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Water Productivity of Capsicum and Tomato under different Growing Environments

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***Abstract*:** Effect of growing environments and fertigation levels on capsicum and tomato crops were studied at Precision Farming Development Centre, ICAR-Central Institute of Agricultural Engineering, The experiments were designed with six treatments consisting of three growing environments namely open field, shade net and poly house with two levels of fertigation (100 % and 80 %) through the drip irrigation. Recommended dose of fertilizer 100 % was found better in all the growing environments for both the crops as compared to 80 %. Water productivity of capsicum under 100 % drip fertigation treatment was 28.0, 17.1 and 9.6 kg/m^3 respectively for growing environments of poly house, shade net house and open field cultivation. For tomato crops under these environments water productivities were as 18.4, 13.7 and 12.9 kg/m^3 respectively. Since, there was no significant difference in the yield was observed between 100% drip fertigated and 80% drip fertigated treatments of both the crops in polyhouses, the study recommended to adopt 80% drip fertigation for cultivating capsicum and tomato as there would be a saving of 20% of water and fertilizers.

Keywords: Drip irrigation, Poly house, Shade net house, Fertigation and water productivity

Among the many vegetable grown across the world capsicum (*Capsicum annuum* L) and tomato *(Lycopersicon esculentum* Mill.) are most important crops which are very sensitive to externalities of weather conditions. For proper growth and yield capsicum requires little lower temperatures as compared to tomato, but cultivation of these crops under shade nets and poly houses may be effective because it protects the plants from pest infestation and from cold injury since, night temperature inside these structures are higher than outside. In these structures, the factors like temperature, relative humidity and light intensity are changed as per crop requirements to gain maximum production during off-seasons. During the establishment and fruit setting these crops' requirement of water and fertilizers are very high. To produce more crop per unit area with enhanced efficiency of inputs, polyhouse technology is a good option input use efficiency. Different types of structures are being used for improving the productivity and profitability of horticultural crops as well as growing of the crops and planting material throughout the year. The greenhouse/polyhouse technology can be utilized for control of environmental parameters such as temperature, relative humidity, light intensity, light duration, CO_2 level, irrigation, nutrient supply and uptake, spacing, growing medium and root development (Baghel et al 2003). It is, therefore, necessary to adopt technologies to produce more crop per unit of cropped area to meet the demand of the Indian population otherwise per capita availability of vegetables will further go down (Bini and Regeena 2014). The area under different protected cultivation practices in India today is around 250000 ha in which about 2000 ha area is under polyhouses (Senthilkumar et al 2018). In this study, vegetable crop's tomato and capsicum were performed under protected conditions inside the poly house and shade net houses was compared with their performance in open conditions. Various climatic parameters, biometric observations and yield were recorded for performance evaluations.

MATERIAL AND METHODS

Weather and soil: Investigations were carried out to assess the effect of growing environments, fertigation levels on capsicum and tomato crops in three *rabi* seasons (2015-16, 2016-17 and 2017-18). Soils of the experimental site are classified as heavy clay soils with clay content varying between 49.7 to 53.7 % and with field capacity ranging from 28.5 to 31.0 %. The study area is located at North of Bhopal (23º 18' 35'' N and 77º 24' 10'' E) at an elevation of 495 m above mean sea level. During winter, temperature varies between 10°C and 25°C and in summer between 25°C and 44°C. The normal annual rainfall of the region is about 1090 mm.

Experimental details: The drip irrigation system having discharge of 3 litre per hour spacing at 40 cm was operated at 1.5 kg cm $^{-2}$ pressure. The experimental treatments were

performed under open field, shade net house (white colour with 50 % shade factor) and inside a polyhouse. The experiment was conducted with following treatments

T1=100% drip fertigation in open field; T2 = 80% drip fertigation in open field ; T3=100% drip fertigation in shade net ; T4 = 80% drip fertigation in shade net; T5 = 100% drip fertigation in polyhouse and T6 = 80% drip fertigation in polyhouse.

Fertilizer application: Recommended doses of fertilizer (RDF) were applied in all the treatments. For capsicum RDF applied @ 200:150:250 NPK kg ha^{-1} and for tomato @ 350:120:390 NPK kg h^{-1}. One third portion of nitrogen of RDF was applied as a basal dose of fertilizer for each treatment and the remaining fertilizers were applied in fifteen days interval.

Varieties: Thirty days old seedlings prepared in protrays were transplanted in the third week of December in experimental plots. *Heemsonha* and *Swarna* varieties of tomato and capsicum crops were considered in the study, as they are popular in the region.

Crop water requirement: The daily weather data during the crop growth period were collected from the meteorological observatory of ICAR-Central Institute of Agricultural Engineering, Bhopal. The daily irrigation water requirement for both the crops were estimated by using the following relationship

$WR = ET_0 * Kc * Wp * A$

Where, WR = Crop water requirement (mm d^{-1}); ET_0 = Reference evapotranspiration (mm d^{-1}) ; Kc = Crop coefficient ; Wp = Wetting fraction (taken as 1 for close growing crops) ; A = Plant area, m^2 (i.e. spacing between rows, m x spacing between plants, m)

The values of pan coefficient and crop coefficients were taken from Doorenbos and Pruitt (1977). Daily time to operate drip irrigation system was worked out taking the application rate per plant. Working of drip system was scheduled on alternate days. Water applied for tomato crop in poly house, shade net house and open filed were 719, 719.4 and 354.2 mm respectively in 100 % drip irrigation likewise water applied in capsicum crop were 213, 318 and 353 mm respectively as 100 % drip Irrigation.

Data collection and analysis: The plants were spaced 50 x 50 cm between plant-to-plant and row-to-row, respectively for both of crop tomato and capsicum. Each treatment was replicated three times. Five plants were randomly selected from each experimental plot for recording of plant height, number of flowers per plant, number of fruits per plant, air temperature, relative humidity, light intensity, root development parameters, maximum fruit weight and yield per plant, water productivity (kgm^{-3}) and total yield (kg ha^{-1}) were recorded. The data collected were analyzed by using Fisher's analysis of variance technique and CBD test with the confidence level at 5% was used to compare the differences among the treatment means.

Plant data: Plant height was measured from the ground surface to the top of the plant. Chlorophyll content was measured with a SPAD-502 chlorophyll meter (Konica, Minolta), which gives chlorophyll index. Measurements were taken from apical leaves at 45 days after transplanting from the bottom of the plants.

Weather data: Air temperature was measured at 1.5 m above the ground surface at 14.00 h by Hygro-thermometer (Testo 623). Light intensity was measured at the same location by Lux meter (Testo -540) at same time

Water productivity: Water productivity of each treatment was calculated using the following equations: Water productivity (WP) (kgm^{-3}) = CY / WA; Where CY = Crop Yield (kg ha^{-1}); WA = Water applied (m^3 ha^{-1})

Root analysis: The root studies were carried out by measuring root length (cm), root volume (ml) and root dry mass (g) at crop maturity stage in five randomly sample plants.. Root characters were assessed by modified trench method (Bohm et al 1977). The plants were carefully excavated until the tip of each plant root was just visible. Debris and dead roots were manually removed from vital roots. Roots kept for deep soaking in saturated NACL (winRHIZO method) for one night (Delory 2017). After drying, roots were placed on plane surface and then measured their length from the crown gall region to tip of the deepest root. Root samples were air dried initially followed by oven drying at $65 \pm 5^{\circ}C$ till a constant weight is attained and root mass was expressed as g per plant.

RESULTS AND DISCUSSION

Crop parameters: Plant growth parameters such as plant height, number of flowers per plant and were measured under open field; shade net and poly house (Table 1). Plant height of capsicum crop was highest in polyhouse (66.2 cm and 62.7cm) followed by shade net house (53.9 cm and 52.8 cm) in both the treatments of 100 and 80% drip fertigation as compared to open field (33.97cm & 33.12 cm). Similarly tomato crop also were recorded highest plant height under polyhouse (172.1 and 143.6 cm) and shade net (127.0 and 122.7cm) as compared to open field (85.2 and 82.8 cm). The highest numbers of leaves per plant were recorded from the crop grown under poly house followed by shade net and open field in both the treatments 100 and 80% fertigation in both of crop capsicum and tomato.

Phenology: Flowering, fruit setting and fruit maturity in polyhouse and shade net plants were advanced by about 6,

7, 8 and 3, 4, 5 days, respectively compared to the crop raised in open field condition in case capsicum cultivation. SPAD (58.0) was also highest under the poly house followed by shade net (54.1) and open field (51.8).

Yield: The highest fruit yield of capsicum per plant were obtained from the polyhouse (2.84 and 2.26 kgplant^{-1}) followed by shade net and open field (Fig. 2). Similarly highest fruit yield of tomato crop were recorded from polyhouse (5.40 kg plant $^{-1}$ and 4.10 kg plant^{-1}) followed by shade net and open field conditions (Fig. 3).

Temperature: Thee maximum temperatures under polyhouse were 2-5 °C higher than that of open field temperatures during December to February months (Fig. 2). The open field temperatures are more thereafter, where as temperatures under polyhouse were managed by operating foggers and passive cooling systems. The temperatures inside shade net house are mostly lower than the temperatures of open field conditions as well as under polyhouses. Further it is also observed that the variations between maximum and minimum temperatures are minimum under polyhouse as well as in shade net house conditions as compared to open field conditions (Fig. 2 and 3). According to Halim and Islam (2013) under the protected structures crop is protected from biotic and abiotic stresses. Protection of plants from low night temperature during heavy cold, from mite and insects are the prime prerequisite for successful capsicum production. Jakhar et al (2017) concluded that Indira variety of capsicum can be better cultivated under shadenets. The present study also observed similar findings under protected conditions.

Relative humidity: The relative humidity values during the day time were maintained at around 60 per cent in polyhouse by operating foggers, where as in shadenet house and in open field atmospheric relative humidity fluctuated from 50 per cent to 30 per cent.

Root characteristics: The root characters were observed maximum for both the crops under polyhouse with 100% RDF as compared to shade net with 100% RDF and lowest in open field condition (Table 2) .

Water productivity: Water productivity is highest for both the crops grown under the polyhouse with the magnitude of

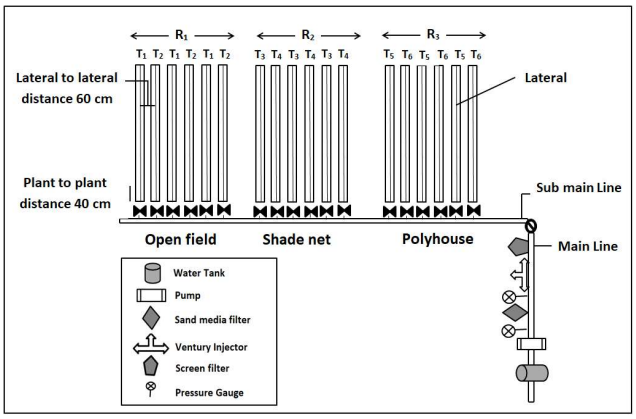

Fig. 1. Layout of drip irrigation system for capsicum and tomato

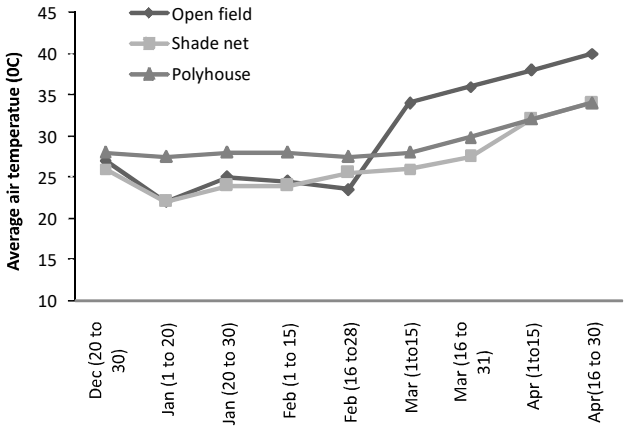

Fig. 2. Average maximum temperature (°C) during cropping period

Table 1. Growth and yield contributing parameters of capsicum and tomato

Treatments		Capsicum				Tomato			
		Plant height (m)	No. of flowers /plant	SPAD value	Yield /plant (kg)	Plant height (m)	No. of flowers/plant	SPAD value	Yield/ plant (kg)
Open field	T1	0.34	29.71	51.80	0.66	0.85	48.5	52.2	1.32
	T2	0.33	28.60	51.30	0.51	0.83	44.1	51.0	1.20
Shade net	T3	0.54	32.51	54.10	1.73	1.3	59.3	54.4	3.60
	T4	0.53	30.61	52.70	1.34	1.2	57.7	52.5	3.10
Poly-house	T5	0.66	35.48	58.00	2.84	1.7	72.1	57.0	5.40
	T6	0.63	33.50	55.80	2.26	1.4	70.4	54.1	4.10
SEM±		0.07	1.45	1.83	0.58	0.16	1.78	1.2	0.34
CD (p=0.05)		22.2	4.32	5.40	1.7	46.8	5.12	3.6	1.02

Table 2. Average root parameters of capsicum and tomato

Treatments	Root length (cm)		Root volume (ml)		Root dry mass (gm)	
	Capsicum	Tomato	Capsicum	Tomato	Capsicum	Tomato
T1	17.11	19.52	11	12	2.38	3.42
T2	10.20	17.67	08	11	1.76	2.50
T3	21.15	24.85	26	25	4.52	4.22
T4	17.41	22.40	20	23	4.4	3.96
T5	8.39	29.78	32	28	5.86	4.56
T6	0.22	27.48	31	27	4.48	4.32

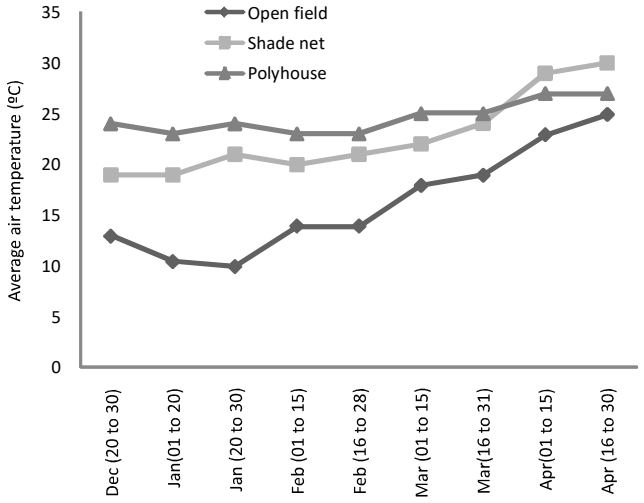

Fig. 3. Average minimum temperature (°C) during cropping period

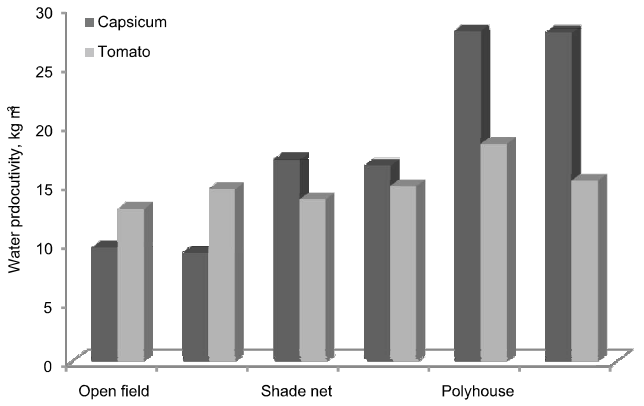

Fig. 4. Water productivity of capsicum and tomato from different growing environments

mean values is in order T6>T5>T4>T3>T2>T1 (Fig. 4). This may be due to the higher water losses through evaporation and transpiration in open environment conditions as compared to protected environment. Water productivity of capsicum crop under 100 % drip irrigation and fertigation treatment was 28.0 17.1 and 9.6 kgm^{-3} respectively for growing environments of poly house, shade net house and open field cultivation. In case of tomato crop also similar results were found. The water productivity of tomato under poly house, shade net house and open field conditions were 18.4, 13.7 and 12.9 kgm^{-3} respectively for 100 % drip irrigation and fertigation treatments. Thus, use of protected structure like polyhouse and shade net house would lead to more crop per drop of water.

CONCLUSIONS

The present study concludes that for better growth, development, productivities of capsicum and tomato can achieve under polyhouse due to the optimum temperature and relative humidity during the winter months. Both the crops gave higher yield (> 3 times higher than open field) if grown under polyhouse conditions with 100% drip irrigation and fertigation as compared to open field cultivation. Since, there is no significant difference in the yield was observed between 100% drip fertigated and 80% drip fertigated treatments for both the crops in polyhouses, the study recommended to adopt 80% drip fertigation for cultivating tomato and capsicum.

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