (Group-1) for period of 120 days (4 months). 20g of each preparation per day provided 100per cent RDA for iron need of the adolescent girls. So, weekly package of 4 day for *laddoo* and 3 day for *mathri* were provided to selected moderately anemic adolescent girls. The respondents were supervised for regular intake of dietary preparations. The composition of dietary preparations is as below.

Effectiveness of interventions for diet and nutrient intake

Diet and nutrient intake (ICMR 2010): Information regarding the dietary intake of respondents was collected by using 24 hrs Dietary Recall Method, for three consecutive days. The food consumed was converted into their raw equivalents and the average daily intake of food and nutrients was calculated by using 'Diet Cal' software. The food and nutrient intake was compared with Suggested Dietary intake (SDI) and Recommended Dietary Allowances (RDA) as given by ICMR. Nutrient intake pattern of all the 90 subjects was calculated from their dietary intake before and after conducting nutrition intervention. The per cent nutrient adequacy was also calculated.

Per cent diet adequacy = Diet intake of subjects/SDI of food groups x 100

Per cent nutrient adequacy = Nutrient intake of subjects /RDA of nutrients x 100

Effectiveness of interventions for hemoglobin level: Hemoglobin level of all the 90 selected subjects was measured before and after nutrition intervention using Sahli's hemoglobinometer. Thus, anemia is classified as normal (>12gm dl^{-1}), mild degree (11-11.9gm dl^{-1}), moderate (8-10.9gm dl^{-1}), severe (<8gm dl^{-1}) (WHO 2001).

Data analysis: After collection of field data, the information was coded on the master sheets and then tabulated into master tables. Paired-'t' test was used to compare pre and post exposure mean scores of experimental groups.

RESULTS AND DISCUSSION

Dietary intake: The per cent adequacy of cereals intake was reported above 90 in group-I and below 90 in group-II (88.89) and control (85.00) after intervention. A significant difference was found with regard to pulses intake within and between the group-I and group-II (for pre and post II and control after intervention respectively. The intake of milk per cent adequacy was in range of 67.53 to 79.63 after intervention. Variation in intake within experimental group at both stages was observed. Daily intake of roots and tubers by control (90.80g), group-I (87.16g) and group-II (99.43g) were statistically similar. The daily consumption of green leafy vegetables was very low in subjects belonging to all selected groups. The per cent adequacy was also reported less than 50 per cent after intervention in all groups. This low intake may be due to the less availability of green leafy vegetables during summer season i.e. when food intake was recorded and partially due to the fact that most of the adolescent girls did not like to take green leafy vegetables in their daily menu. A non-significant difference was also observed in the consumption of other vegetables between all groups. The daily intake of important food group fruits was lower when compared with suggested dietary intake and lesser adequacy was recorded in all experimental groups. Intake of sugar had insignificant difference at initial and final stage of intervention program. The per cent adequacy intake of fats and oils was 98.00, 99.04 and 101.87 in group-1, group-II and control after intervention. Adequacy of oils and fat in diet was near to suggested dietary intake and even above recommendation. Respondents of experimental group I and II consumed less oil as compared to control group after intervention.

Nutrient intake: The daily mean energy intake of group-I and group-II increased from 1638.52and 1659.87kcal to 1973.41 and 1729.43 kcal at the end of intervention period, whereas that of control group was similar before and after the study.

Table 1. Impact of nutrition intervention on mean food intake of selected adolescent girls

Particulars	SDI (g day^{-1})	Group-I			Group-II			Control		
		Pre	Post	t-value	Pre	Post	t-value	Pre	Post	t-value
Cereals & millets	300	251.00	273.06	2.56^{S}	230.66	266.66	2.73^{S}	248.00	255.00	0.58^{NS}
Pulses	65	42.00	57.53	7.01^{S}	33.27	43.27	3.51^{S}	41.80	42.56	0.20^{NS}
Milk (ml) & milk products	500	348.83	398.16	2.60^{S}	302.23	337.33	2.21^{S}	338.66	337.66	-0.07^{NS}
Roots & tubers	133	87.16	98.43	2.03^{NS}	99.43	102.33	1.57^{NS}	90.80	91.35	1.53^{NS}
Green leafy vegetables	100	41.60	43.66	1.11^{NS}	39.23	40.43	1.77^{NS}	41.96	42.76	1.46^{NS}
Other vegetables	200	140.00	149.50	1.09^{NS}	113.13	117.13	2.01^{NS}	106.33	107.03	0.03^{NS}
Fruits	100	19.50	21.50	1.09^{NS}	18.13	19.12	0.42^{NS}	19.90	16.70	-0.10^{NS}
Sugar	26	28.50	24.50	-1.81^{NS}	26.91	24.91	-0.24^{NS}	28.66	29.40	-0.92^{NS}
Oils	36	47.50	44.50	-3.66^{NS}	42.50	41.50	-0.44^{NS}	41.16	43.60	-0.91^{NS}

Significant at 5%; NS- Non significant

Table 2. Impact of nutrition intervention on mean nutrients intake per day of selected adolescent girls

Nutrients	RDA	Group-I			Group-II			Control		
		Pre	Post	t-value	Pre	Post	t-value	Pre	Post	t-value
Energy (kcal)	2170	1638.52	1973.41	2.84^{S}	1659.87	1729.43	3.06^{S}	1637.16	1635.60	1.66^{NS}
Protein (g)	51	35.50	48.88	4.33^{S}	35.02	37.06	3.33^{S}	36.21	36.34	1.39^{NS}
Fat (g)	32	46.97	44.13	-7.62^{NS}	45.45	44.63	-5.60^{NS}	45.95	45.21	-5.39^{NS}
Calcium (mg)	750	295.34	418.32	11.24^{S}	295.05	360.64	7.31^{S}	298.52	296.89	-1.78^{NS}
Iron (mg)	26	13.68	26.14	11.62^{S}	13.41	16.32	6.44^{S}	13.86	13.55	-1.45^{NS}
Zinc (mg)	10	5.15	7.70	4.07^{S}	5.35	5.91	1.26^{NS}	5.03	5.22	1.07^{NS}
Carotene (µg)	4800	510.38	639.6	9.70^{S}	502.47	522.33	0.28^{NS}	505.36	505.64	1.97^{NS}
Vitamin B_1 (mg)	1	0.26	0.38	2.98^{S}	0.28	0.33	1.28^{NS}	0.28	0.31	0.60^{NS}
Vitamin B_2 (mg)	1	0.39	0.52	2.76^{S}	0.39	0.44	1.12^{NS}	0.38	0.40	0.86^{NS}
Vitamin B_3 (mg)	13	6.04	10.05	6.04^{S}	6.05	7.18	1.61^{NS}	6.03	6.61	1.30^{NS}
Vitamin B_6 (mg)	1	0.46	0.68	2.85^{S}	0.48	0.55	1.19^{NS}	0.49	0.43	-1.33^{NS}
Ascorbic (mg)	40	21.86	28.40	6.40^{S}	21.74	26.78	6.32^{S}	22.96	23.16	1.11^{NS}
Folate (µg)	172	49.02	58.25	3.34^{S}	45.78	46.55	1.69^{NS}	45.27	45.75	1.20^{NS}
Vitamin B_{12} (mg)	1	0.34	0.40	7.12^{S}	0.33	0.38	1.13^{NS}	0.33	0.30	-1.03^{NS}

Significant at 5%; NS- Non significant

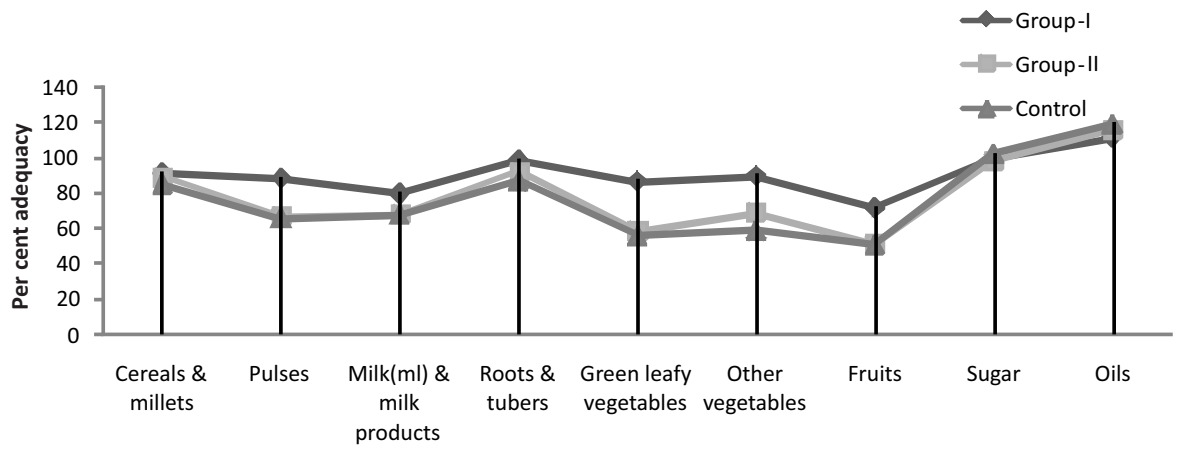

Fig. 1. Impact of nutrition intervention on per cent adequacy of food intake of control and experimental group of selected adolescent girls (n=90)

The per cent adequacy (Table 3) was higher in group-I (90.94) followed by group-II and control at the end of intervention. Significant differences were observed in energy intake among respondents of experimental groups (group-I and II). The per cent increase in protein intake was 76.50 to 76.92 by group-I and II which was higher than control group. The mean daily fat intake of different groups was similar initially that ranged from 45.45to 46.97 g before conducting the intervention study. However, after intervention, intake of fat by group-I (44.13g), group-II (44.63g) and control group (45.21g) reduced and variation therefore was not significant differences were observed in calcium and iron intake at both initial and final stages in groups except control group and intake of iron in group-I met 100 per cent to RDA after intervention. The reasons of higher adequacy in post intervention may be due to fact that dietary intervention of 100 per cent RDA was provided for iron by giving them sweet and savory preparation of *ladoo* and *mathri* for period of four months. A significant per cent increase was found between the group-I at pre and post stages of zinc intake and non-significant change was observed between group-II and control group. Carotene intake after intervention in group-I was higher among groups. Intake of carotene was less than RDA. Lower intake of green leafy vegetables and fruits by

Table 3. Impact of different nutrition intervention on mean nutrient intake (g day^{-1}) of selected adolescent girls

Group	Nutrients													
	Energy (kcal)	Protein (g)	Fat (g)	Ca (mg)	Iron (mg)	Carotene (µg)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	Vit. C (mg)	Folate (µg)	B 12 (g)	Zinc (mg)
RDA	2170	50.82	32.5	750	25.25	4800	1.05	1.22	13.25	1.9	40	172.5	1	228.75
Group-1	1973.41	38.88	34.13	518.32	24.14	939.6	0.38	0.52	10.05	0.68	28.40	58.25	0.08	39.44
% Adequacy	90.94	76.50	105.02	69.11	95.60	19.58	36.19	42.45	75.85	35.79	71.00	33.77	8.00	17.24
Group-2	1929.43	37.06	35.63	460.64	21.32	822.33	0.33	0.44	9.18	0.75	26.78	53.55	0.08	40.60
% Adequacy	88.89	72.92	109.63	61.42	84.44	17.13	31.43	35.92	69.28	39.47	66.95	31.04	8.00	17.75
Control	1675.60	36.34	46.21	296.89	14.55	505.04	0.31	0.40	7.61	0.43	23.16	45.75	0.08	34.26
% Adequacy	77.22	71.50	142.18	39.59	57.62	10.52	29.52	32.65	57.43	22.63	57.90	26.52	8.00	14.98
CD (p=0.05)	161.38	2.89	3.04	32.16	1.84	78.25	0.07	0.10	NS	0.11	1.29	6.00	0.01	3.47

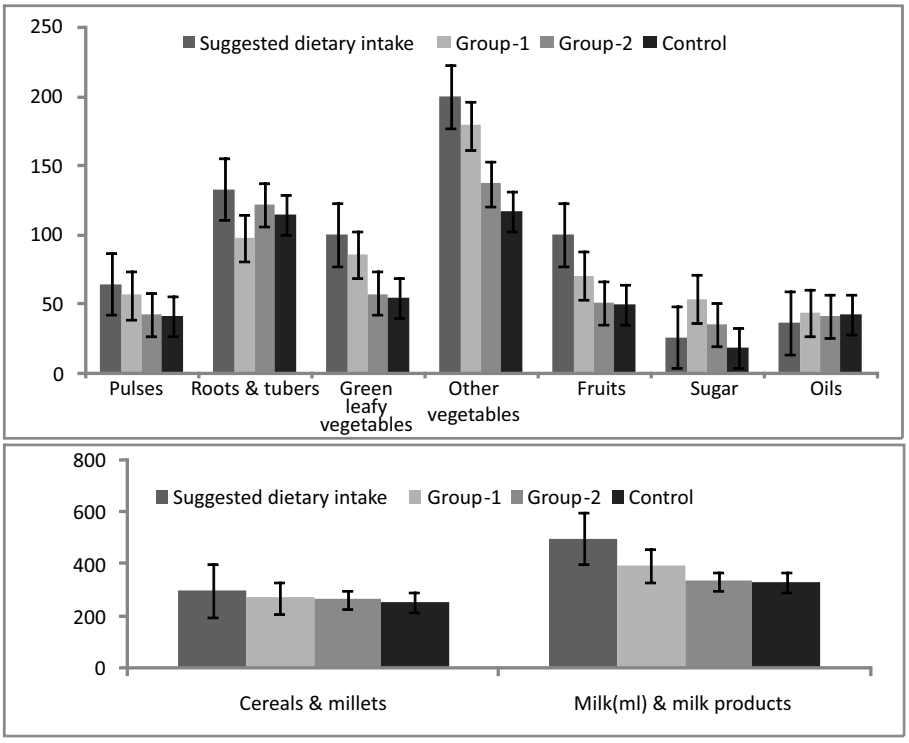

Fig. 2. Comparison of dietary intake of control and experimental groups of selected adolescent girls (n=90)

these groups might be the reason for very low intake of carotene. The vitamin B_1intake in different groups ranged between 0.26to 0.38 mg and was at par with each other. The observed per cent adequacy of vitamin B_2 intake after intervention in group-I was 42.45 against31.43 and 32.65in group-II and control. Adequacy of niacin intake was below 76 per cent at the end of intervention.

The per cent adequacy of B_6 all groups was in the range of 22.63-35.79 which was lower than daily recommendation. The vitamin C intake was significantly different among experimental group before and after intervention except control groups. This may be due to the fact that the respondents included lemon juice and guava (both good sources of vitamin C) in their diets after intervention stage. The folic acid intake in all experimental groups was lower than 40 per cent of RDA. The final intake of vitamin B_{12} was

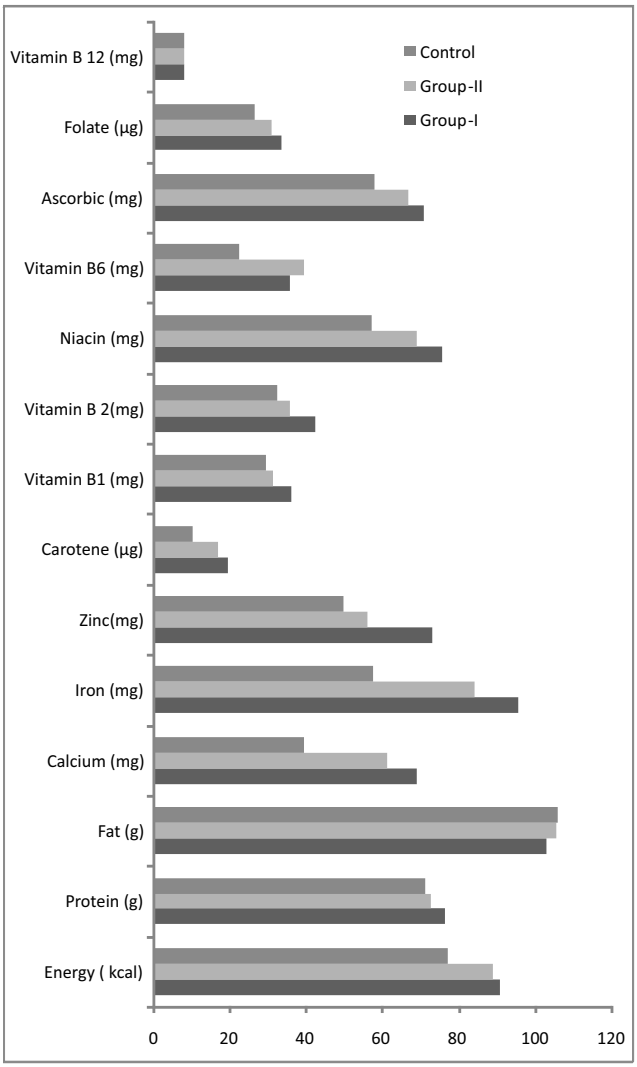

Fig. 3. Impact of nutrition intervention on per cent adequacy of nutrient intake of different groups

significantly higher than initial intake in group-I and non significant difference was observed in control and group-II during pre and post intervention. Sehgal and Kawatra (2002) also observed that all the food and nutrient intake of supplement group increased significantly than pre intervention periods. Rani and Palraj (2013) supplement anemic coffee plantation laborers with *spirulina* in soup and recorded their diet and nutrient intake before and after 120 days of intervention periods. They found that after intervention intake of iron, protein and carbohydrate increased significantly. Singh and Grover (2015) studied the seasonal variation of iron status of adolescent girls of Ludhiana city and found that intake was low then recommended intake. Nutritional inputs and awareness helped to increase the percent adequacy of food and nutritent and comparatively higher intake was reported in winter season. Smita et al (2015) study data showed that girls residing in university consumed inadequate of energy, protein, Calcium and Iron was far less than the daily requirement and fat was more than the daily requirement. Kamalaja et al (2016) observed that when rural adolescent girls were given nutrition intervention for 3 months the intake of calories increased to 85% adequacy, vitamins like thiamine, riboflavin, B carotene, retinol increased and minerals like calcium, iron and zinc intake of experimental group also increased after intervention due to food based strategies like increased knowledge and awareness of food groups and their functions. Geetha et al (2017) indicated that the lack of awareness, knowledge and practice on dietary habits and health has definitely had negative effect on adolescent girl's dietary intake of nutrients.

Hemoglobin level: The hemoglobin level of 90 moderately anemic adolescent girls was recorded before and after nutrition intervention. The mean initial level of hemoglobin in experimental group-I was 9.31g dl^{-1} which increased significantly to 11.44 g dl^{-1}. In group-II the initial value of 9.51±0.11 g/dl also increment significantly to 10.97g dl^{-1} at final level, whereas the mean initial level of hemoglobin increased non significantly in control group after 4 months of nutrition intervention. All the adolescent girls analyzed were moderately anemic (8-10.9 g dl^{-1} Hb) during pre intervention time and after receiving intervention for a period of 120 days

Table 4. Impact of nutrition intervention on mean hemoglobin level of selected adolescent girls

Parameters	Pre test	Post test	t-value
Group-I	9.31	11.44	11.94*
Group-II	9.51	10.97	7.48*
Control	9.35	9.84	1.38NS

*Significant at 5%, reference value: ≥12

in group-I, 13.33 per cent were not anemic at all while, 76.66 fall into mild anemic category, only 10 per cent did not show any improvement. Group-II respondents were imparted nutrition counseling only and 86.66 per cent remained in the same category of moderately anemic and 13.33 shifted to mild anemic category. There was no specific change in control group. Various studies done in India have suggested that anemia prevalent in our country appears to be caused mainly by lower dietary intake and poor absorption of iron from cereal based vegetarian diets which leads to nutritional anemia. Further revealing of data showed that dietary intervention had remarkable significant result on hemoglobin as compared to nutrition education intervention. During the dietary intervention, subjects of group-I were provided with iron rich food preparations i.e. *ladoo* and *mathri* for period of four months. 20g of each preparation per day provided 100 per cent RDA. Gitau et al (2016) done intervention study on school children with nutrition education classes using the FAO curriculum chart for three month. Which showed that children haemoglobin status were not significantly different (p>0.05) between the experimental and control schools at baseline. However, notable differences in haemoglobin levels occurred in the experimental schools after the interventions. Bandyopadhyay et al (2017) study aimed to assess the effectiveness of health education intervention on baseline knowledge of anemia prevention among school going adolescents. There was an expressive improvement in the haemoglobin level of the participating children after educational intervention. Karkada et al (2018) evaluated the effect of dietary supplementation of ragi porridge on hematological parameters on the intervention group 30 girls at 45 and 90 days. A statistically significant increase in hemoglobin levels was observed in the intervention group after 90 days (from a mean of 11.3 g% to 12.54 g%; $t_{(29)} = 7.514$, $p < .0001$), with no significant changes in the control group. The data of their study suggested that daily dietary supplementation with ragi porridge has a positive effect on hemoglobin levels in adolescent high schools girls.

CONCLUSION

Intervening with diet and nutrition education showed that intake of fruits and vegetable was increased in post intervention phase which was negligible at pre intervention phase. Intake of almost all nutrients in experimental groups I and II was more than before intervention. Thus it is concluded that dietary intervention with nutrition education is an effective tool in increasing food and nutrients intake as well as increasing the level of hemoglobin among moderately anemic girls who are future mothers and who are responsible for health of their family members.

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Contribution of "Green Libraries" for Cycling into a Sustainable Greener Planet

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Abstract: The "Sustainable Development Goals" of United Nations' 2030 agenda prioritize the goal of tackling the "climate change" as the top consideration while formulating strategies and accomplishing the designated goal(s). Libraries, being visited by diverse people throughout the world for garnering the knowledge, can play a pivotal role in enlightening human minds to combat the climate change and can make this commitment to a sustained environmental improvement by adopting "Go-Green", an eco-friendly approach in library activity/operation(s) and transforming their own existence into "Green Libraries" and can start eco-friendly i.e. paperless document delivery approach by adopting and encouraging users to use electronic information resources. This paper highlights the approaches that libraries can follow to "Go Green".

***Keywords*:** Climate change, Go-green, Green libraries, Greener planet, Sustainable development

The greener the planet, the healthier the life is the way to a healthy and prosperous life because the existence of life on a planet depends on its climate. These initiatives were mainly thematic and short on action. As the climate of our planet is changing at fast pace and its effects are clearly felt worldwide, therefore, in 2015 all United Nations Member States adopted "Transforming our world: the 2030 Agenda for Sustainable Development" (United Nations 2019). All the "Sustainable Development Goals" of this agenda recognize that the goal of tackling climate change should be given utmost importance while formulating strategies and accomplishing other goals. "Go Green" concept is fundamental to combat climate change and to reach its full potential, the inner soul of humankind needs to be awakened for this. In this direction, we need to re-order our priorities, providing resources to re-forest the earth, stop pollution and develop energy sources to stabilize earth's climate.

Though global economic production has grown manifold and a cause of celebration, but instead there is a sense of illusion, stating over-progress, which is eclipsed by poor environment around us and inflicting us. Thus, one of the net results of this attempted global upgrading of human societal life has been the global downgrading of the physical environment and, ultimately, of human societal life as well (Sharma 2019). Earlier, it was taken as that economic trends have shaped environmental trends, often altering the earth's natural resources, but now the reverse is beginning to happen, the environmental trends are beginning to shape economic trends, which seems to be bullish, whereas the biological indicators are bearish. Therefore, natural resources should be managed while maintaining a balance with the social, economic and technological developments. The focus should be on the development to meet the requirements of present without affecting the future needs. There is need to apply ecological deflator, if we need to measure real progress for maintaining our sustainability based on the climate resilience affects. Therefore, policymakers need to understand the local climate change impacts pertaining to their constituencies, and accordingly develop multi-pronged strategies of using indigenous coping mechanisms, wider adoption of the existing technologies and or concerted R&D efforts for evolving new technologies to combat climate change (Singh et al 2017).

Libraries are a kind of "living labs" that are an integral component of the teaching, learning and research system (Fedorowicz-Kruszewska 2019). These living labs are visited by all types of pluralistic people throughout the world for seeking information and enriching their knowledge. Libraries help communities to learn about sustainability issues and the ways to tackle these (Long 2000). Communities need libraries and librarians to act as role models for sustainability by providing accurate information on all manner of green topics, from alternative building practices to renewable energy options (Antonelli 2008). Therefore, libraries are key institution(s) supporting the attainment of the Sustainable Development Goals. The International Federation of Library Associations and Institutions (IFLA) have been pro-actively involved with the creation of the UN 2030 Agenda, advocating for the inclusion of access to information in the framework (IFLA 2019). One of the essential purposes of libraries is to support human beings, build human potential and to provend human aspirations (Genovese and Albanese 2012).

Green Libraries

Libraries can make this commitment for a sustained environmental improvement by adopting "Go-Green", an eco-friendly approach in library operations and transforming their own existence into "Green Libraries" as a beacon of light for others to follow. Bhattacharya (2017) terms the Green Libraries as "the edifice that is designed, built, renovated, operated or reused in an ecological and resource efficient manner". Reitz (2019) gives more explicit definition of the green library or sustainable library as "designed to minimize the negative impact on the natural environment and maximize indoor environment by conservation of resources like energy, water, paper, etc. while satisfying information needs of users". Therefore, green Library is all about implementing the elements of eco-design and ecology in everyday library practice (Hauke et al 2014).

Approaches for Libraries to Go-Green

Green library is a multi-faceted concept including green buildings, green operations and practices, green programmes and services, green information systems, green collections, etc. (Kurbanoglu and Boustany 2019). Some of the approaches for libraries to go-green include:

Green building: Buildings of new libraries should be constructed or even buildings of existing libraries should be modified to green buildings by using recyclable and eco-friendly materials. There are lot of national and international standards and protocols for green building viz. Indian Green Building Council (IGBC), Leadership in Energy and Environmental Design (LEED). IGBC provides various services including development of green building rating and training programmes, and certification services (Indian Green Building Council 2019). LEED is the most widely used green building rating system in the world that provides a framework to create healthy, highly efficient and cost-saving green buildings (U.S. Green Building Council 2019). By following these standards, libraries can use eco-friendly material; and also make natural light and air a key architectural focus. Natural light and air offers a wide variety of benefits in an educational environment, from improved focus to better student health, with decrease in electricity consumption. Therefore, green libraries should have sufficient windows, glass windows and skylights that pass natural light and air into the library building (Meher and Parabhoi 2017).

Green surroundings: Libraries can contribute to a greener planet by planting more number of herbal and decorative plants/trees outside as well as within the library premises at appropriate places. This will reduce the "Heat Island Effect" on environment. Further, this will not only add magnificence to the library building while contributing positive ambience to the environment, but will also allure the users to come to beautiful place to have pleasant reading, in good ambience.

Use of solar and geo-thermal energy: Global energy demand rose by 2.3 per cent in 2018, its fastest pace in the last decade (IEA 2019). With this rising demand for energy, conventional energy sources viz. fossil fuels are inadequate to meet the long term demand. Further, the use of fossil fuels has a negative environmental impact and the major challenge for sustainability world over is to find renewable, efficient, cost-effective and environment-friendly sources of energy (Singh et al 2016). On the similar lines, libraries use electricity in reading halls, discussion rooms, research carrels, auditoriums, computer rooms, circulation counters, photocopy and printing section, offices, etc. and the consumption of energy is on accretion. To meet this ever increasing demand of electricity, green libraries can set paradigms by adopting solar and geo-thermal energy, the renewable and clean sources of energy. Libraries can utilize the free roof space to install solar panels. The uniform, flat and unshaded roof space of library building let the rays to hit more optimally on panels, which adds to output and efficiency of the power generated by the panels.

Geo-thermal technologyis another renewable source of energy, which uses the heat contained in the ground to generate electricity and also advocates direct use of heat (Manzella 2015). Resources of geothermal energy range from the shallow ground to hot water and down even deeper, and almost everywhere, the shallow ground or upper 10 feet of the Earth's surface maintains a nearly constant temperature between 50° and 60°F (10° and 16°C) (Renewable Energy World 2019). The geothermal heat pumps (GHPs) take advantage of this constant temperature of earth's surface. GHPs transfer heat stored in the earth or in ground water into a building during the winter, and transfers it out of the building back into the ground during the summer (Office of Energy Efficiency & Renewable Energy 2019). Use of geo-thermal energy is increasing 4 per cent annually and has become the third most used renewable energy source in the world (Ngo and Natowitz 2016). Green libraries can also use the geo-thermal energy for heating and cooling the library buildings during summers and winters, respectively. By fostering these renewable sources of energy, green libraries can cut down on emission levels and fossil fuel consumption.

Rain water harvesting: Ground water is major source of water for human use in many parts of the world, and the level of ground water is depleting with the passage of time due to its large scale consumption. This is leading to water crisis. One of the best ways to tackle water crisis is rainwater harvesting that captures this precious resource, an elixir of

life. Rainwater harvesting is a simple method by which rainfall is collected for future usage and the collected rainwater may be stored, utilized in different ways or directly used to recharge local aquifers (India Water Portal 2019). It can also help to reduce urban flooding and ensure water availability in water-scarce zones. Libraries can also come forward to fight water crisis by implementing rain water harvesting system. Libraries can harvest the rooftop rainwater for non-potable functions such as irrigating landscaping, flush toilets, cleaning floor, and it can even be purified for human consumption. This will reduce the demand of potable fresh water significantly in libraries.

Eco-friendly document delivery service: Green libraries should come forward to support eco-friendly learning by encouraging users to read e-books, e-journals, e-newspaper and other electronic information sources. Further, libraries should give an impetus to use of digital document delivery service by supplying scanned copies of information sources to end users/library visitors rather than supplying the photocopies, without violating copyright laws. This "save paper drive" will curtail the wastage of paper, resultantly the pressure on cutting of trees. Further, with digital services, there will be reduction in use of ink, production and transportation costs, and thus a reduction in carbon emissions (McElrath and Sutherland 2015). Therefore, digital services are more environmentally sustainable and contribute towards greener planet.

Electronic waste management: With the advancement(s) in information and communication technologies, the electronic gadgets are becoming obsolete and with their increased use they are also getting damaged/non-functional and/or repeated repairs. This generates taxing electronic waste (e-waste) including monitors, central processing units, UPS, laptops, modems, cables, keyboards, printers, scanners, mouse, air-conditioners, refrigerators, mobiles, telephones and other electronic equipment. Management of e-waste becomes a major challenge for many countries as they lack proper technology, infrastructure, tools, resources and trained workforce for this and its inappropriate management has extremely hazardous impacts not only to soil, water and ozone layer, but also to humans and wildlife (Firdaus et al 2014). Therefore, it is the apt time for libraries and information centres to step in and plan e-waste management system at the institution level and suggest/take necessary steps for uplifting the e-waste to government authorized agencies for re-cycling of the e-waste, thus contributing to greener environment.

Outreach activities to enlighten masses: The concept of sustainable/green library involves not only design/ refurbishment of library building, but also improvement in day-to-day operations of the library by implementing sustainable strategies. Libraries are the community role models for educating masses about the friendly environmental practices (Binks et al 2014). Therefore, green libraries can play a dynamic role to make our planet a "Greener Planet" by organizing seminars for community in general and students/faculty in particular to make them aware about dire consequences of climate change and the steps to be taken to combat it. Workshop(s) can be conducted at suitable places by green libraries to acquaint people by demonstrating them the technique(s) used by green libraries to go-green. Marathons and cycle rallies can be organized by the libraries to highlight the pollution caused by vehicles using fossil fuels. Green libraries can become a role model by associating with various NGOs to initiate plantation drives and can organize street plays and develop videos by involving students/faculty for general public to educate them in positive direction.

Green week celebration: Green libraries can come forward to take a new initiative of celebrating "Green Week" in a new exemplar by instigating a drive of "Zero consumption, zero emission and zero pollution". This can be made realistic by creating a "Green Reading Hall" for a week in an appropriate weather conditions e.g. during the onset of winters when weather is pleasant. All this needs to be chalked out while paying special attention to the academic calendar of the institution. "Green Reading Hall" can be created by shifting limited library furniture i.e. tables and chairs of the library to the lawns/empty space surrounding libraries and using tents for fencing this hall. This "Green Reading Hall" will use natural day light and fresh air. Hence, there will be no consumption of electricity for lights, fans, air-conditioners, etc. Due to no extra demand of electricity, consumable energy sources will not be burnt, leading to zero emission and zero pollution. This will set a model for other departments within the institution as well as for other institutions to adopt such practice to curtail energy consumption. Hence "Green Week" movement by green libraries can considerably contribute to a greener planet.

Green library initiatives at international level: Various initiatives have been taken by the libraries and library associations worldwide to move towards a greener planet. IFLA immensely support the Green Library movement. IFLA has set up various groups to further the profession. Environment, Sustainability and Libraries (ENSULIB) is one of the Special Interest Group(s) of IFLA that considers sustainable development as major concern of society, and consequently of libraries. ENSULIB (2019) has described its mission in detail to address the effects of climate change on libraries like modification of storage/preservation and

buildings insulation. It embraces use of eco-friendly approaches like recovery of rainwater, use of renewable energy, controlled printing, recycling of paper, etc. It also encourages libraries to build collections and expand outreach services on sustainable environmental themes. IFLA have also set up “IFLA Green Library Award”. This award helps to advance the profession through illuminating the role of libraries and librarians in the advancement of sustainability standards and the promotion of specialized knowledge within professional practice (IFLA 2019). National and University Library (NUL) in Zagreb, Croatia executed a project with the motto, “Green Library for Green Croatia” and organized the International Green Library Conference during November 2018 in association with the Croatian Library Association. The conference aimed to develop guidelines for helping libraries for enhancing the awareness about the green libraries and fortify the cooperation amongst similar institutions (Greenyourlib 2019). Some of the prominent examples of international green libraries include:

National Library Building in Singapore is internationally recognized architectural icon designed as a 'green' building (National Library Board Singapore 2019). This library uses bioclimatic vegetation and landscaping to improve the indoor thermal environment and a lighting control system. Light shelves that extend into the library space and automatic rain sensors that irrigate landscaped areas are other key features of this green library. Anythink Brighton library is the first carbon-positive library in the U.S. This library uses photovoltaic system i.e. solar energy as a source of power (Anythink 2019). The library building has features like the ground source heating and cooling, day lighting strategies and use of recycled materials in the building to lower its impact on the environment.

Spanish Peaks Library, UK was designed around an intuitive layout for sustainability. Some of the sustainable features include: recycled rubber flooring, chairs made from recycled car battery plastic and seat belts, recycled shelving from another library, and geothermal heating and cooling (Spanish Peaks Library 2019). Minneapolis Central Library is a building with a highly sustainable design. The roof of the building is planted with drought-resistant ground cover with an 18,500-square-foot roof garden (Culture Now 2019). This reduces storm water runoff and decreases the urban heat island effect. The library building also uses under-floor ventilation system to reduce cooling cost. Dexter Library of Northland College, Wisconsin started using ground-source heat pumps (GHPs) in 2008 to provide all-season temperature control for the library. This GHP system has 30 boreholes drilled 230 feet deep (Cross et al 2011). Solar panels were also installed on the roof of the Dexter Library. These bifacial panels produce that much power, which is sufficient for use by the building's geothermal heating and cooling system. This makes the building heating and cooling neutral and less reliant on the traditional electric grid, an impressive feat in Northern Wisconsin (Waligora and Hintz 2009).

Darien Library, Connecticut, United States is an environmentally responsible green building. Some of the sustainable features of this library include geothermal heating and cooling, natural lighting in all spaces, multi-level lighting controls, bio filtration of storm water, site irrigation from geothermal wells, and detention of all storm water on site (Darien Library 2019). TU Delft Library, Netherlands is an excellent exemplar of landscape. It has a unique design, grass is lifted up at one corner and supported by columns. The central hall created by this effect has glass facades to use natural light. The grass roof has an insulating effect and reduces large changes in temperature (TU Delft Library 2019). The rain water is retained by the grass roof and slow condensation of this water creates natural cooling in summer, making the building energy efficient. It also provides excellent noise reduction. The building uses groundwater as cold storage to keep it cool or warm as required. The Bozeman Public Library, Bozeman, Montana (United States) is another green building that has sustainable strategies to conserve water and energy for the long term, and provide a healthy and comfortable environment for patrons and staff (Bozeman Public Library 2019).Villanueva Public Library, Colombia is an excellent example of sustainable and low maintenance building. The building is constructed out of locally-sourced river rocks and pine wood harvested from a nearby sustainably managed forest (Meinhold 2011). Local inhabitants worked as part of a rehabilitation program for the construction of library. Vennesla library, Norway has a striking appearance and is mainly built of wood. All the ribs, inner and outer walls, slabs and parts of the roof are made of prefabricated glue-laminated timber elements. The facade consists of glass for use of natural day lighting (Library buildings 2018). The library is a sustainable 'low-energy' building by the using high standard energy-saving solutions.

Scottsdale Public Library, Arizona has started a new of its kind service of 'Seed Library' in its efforts to go-green in partnership with Garden Pool, a nonprofit organization. This seed library is stocked with edible plant and herb seeds appropriate for Arizona growing conditions and seasons (Scottsdale Public Library 2019). Three seed packets per month can be checked out by library card holders. Availability of seeds is dependent on seasonal growing conditions. Borrowed seeds are not required to be returned like other library materials, however, members can contribute by

donating their harvested seeds. Fayetteville Public Library, Seattle Central Library are other popular international libraries that harvest rain water for landscaping and irrigation purposes (Thomas 2017). Some libraries have also come forward for management of e-waste. Under an extension of eCycle initiative of Department of Energy and Environment, District of Columbia, USA, public libraries holds electronic recycling events to collect computers, keyboards, TVs, video game consoles and more, free of charge (Nania 2019). Similarly, Council of Port Phillip, Victoria, Australia has designated libraries at St Kilda, Port Melbourne and Albert Park Libraries to collect e-waste and to keep it out of landfill so that it doesn't harm our environment - or our health (City of Port Phillip 2019). Similarly, the University Library, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India manages the e-waste at university level and hands it over to the Punjab Pollution Control Board authorized e-waste agency for dismantling and recycling.

CONCLUSION

Libraries can adopt the strategies for Green Marketing of library products and services by following the 4 P's of Green Marketing Mix viz. Product, Price, Promotion and Place to make them more ecological-viable and economical viable . The practice and demonstration of “Go-Green” and “Sustainable Thinking” throughout the library building, equipment, management, and services makes it clear that libraries care about users as individuals and about community as whole – locally and globally. The efforts of green libraries for taking up such responsible and creative steps will be appreciated by the students, parents and public in general. This will create zeal in their minds and will further motivate them to “Go Green”. Thus, green libraries can contribute a bit to the society as trend setters around the world that are focusing to transform our planet to “Greener Planet” to tame climate change, which involves embarking each and every sect of society.

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CONTENTS

2943	An Investigation of Firewood Species used by Community of Gundani Village in Vhembe District, Limpopo Province, South Africa *O. Leshabana and M.P. Tshisikhawe*	921
2944	Study on Work Pattern and Drudgery Experience of Hill Farm Women of Himachal *Radhna Gupta and Rakesh K. Gupta*	926
2945	Iron and Zinc Status of Adult Women from Low Income Rural Families of Punjab, India *Kiran Bains, Harpreet Kaur and Navjot Kaur Bajwa*	933
2946	Impact of Mid-Himalayan Watershed Development Project on Employment, Income Generation and Problems Faced by Farmer's in Himachal Pradesh *Kapil Dev, Ravinder Sharma and Amit Guleria*	938
2947	Effectiveness of Nutritional Intervention on Food and Nutrient Intake and Hemoglobin Level of Moderately Anemic Adolescent Girls *Preeti Chaudhary and Radhna Gupta*	943
2948	Contribution of “Green Libraries” for Cycling into a Sustainable Greener Planet *Dhiraj Kumar and Nirmal Singh*	949

CONTENTS

2920 Evaluation of the Spread of *Orobanche crenata* in Carrot (*Daucus carota* L.) 792
Toufik Chedadi, Omar Idrissi, Abdelmajid Haddioui and Mohammed Elhansali

2921 Effect of *Ascophyllum* Extract and Water Stress on Soil Biological Properties and Growth of Onion (*Allium Cepa* L.) 796
Salwan Al-Maliki, Ameer Adnan, Kifah Abd Alhussain Huda AL-Mammory and Alaa A. ALmoslimawi

2922 Marker-assisted Selection for Incorporating Bacterial Blight Resistance Genes in the Segregating Generation of Rice Variety CO 43 803
Navaneetha Krishnan J., N. Kumaravadivel, A. Ramanathan, A. Chandrasekar and M. Bharathi

2923 Combining Ability of Early Segregating Generation RGR F_4 Lines of Heteroticbox in Cotton 810
Girish Tantuway and Shreekant S. Patil

2924 Bio-monitoring and Detection of Water Quality using Ephemeroptera, Plecoptera and Trichoptera (EPT) Complex in Karanthamalai Stream of Eastern Ghats 818
Srinivasan Pandiarajan, Sivaruban Thambiratnam, Isack Rajasekaran and Barathy Sivaruban

2925 Impact of Industrial Wastewater Disposal on Surface Water Bodies in Kalingarayan Canal, Erode district 823
R. Divahar, P.S. Aravind Raj, S.P. Sangeetha and T. Mohanakavitha

2926 Fertility Status of Soils under Different Land Uses in Lesser Himalayan region of Himachal Pradesh 828
Deepika Suri, V.K. Sharma, Gazala Nazir, Anjali and Ankit Gill

2927 Impact of Probability of Well Success on Unit Cost of Irrigation in Karnataka 835
Kiran Kumar R. Patil, M.G. Chandrakanth and G.R. Manjunatha

2928 Water Use Efficiency and Yield of Baby Corn under Different Drip Irrigation Regimes in Sandy Loam Soil 839
K. Sai Manogna, A. Rama Rao, V.V. Tejaswini and K. Murali Naik

2929 Assessment on the Water Quality of Tsurang River, Nagaland Affected by Coal Mining Drainage 845
Khikeya Semy and M.R. Singh

2930 Physico-chemical Properties of Soil Affected by Different Sources of Nutrients 850
Arvind Chahal, G.D. Sharma, Naveen Kumar and Ashish Kumar

2931 Nutrient Status of Runoff Water from Rice and Wheat Fields of Ludhiana District of Indian Punjab 853
Nandita Sharma, Mahesh Chand Singh and J.P. Singh

2932 Fishery Policies and Acts in Present Context-Experiences from Coastal Bangladesh 857
Paramjit Singh Jamir Singh, Mohammed Mamun Rashid, Azlinda Azman and Isahaque Ali

2933 Food Availability and Diet Composition of the Eurasian Otter *Lutra lutra* (L. 758) in Saharan Aquatic Ecosystem, Dam of Djorf Torba's, Bechar-Algeria 862
Z. Kaci, M. Biche and M. Sellami

2934 Native Species Displacement by Invasive Alien Species Yellow Crazy Ant: *Anoplolepis gracilipes* (Smith 857) (Hymenoptera: Formicidae) 867
Jaya Kishor Seth, Sandeep Kumar Mohapatra, Pabitra Mishra, Rajashree Behera and D. Suresh Lingam

2935 Optimization of Compost Quantity for Fruit Body Yield in Button Mushroom (*Agaricus bisporus*) 871
R.S. Netam, S.C. Mukherjee, Poonam Kumari and P.S. Netam

2936 Acute and Chronic Toxicity of Fluoroquinolone Antibiotics through Fresh Water cladoceron *Daphnia magna* 874
Aijaz A. Mala and Joydeep Dutta

2937 Cell Growth and Carotenoids Production by Moroccan Strain of *Dunaliella Salina* 880
FZ. EL Fihri, F. Hmimid, F. Bellali, F. Souilmi , R. Flower, M. Ramdani and N. EL Khiati

2938 Arthropod Diversity in Horticultural Ecosystems in Keelaiyur Block, Nagapattinam District, Tamil Nadu 889
M.P. Sugumaran and B. Duraimurugan

2939 Antropogenic Factors of Azov Sea Bioproductivity Transformation: Ecological History of Industrial Epoch 892
Ihor Olegovych Pylypenko, Daria Serhiivna Malchykova, Oleksiy Vitaliyovych Davydov and Kira Mykolayivna Baysha

2940 Influence of Elevated Zn on the Hematology, Serum Biochemistry and Productive Indicators in Laying Hens 901
V.L. Petukhov, I.A. Afonina, M.A. Kleshev, O.I. Sebezhko, O.S. Korotkevich, N.M. Kostamakhin, T.V. Konovalova, K.N. Narozhnykh, D.S. Adushinov, G.M. Goncharenko, A.G. Nezavitin, I.I. Klimenok, A.V. Nazarenko, E.A. Klimanova and L.V. Osadchuk

2941 Incidence and Population Dynamics of Land Snails at Sharkia Governorate, Egypt 907
Salwa, A.E. Abd-El-Haleem, M.F.N.G. Farag and M.M.H. Kandeel

2942 Evaluation of Local Design Machine for Corn Threshing 913
Mousa A. Aljibouri and Salih K. Alwan Alsharifi

Indian Journal of Ecology (2019) 46(4)

Indian Journal of Ecology

CONTENTS

2901 Land Use Land Cover Change Detection Using Remote Sensing and Geographic Information System in Canal Command Area, Karnataka 683
Ayyanna, B.S. Polisgowdar, A. Rama Roa and B. Harish Bachina

2902 Tree-Based Classification of Mangrove Forest using Hyperspectral Remote Sensing Data 691
Ayyakkannu Selvaraj and Subbarayan Saravanan

2903 Land Degradation Index using Salinity Index by GIS-MCDM Method in Al-Hashimiya Irrigation Project in Babil Province, Iraq 697
Ayad Kadhim Ali and Waleed M. Mukhlif Al Shafei

2904 Application of Artificial Intelligence to Estimate the Reference Evapotranspiration at North Bihar, India 703
Namrata Sah, P.S. Kashyap and Priyanshu Raj

2905 Meteorological Drought Assessment Based on Standardized Precipitation Index 707
Priya Rai, Praveen Vikram Singh and Akhilesh Kumar

2906 Evaluation of Land Degradation Assessment Studies: Attributes Applicable to Various Geographical Regions 714
Manish Mathur and S. Sundaramoorthy

2907 Dendrochronological Potential of *Tectona grandis, Pinus kesiya* and *Quercus serrata* from Mizoram, Northeast India for Growth 722
Keshav Kumar Upadhyay, Santosh K. Shah, Arijit Roy, Nivedita Mehrotra and S.K. Tripathi

2908 Systematic Position of *Tamarix* in the Region of Tlemcen (Western Algeria) 729
Khadoudja Benkelfa and Hassiba Stambouli-Meziane

2909 Population Dynamics of Midrib Folder, *Banisia myrsusales elearalis* (Walker) in Sapota and its Rootstock, Khirnee 733
K.D. Bisane and B.M. Naik

2910 Development of Ecological Regional Maximum Permissible Concentrations of Fuel Oil in Arid Soils of South of Russia 740
Daoud Rama Mohammed, Kolesnikov Sergey Ilyich and Kazeev Kamil Shagidullovich

2911 Effects of Overgrazing on the Physico-chemical and Biological Properties of Semi-arid Forest Soils in Western Algeria 745
Allam Ayoub, Borsali Amine Habib, Kefifa Abelkrim, Zouidi Mohamed and Gros Raphael

2912 Preparation of Activated Charcoal from Wood Sawdust 751
Ali Omairi Mohammed

2913 Study on Some Threatened, Rare and Endangered Plant's Species in Reserve Forest Area of Jhunjhunu District, Rajasthan 755
Anita Jeph and J.B. Khan

2914 State of Benthic Macroinvertebrate Community in Bhagirathi River Ecosystem Impacted by Hydroelectric Projects 760
Sandeep Kumar and Prakash Nautiyal

2915 Capsule Maturation Timing in *Rhododendron arboreum* Smith in the Central Himalayan Region 768
Bhawna Tewari and Ashish Tewari

2916 Physico-chemical Properties of Soils Underneath Tuberous Medicinal Plants from Sitamata Wildlife Sanctuary 772
Arti Soni and Pawan Kumar Kasera

2917 Effect of Abiotic Factors on Seed Germination of *Anacyclus pyrethrum* (L.) Link, and Modeling of Habitat Suitability in Saida (Algeria) 777
Djebbouri Mohammed and Terras Mohamed

2918 Nutrient Release Pattern in Different Growth Media for Container Cultivation of Elephant Foot Yam 783
N.P. Limisha and O.K. Swadija

2919 Inducing Systemic Resistance in Tomato Plants against *Fusarium* Wilt Disease using Salicylic Acid 788
Jasim Mahmood Abed, Theyab A. Farhan, Hayder H, Nawar and Ali A. Khadhum

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