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Performance of Promising Okra Varieties and Fertilizers under Fruit Tree Based Agroforestry Systems

Purnima Thakur, C.L. Thakur , D.R. Bhardwaj and Subhash Sharma

Department of Silviculture and Agroforestry
Dr Y. S. Parmar University of Horticulture & Forestry, Nauni, Solan-173 230, India
E-mail: purnimathakur394@gmail.com

***Abstract*:** The performance of different varieties of Okra (*Abelmoschus esculentus* Moench) was studied under different agroforestry systems and open conditions. The treatments included 2 agroforestry systems (apricot, pear), 2 planting conditions (inside canopy and outside canopy), 3 fertilizer doses (RDF-75:50:50 NPK Kg ha^{-1} + FYM @ 15 tha^{-1}, Jeevamrut @500 l ha^{-1}, FYM @ 15 t ha^{-1}) and 3 okra varieties viz. Kranti, Nauni P-8 and Tender. The plot size was 2m x 1m. The experiment was laid out in Randomised Block design (factorial) and data was recorded in three replications for each treatment including tree and treeless plots. Plant height (63.00 cm) and internodal length (11.76 cm) were found maximum under open system as compared to agroforestry systems. Among varieties, the maximum number of nodes per plant (10.43), yield (82.10 q ha^{-1}) and number of fruits per plant (11.51) were maximum in Nauni P-8 variety. Plant height (62.03cm) was found maximum in Kranti variety. Amongst different fertilizer doses, NPK + FYM @15t ha^{-1} significantly produced maximum plant height (64.30 cm), internodal length (11.96 cm), number of fruits per plant (11.69) as compared to other fertilizers. Hence it may be concluded that among varieties, Nauni P-8 variety performed better as compared to other varieties and should be grown under the influence of NPK + FYM @15t ha^{-1} for better growth and production.

***Keywords*:** FYM, RDF, Jeevamrut

Agroforestry is the collective name for land use system in which woody perennials (trees, shrubs etc.) are grown in association with herbaceous plants (crops, pastures) and/or livestock in spatial arrangement, a rotation, or both and in which there are both ecological and economic interactions between the tree and non-tree component of the system (Young 1989). Fruit-tree-based agroforestry systems have been only modestly studied, especially in terms of quantification of biophysical interactions occurring in mixtures of fruit trees and crops (Bellow 2004). In Himachal Pradesh temperate trees such as apple, apricot, peach, pear and plum are most commonly used in agroforestry system. The aspect and season also play a significant role in grain, straw and biological productivity of agricultural crops present in agri-horticulture and sole cropping system.

In case of sloppy land sole agricultural practices are difficult, therefore different agroforestry combinations are preferred by the farmers. Retention of fruit trees on their agricultural fields for additional monetary gain from the fruits and therefore, agri-horticulture practice is the priority of high land holding farmers as the climatic and geographical situations also permit such practices (Bijalwan 2012).

The development of agroforestry for the industrialized countries can be furthered by an understanding of the history and present functioning of traditional systems. In temperate Europe also fruit trees were traditionally grown on agricultural lands under-sown with crops or managed grasslands called Streuobst (Herzog 1998). In 1981-86, an average 74.3 per cent fruits harvested in Germany came from Streuobst and from fruit trees in gardens. In Himachal Pradesh, diversification from cereal based cropping to vegetables is gaining momentum. The temporal changes in the cropping pattern bring out the process of crop diversification towards fruits and vegetable crops in Kullu, Shimla, Kinnaur and Lahaul Spiti followed by Solan, Sirmour and Chamba. The process of diversification varies across districts depending upon agroclimatic conditions (Sharma 2011). Locally adapted niche based indigenous vegetables are consumed traditionally as special dishes based on age-old indigenous wisdom of their nutritive and medicinal values in different areas (Kumar et al 2014).

The glorious food grain production couldn't save our majority of population from malnutrition problem due to inadequate consumption of costly animal food products. Vegetables being cheap and rich source of nutrients, vitamins and carbohydrates may lead to solve this problem upto a greater extent. The present production system has endangered our health and environmental security due to abundant use of chemical fertilizers and pesticides. Organic farming has been used to develop an alternative eco-friendly

technology for sustainable vegetable production (Singh et al 2000).

Okra (*Abelmoschus esculentus* L. Moench) also known as lady's finger or bhindi belongs to family Malvaceae. India is one the leading okra producer with the production of 6.346 million tonnes per year from an area of 0.532 million ha, with the productivity of 11.9 t ha^{-1} (National Horticulture Board 2014) and it is cultivated extensively round the year for its immature fruits. Higher production of this crop is possible by the cultivation of varieties or hybrids which show remarkable enhanced returns, compared to other cultivars grown at same climatic conditions and inputs applied (Javed et al 2009).

The present production system has endangered our health and environmental security due to abundant use of chemical fertilizers and pesticides. Organic farming has been used to develop an alternative eco-friendly technology for sustainable vegetable production (Singh et al 2000). Organic products fetch very high premium prices in the market from the consumers, which are often as high as 2-3 times more than that of inorganic produce which makes organic farming a highly profitable enterprise (Thakur and Sharma 2005).

MATERIAL AND METHODS

An experiment was conducted in the experimental field of the Department of Silviculture and Agroforestry, Dr. YSP University of Horticulture and Forestry, Nauni, Solan (H P) during June, 2020. The experimental site falls in mid hill zone of Himachal Pradesh at 300 51' N latitude and 760 11' E longitude, with an elevation of 1200 m amsl. The area falls in sub-tropical, sub-humid agro-climatic zone of Himachal Pradesh, India. May and June are the hottest months, whereas December and January are the coldest months and experience severe frost during winter. On an average the annual rainfall received varies from 1000-1400 mm; about 75 per cent being received during the monsoon period (June-Septmber). The soils of the area belongs to Typic Eutrochrept at subgroup level according to Soil Taxonomy of USDA.

The design used for the experiment was Randomised Block Design and treatment combinations include 2 (tree components: apricot and pear), 2 (planting condition: Inside and outside canopy), 3 varieties (Kranti, P-8, and Tender), 3 nutrient and fertilizer doses viz. RDF (75:50:50 NPK Kg ha^{-1} + FYM @15 t ha^{-1}), Jeevamrut (500 litres ha^{-1}) and FYM (15 t ha^{-1}).

The cropped area was managed in the same way as commercial crops. Open plots was an area where different bhindi varieties were sown without trees (pear and apricot), and it was established in close proximity to agroforestry systems. Bhindi varieties were sown at a spacing of 45 cm x 15 cm. Open plots were also subjected to same fertilizer doses. The data were subjected to analysis of variance (ANOVA) using IBM_ SPSS Statistics_ 26 software to evaluate difference between treatments, where ANOVA indicated that treatments effects were significant at p=0.05

The height and girth were measured with the help of calliper and tape, respectively during the two years. The crown spread (m2) was also measured with the help of measuring tape. Light Transmission Ratio of two systems pear and apricot was taken with the help of luxmeter. Fruit yield of tree was measured during the two respective years (2020-2021).

RESULTS AND DISCUSSION

Tree growth parameters: The mean tree height was 2.03 m, 2.15 m in pear based agroforestry system and 5.12 m, 5.29 m in apricot bsed agroforestry system during 2020-2021. Crown spread was found more in apricot trees during ist and 2nd year (1.24 m^2, 1.31 m^2) as compared to pear trees (0.70 m^2, 0.58 m^2). Light transmission ratio was more under pear based agroforestry system (86.74%, 87.55%) as compared to apricot (77.50%, 78.34%) during two years of study. Light is considered to be major limiting factor under agroforestry systems. Fruit yield (t ha^{-1}) was also found to be more in pear based agroforestry system (50.35 t ha^{-1}, 6.06 t ha^{-1}) as compared to apricot (45.55 t ha^{-1}, 62.53 t ha^{-1}) during 2020 - 2021.

Effect of systems, varieties and fertilizers on okra growth parameters: Various crop parameters were recorded and the performance of three okra varieties and three fertilizers doses is presented in Table 1, 2 ,3 and 4. Pooled data of both the years (2020-2021) revealed that plant height and internodal length were found to be maximum (63.00 cm, 11.76 cm) in open system and minimum (54.01 cm, 10.21 cm) under apricot based agroforestry system (Table 1 and 2). Days to first flowering (53.74 days) were found maximum under apricot based system and minimum (50.27 days) under open system. Number of nodes plant^{-1}were found maximum (10.41) under open and minimum (8.95) in apricot based system. The probable reason might be less availability of light under apricot system (Table 1). These results are in accordance with Bhusara et al (2018) while studying the performance of different okra varieties under different spacings of Melia composita based agroforestry system and found that varieties performed better under open conditions as compared to agroforestry systems. Das et al (2020) also found that yield of okra was reduced to 7.57% under agroforestry system as compared to open.

Bhindi varieties performed significantly with respect to

Table 1. Effect of systems, varieties and fertilizer doses on plant height (cm), days to Ist flowering and no. of nodes per plant of *Abelmoschus esculentus*

Treatments	Plant height (cm)			Days to Ist flowering			Number of nodes plant^{-1}		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Systems									
Apricot (S_A)	52.42^{c}	55.59^{c}	54.01^{c}	53.79 ^{a}	53.69^{a}	53.74 ^{a}	8.99^{c}	8.90^{c}	8.95^{c}
Pear (S_P)	56.99^{b}	59.32^{b}	58.16^{b}	53.29 ^{ab}	53.63 ^{ab}	53.46 ^{ab}	9.58^{b}	9.63^{b}	9.60^{b}
Open (S_O)	61.57^{a}	64.43^{a}	63.00^{a}	49.97 ^{c}	50.57 ^{c}	50.27 ^{c}	10.08^{a}	10.74^{a}	10.41^{a}
CD (p=0.05)	4.01	3.53	3.73	2.30	2.23	2.20	0.39	0.44	0.40
SE (m)	1.41	1.24	1.31	0.81	0.78	0.77	0.13	0.15	0.14
Varieties									
Kranti (V_1)	61.15^{a}	62.90^{a}	62.03^{a}	51.98	52.03	52.01	8.99^{bc}	9.18 ^{bc}	9.08 ^{bc}
Nauni P-8 (V_2)	56.16^{b}	59.12^{b}	57.64^{b}	52.78	52.88	52.83	10.29 ^{a}	10.57 ^{a}	10.43 ^{a}
Tender (V_3)	53.66^{bc}	57.33^{bc}	55.50^{bc}	52.28	52.97	52.63	9.37 ^{b}	9.53 ^{b}	9.45 ^{b}
CD (p=0.05)	4.01	3.53	3.73	NS	NS	NS	0.39	0.44	0.40
SE (m)	1.41	1.24	1.31	0.81	0.78	0.77	0.13	0.15	0.14
Fertilizers									
RDF+ FYM (F_1)	62.88^{a}	65.73 ^{a}	64.30 ^{a}	54.01 ^{a}	54.49 ^{a}	54.25	10.15 ^{a}	10.53 ^{a}	10.34 ^{a}
Jeevamrut (F_2)	51.92^{c}	54.80 ^{c}	53.36 ^{c}	51.07 ^{c}	51.22 ^{c}	51.15	9.68 ^{ab}	9.85 ^{b}	9.76 ^{b}
FYM (F_3)	56.18^{b}	58.82 ^{b}	57.50 ^{b}	51.96 ^{b}	52.18 ^{b}	52.07	8.82 ^{c}	8.89 ^{c}	8.85 ^{c}
SE (m)	1.41	1.24	1.31	0.81	0.78	0.77	0.13	0.15	0.14
CD (p=0.05)	4.01	3.53	3.73	2.30	2.23	2.20	0.39	0.44	0.40

Table 2. Effect of systems, varieties and fertilizer doses on internodal length (cm), number of fruits plant^{-1} and fruit length (cm) of *Abelmoschus esculentus*

Treatments	Internodal length (cm)			Number of fruits plant^{-1}			Fruit length (cm)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Systems									
Apricot (S_A)	10.07 ^{c}	10.36 ^{c}	10.21 ^{c}	10.06 ^{c}	10.09 ^{c}	10.07 ^{c}	10.78 ^{c}	11.01 ^{c}	10.90 ^{c}
Pear (S_P)	11.04 ^{b}	11.58 ^{b}	11.31 ^{b}	11.04 ^{b}	11.07 ^{b}	11.05 ^{b}	11.88 ^{b}	12.12 ^{b}	12.00 ^{b}
Open (So)	11.52 ^{a}	12.01 ^{a}	11.76 ^{a}	11.52 ^{a}	11.54 ^{a}	11.53 ^{a}	12.41 ^{a}	12.85 ^{a}	12.63 ^{a}
SE (m)	0.11	0.14	0.11	0.15	0.15	0.15	0.17	0.18	0.18
CD (p=0.05)	0.31	0.39	0.33	0.43	0.43	0.43	0.50	0.53	0.51
Varieties									
Kranti (V_1)	10.80	11.18	10.99	10.05 ^{c}	10.07 ^{c}	10.06 ^{c}	10.99 ^{c}	11.27 ^{c}	11.13 ^{c}
Nauni P-8 (V_2)	10.93	11.33	11.13	11.50 ^{a}	11.52 ^{a}	11.51 ^{a}	12.17 ^{a}	12.49 ^{a}	12.33 ^{a}
Tender (V_3)	10.90	11.43	11.17	11.08 ^{ab}	11.10 ^{ab}	11.09 ^{ab}	11.91 ^{ab}	12.23 ^{ab}	12.07 ^{ab}
SE (m)	0.11	0.14	0.11	0.15	0.15	0.15	0.17	0.18	0.18
CD (p=0.05)	NS	NS	NS	0.43	0.43	0.43	0.50	0.53	0.51
Fertilizers									
RDF+ FYM (F_1)	11.82 ^{a}	12.11 ^{a}	11.96 ^{a}	11.68 ^{a}	11.70 ^{a}	11.69 ^{a}	12.47 ^{a}	12.78 ^{a}	12.62 ^{a}
Jeevamrut (F_2)	10.87 ^{b}	11.27 ^{b}	11.07 ^{b}	10.99 ^{b}	11.01 ^{b}	11.00 ^{b}	11.65 ^{b}	11.99 ^{b}	11.82 ^{b}
FYM (F_3)	9.94 ^{c}	10.56 ^{c}	10.25 ^{c}	9.97 ^{c}	9.99 ^{c}	9.98 ^{c}	10.95 ^{c}	11.21 ^{c}	11.08 ^{c}
SE (m)	0.11	0.14	0.11	0.15	0.15	0.15	0.17	0.18	0.18
CD (p=0.05)	0.31	0.39	0.33	0.43	0.43	0.43	0.50	0.53	0.51

number of nodes per plant, internodal length, and number of fruits per plant. Kranti variety showed maximum plant height (62.03 cm) and minimum (55.50 cm) in Tender variety. Nauni P-8 variety showed maximum number of nodes per plant (10.43), number of fruits per plant (11.51) as compared to other two varieties. Prasad et al 2018 also demonstrated that the maximum fruit length was found in OKHYB-15 (13.26 cm) and minimum (10.32 cm) in OKHYB-12. This is due to differences in genetic makeup and prevailing environmental conditions. Similar results have been reported by Dhankar and Singh (2008). The difference in days to flowering in different varieties may be due to differences in their genetic makeup.

Different fertilizers varied significantly with respect to their plant height, internodal length, numberof fruits per plant. Pooled data of both the years showed that fertilizer NPK + FYM @ 15 t ha^{-1} produced significantly maximum plant height (64.30 cm), internodal length (11.96) than the rest of other fertilizers used. Number of fruits per plant (11.69) were found to be maximum in NPK +FYM @ 15 t ha^{-1} and minimum (9.98) in FYM @ 15 t ha^{-1} as depicted in Table 2. Kumar et al 2011 also demonstrated that yield of *pennisetum glaucum* was 153.90% higher in treatment combination of NPK (NPK 100:60:40 + FYM @ 10 t ha^{-1} as compared to usage of FYM @ 10 tha^{-1}. These findings are also found coherent with Islam et al. (2019) and Ullah et al (2008). Inorganic fertilizers release nutrients abruptly whereas organics release nutrients slowly; therefore, plants get nutrients for a longer period of time allowing better growth and productivity.

Effect of systems, varieties and fertilizers on growth and yield attributes of okra: The fruit length, fruit diameter, fruit weight and yield were significantly influenced by the systems. The fruit diameter, fruit weight and yield were found maximum under open system (12.20 mm, 12.07 gm, 83.25 q ha^{-1}) than other agroforestry systems. Among varieties fruit length and fruit weight (12.33 cm, 11.98 gm) were maximum in Nauni P-8 variety and minimum under Kranti variety (Table 2 and Table 3).

Fruit yield per plot and yield were also found to be

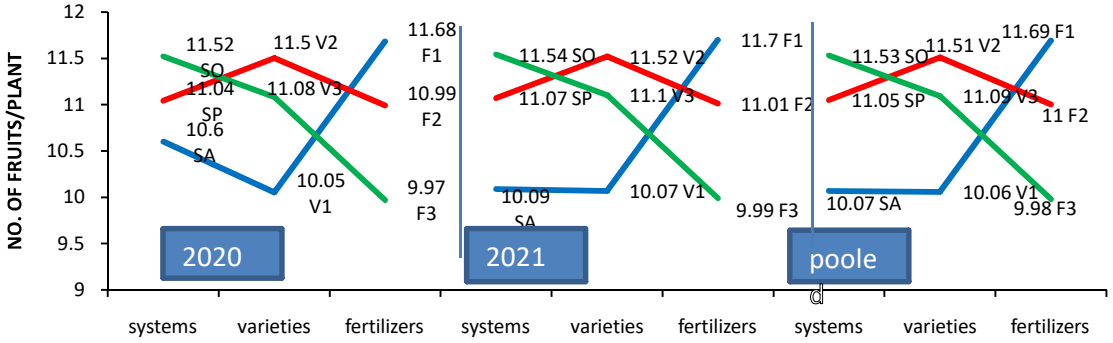

Fig. 1. No. of fruits per plant of *Abelmoschus esculentus* L. Moench as influenced by systems, varieties and fertilizer doses

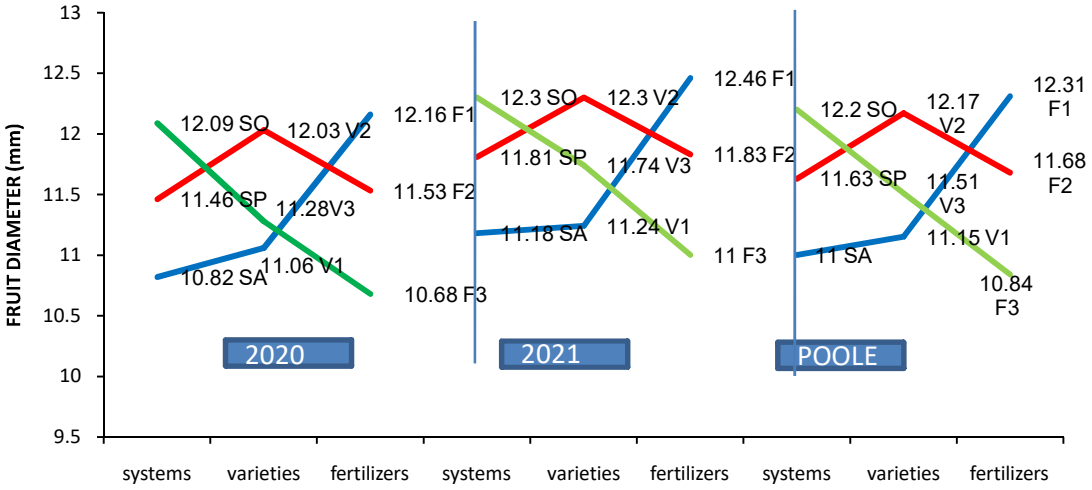

Fig. 2. Fruit diameter of *Abelmoschus esculentus* L. Moench as influenced by systems, varieties and fertilizer doses

Table 3. Effect of systems, varieties and fertilizer doses on fruit diameter (mm) and fruit weight (gm) of *Abelmoschus esculentus*

Treatments	Fruit diameter (mm)			Fruit weight (gm)		
	2020	2021	Pooled	2020	2021	Pooled
Systems						
Apricot (S_A)	10.82 ^{c}	11.18 ^{c}	11.00 ^{c}	10.67 ^{c}	10.91 ^{c}	10.79 ^{c}
Pear (S_P)	11.46 ^{b}	11.81 ^{b}	11.63 ^{b}	11.30 ^{b}	11.43 ^{b}	11.37 ^{b}
Open (S_O)	12.09 ^{a}	12.30 ^{a}	12.20 ^{a}	12.01 ^{a}	12.13 ^{a}	12.07 ^{a}
SE (m)	0.13	0.12	0.12	0.16	0.17	0.16
CD (p=0.05)	0.38	0.36	0.36	0.46	0.50	0.46
Varieties						
Kranti (V_1)	11.06 ^{bc}	11.24 ^{c}	11.15 ^{bc}	10.50 ^{c}	10.80 ^{c}	10.65 ^{c}
Nauni P-8 (V_2)	12.03 ^{a}	12.30 ^{a}	12.17 ^{a}	11.92 ^{a}	12.04 ^{a}	11.98 ^{a}
Tender (V_3)	11.28 ^{b}	11.74 ^{b}	11.51 ^{b}	11.54 ^{ab}	11.63 ^{ab}	11.59 ^{ab}
SE (m)	0.13	0.12	0.12	0.16	0.17	0.16
CD (p=0.05)	0.38	0.36	0.36	0.46	0.50	0.46
Fertilizers						
RDF+FYM (F_1)	12.16 ^{a}	12.46 ^{a}	12.31 ^{a}	12.27 ^{a}	12.37 ^{a}	12.32 ^{a}
Jeevamrut (F_2)	11.53 ^{b}	11.83 ^{b}	11.68 ^{b}	11.32 ^{b}	11.48 ^{b}	11.40 ^{b}
FYM (F_3)	10.68 ^{c}	11.00 ^{c}	10.84 ^{c}	10.38 ^{c}	10.63 ^{c}	10.50 ^{c}
SE (m)	0.13	0.12	0.12	0.16	0.17	0.16
CD (p=0.05)	0.38	0.36	0.36	0.46	0.50	0.46

Table 4. Effect of systems, varieties and fertilizer doses on fruit yield plot^{-1} and yield (q ha^{-1}) of *Abelmoschus esculentus*

Treatments	Fruit yield plot^{-1} (kg)			Yield (q ha^{-1})		
	2020	2021	Pooled	2020	2021	Pooled
Systems						
Apricot (S_A)	1.42 ^{c}	1.46 ^{c}	1.44 ^{c}	71.46 ^{c}	73.29 ^{c}	72.38 ^{c}
Pear (S_P)	1.52 ^{b}	1.57 ^{b}	1.55 ^{b}	76.35 ^{b}	78.90 ^{b}	77.63 ^{b}
Open (S_O)	1.60 ^{a}	1.67 ^{a}	1.64 ^{a}	80.46 ^{a}	86.03 ^{a}	83.25 ^{a}
SE (m)	0.02	0.02	0.02	1.33	1.50	1.34
CD (p=0.05)	0.07	0.08	0.07	3.79	4.27	3.82
Varieties						
Kranti (V_1)	1.40 ^{c}	1.45 ^{c}	1.42 ^{c}	70.18 ^{c}	72.74 ^{c}	71.46 ^{c}
Nauni P-8 (V_2)	1.59 ^{a}	1.66 ^{a}	1.62 ^{a}	79.72 ^{a}	84.48 ^{a}	82.10 ^{a}
Tender (V_3)	1.56 ^{ab}	1.60 ^{ab}	1.58 ^{ab}	78.37 ^{ab}	81.01 ^{ab}	79.69 ^{ab}
SE (m)	0.02	0.02	0.02	1.33	1.50	134
CD (p=0.05)	0.07	0.08	0.07	3.79	4.27	3.82
Fertilizers						
RDF+FYM (F_1)	1.67 ^{a}	1.72 ^{a}	1.70 ^{a}	83.88 ^{a}	86.33 ^{a}	85.11 ^{a}
Jeevamrut (F_2)	1.53 ^{b}	1.58 ^{b}	1.55 ^{b}	76.51 ^{b}	80.33 ^{b}	78.42 ^{b}
FYM (F_3)	1.35 ^{c}	1.41 ^{c}	1.38 ^{c}	67.87 ^{c}	71.57 ^{c}	69.72 ^{c}
SE (m)	0.07	0.08	0.07	3.79	4.27	3.82
CD (p=0.05)	0.02	0.02	0.02	1.33	1.50	1.34

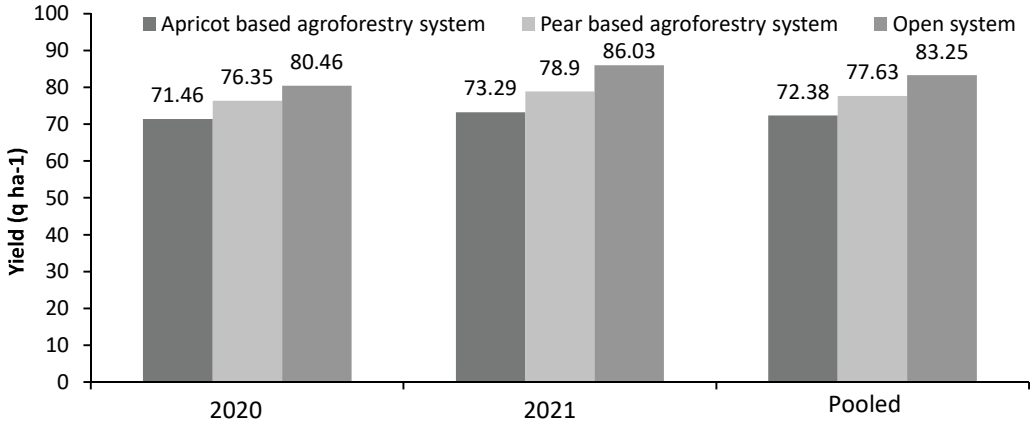

Fig. 3. Yield (q ha^{-1}) of *Abelmoschus esculentus* L. Moench influenced by systems

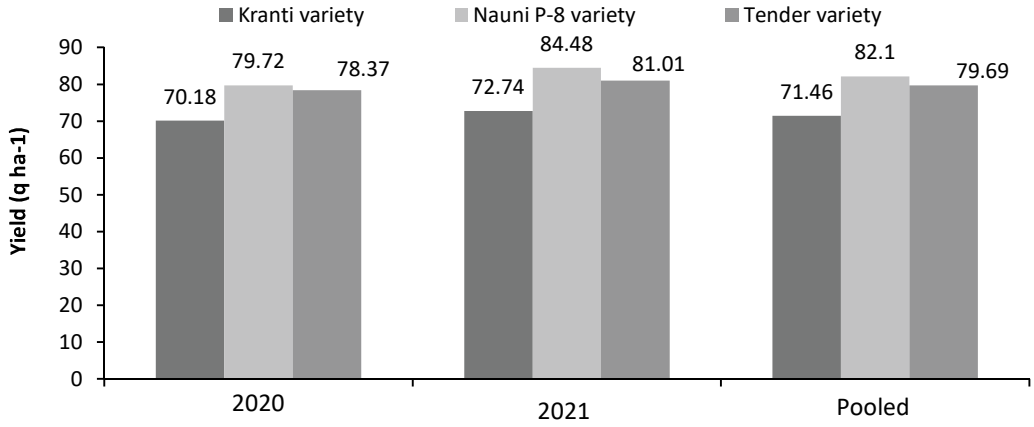

Fig. 4. Yield (q ha^{-1}) of *Abelmoschus esculentus* L. Moench influenced by varieties

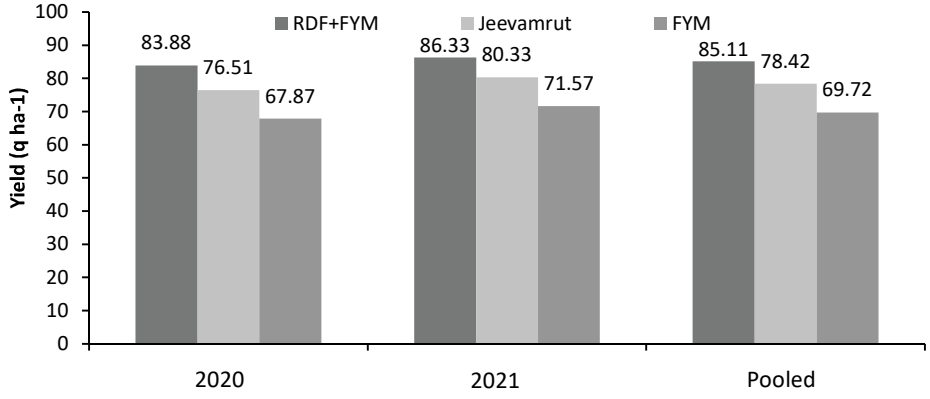

Fig. 5. Yield (q ha^{-1}) of *Abelmoschus esculentus* L. Moench influenced by fertilizer doses

maximum (1.62 Kg^{-plot}, 82.10 q ha^{-1}) in Nauni P-8 variety and minimum was found in Kranti variety as depicted in table4.

Different fertilizers revealed significant result for fruit length, yield and fruit yield per plot. The fruit length, fruit yield per plot and yield was found maximum (12.62 cm, 1.70 kg $^{-plot}$, 85.11 q ha^{-1}) were maximum in treatment comprising NPK + FYM @ 15 tha^{-1}. Results are found similar with Sruthi *et al*. 2020 where fruit weight, fruit diameter and fruit yield per plot were significantly higher in cucumber with the combined application of NPK + FYM as compared to other treatments. However among fertilizers maximum fruit weight (12.32 gm) was found in treatment comprising NPK 75: 50:50 Kg ha^{-1} +

FYM@ 15 t ha^{-1}) and minimum (10.50 gm) was recorded in FYM @ 15 tha^{-1}. Fruit diameter was found maximum (12.31 mm) in NPK + FYM @ 15 tha^{-1} and minimum (10.84 mm) in FYM @ 15 tha^{-1}(Table 3).

CONCLUSIONS

The results of the present study indicates that yield of okra was significantly higher under open system as compared to agroforestry systems. Varieties Nauni P-8 and tender performed better in terms of growth related attributes. Fertilizer NPK + FYM @ 15 tha^{-1} was found effective in controlling growth and yield parameters as compared to sole application of fertilizer doses.

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