www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(8): 2777-2780

www.thepharmajournal.com
Received: 01-06-2023
Accepted: 06-07-2023

TL Neelima
Sr. Scientist, Department of Agronomy, Water Technology Centre, PJTSAU, Hyderabad, Telangana, India

M Uma Devi
Retd. Sr. Professor, PJTSAU, Hyderabad, Telangana, India

K Chaitanya
Assistant Professor, Department of Horticulture, COA, Rajendranagar, Telangana, India

D Madhurya
Project Associate, Water Technology Centre, PJTSAU, Hyderabad, Telangana, India

Corresponding Author:
TL Neelima
Sr. Scientist, Department of Agronomy, Water Technology Centre, PJTSAU, Hyderabad, Telangana, India

Optimizing fruit yield and water productivity of Capsicum (*Capsicum annuum*) hybrids in peninsular India through N and K fertigation under shade net cultivation

TL Neelima, M Uma Devi, K Chaitanya and D Madhurya

Abstract
In the year 2019-20, a field trial was conducted at the Horticulture farm, College of Agriculture, Rajendranagar, Hyderabad, Telangana. The aim was to investigate the impact of N and K fertigation on the growth of coloured Capsicum hybrids cultivated under shade net conditions in sandy loam soils. The trial encompassed four primary plot treatments representing varying N and K fertigation levels *viz.*, F_1: 50% RDF of N, K (50:0:30), F_2: 75% RDF of N, K (75:0:45), F_3: 100% RDF of N, K (100:0:60) and F_4: 125% RDF of N, K (125:0:75) and three varieties *viz.*, V_1: Indra (green variety), V_2: Orobelle (yellow variety) and V_3: Bombey (Red variety). The experiment was conducted using a split-plot design with three replications. Application of 125% RDNK (15.00 t ha^{-1}) through fertigation being at par with that of fertigation @ 100% RDNK (13.69 t ha^{-1}), has significantly outyielded other fertigation treatments. Further, the highest total capsicum fruit yield and water productivity were observed with Indra (V_1) (17.17 t ha^{-1}; 2.82 kg m^{-3}) and was significantly superior to Bombey (V_2: 10.23 t ha^{-1}; 1.68 kg m^{-3}) and Orobelle (V_3: 9.52 t ha^{-1}; 1.56 kg m^{-3}) hybrids.

Keywords: Capsicum, fertigation, hybrid, shade net and water productivity

Introduction
The existence of diverse agroclimatic conditions in India provide opportunities for cultivation of wide ranging crops. Vegetables are an integral part of dietary requirement of each and every individual in the country. The total vegetable production in India is 204.84 million metric tonnes during 2021-22 (Anonymous, 2022 a) [2]. Capscium (*Capsicum annuum* var. *grossum*), a cool season crop from the Solanaceae family, is often referred as bell pepper or sweet pepper. It is a native of Tropical South America. In India, capsicum production was 585.55 million tonnes from an area of 3.7 lakh ha with an yield potential of 15.74 t ha^{-1} during the year 2021-22 (Indiastats.com). India plays a significant role in global capsicum production, contributing a quarter of the total output. Regarding nutrition, every 100 g of capsicum provides essential vitamins and minerals, such as vitamin A (8493 IU), vitamin C (283 mg), as well as minerals like calcium (13.4 mg), magnesium (14.9 mg), phosphorus (28.3 mg), and potassium (263.7 mg) (Dimple *et al.*, 2019) [5]. Moreover, capsicum fruits, including green, yellow, and red varieties, are rich sources of natural antioxidants (Vitamins C and E and carotenoids) (Palevitch and Craker, 1996) [15] and are essentially important in preventing or reducing chronic and age-related diseases. Hence, it is used popularly as vegetable and condiment. Red bell peppers (*Capsicum annuum* L.) are one of the most widely traded health-promoting crops in international market. Colored bell peppers have a huge demand in urban markets (Anonymous, 2022b) [3].

Abiotic stresses like heat, cold, drought, salinity, as well as biotic stresses including leaf spot, viral diseases, powdery mildew, root, stem, leaf and fruit rots and nematodes, constitute the major constraints for low productivity of capsicum. Flowering and fruitset stages are most sensitive for the abiotic stresses. In arid and semiarid regions, protected structures or shade nets have been utilized as an effective solution to reduce harsh climate variations besides pest control and enhance water use efficiency (WUE). So, cultivation in protected structures under controlled climate conditions ensure quality, yield and profitability of the produce. Low cost protected structures helps in climate resilient capsicum cultivation (Jayasurya *et al.*, 2021) [9].

Shade nets, constructed from perforated plastic materials, serve as protective structures aimed at mitigating the effects of intense solar radiation. They prevent leaf scorching or wilting resulting from temperature spikes caused by strong sunlight. These nets come in various shading intensities, spanning from 25% to 90%. They offer permissible amount of temperature (Seera *et al.*, 2020) [18], humidity, light (Nemera *et al.*, 2015) [13], CO_2 concentration (Zaman *et al.*, 2022) [22] besides optimizing radiation (Manjunatha *et al.* 2022) [12] thus enhance the production. A protected environment offers an excellent opportunity for off-season production and year-round cultivation of coloured capsicum. However, agro techniques which can help in sustainable cultivation of crops for achieving higher productivity have to be explored. Inter alia, effective cultivation of suitable hybrid and nutrient management through drip irrigation in shade nets are the most important one.

The micro irrigation with fertigation has been proven to be a win-win solution for enhancing water and nutrient use efficiency and maximize the yield potential (Kapoor *et al.*, 2022) [10]. Fertigation is the application of fertilizer with irrigation water. This method of applying fertilizers has various advantages like minimum losses of nitrogen and potassium due to prevention of leaching, optimization of nutrient balance by supplying nutrients directly to the root zone in available forms, flexibility of fertilization to match crop nutritional requirement at different growth stages. It often produces substantially better outcomes (up to 90%) than traditional nutrient application (40-45%) in terms of nutrient use efficiency and plant nutrient recovery (Agostini *et al.*, 2010) [1]. Since the research on scheduling drip fertigation for different coloured capsicum hybrids under protected cultivation is meager, the present study was taken up.

Materials and Methods

The experiment was conducted at Horticulture research farm, College of Agriculture, Rajendranagar Hyderabad during the year *rabi* 2019-20 to evaluate the impact of fertigation regimes on different colored hybrids of capsicum in shadenets. The site of experiment was situated at 17°19'16.4" North latitude and 78°24'43.7" East longitude.

The soil exhibited a sandy loam texture with a pH level of 7.8, an electrical conductivity of 0.32 dS m^{-1}, and low levels of organic carbon (0.27%). Furthermore, the soil had low availability of nitrogen (142 kg ha^{-1}), medium availability of phosphorus (55.2 kg P_2O_5 ha^{-1}), and low availability of potassium (162.8 kg K_2O ha^{-1}). The capsicum hybrids selected for the study are Indra (Green), Orobelle (Yellow) and Bomby (Red). The seedlings were transplanted on the beds on 27th November, 2019 at a spacing of 45 × 40 cm. It was conducted with four N and K fertigation levels as main plots *viz.*, F_1: 50% RDF of N, K (50:30), F_2: 75% RDF of N, K (75:45), F_3: 100% RDF of N, K (100:60) and F_4: 125% RDF of N, K (125:75) and three hybrids, namely Indra (green color), Orobelle (yellow color), and Bombey (red color), were evaluated in a split-plot design replicated three times.

The 100% recommended dose of fertilizer (RDF) 100, 80 and 60 kg N, P_2O_5 and K_2O ha^{-1} was applied in the form of Urea, Single Super Phosphate (SSP) and white Muriate of Potash (MOP), respectively. A common dose of phosphorous was applied at the time of bed preparation along with 12.5 t ha^{-1} of vermicompost and 1500 kg neem cake ha^{-1} uniformly to all the treatments. Nitrogen and Potassium was applied at three days interval starting from 9 DAT to 153 DAT totalling 37 splits through drip irrigation. The dosages were calculated treatment wise and fertigation was given accordingly. Depending on the crop growth stage fertigation is scheduled with different dosages as presented in Table 1.

Table 1: Crop growth stage wise fertigation schedule adopted for Capsicum (*rabi* 2019-20)

Sl. No	Stage of crop	DAT	Number of fertigation	N (%)	N (kg day^{-1} ha^{-1})	K_2O (%)	K (kg day^{-1} ha^{-1})
1	Crop establishment stage	1 to 13	2	10	0.830	10	0.500
2	Vegetative stage	14 to 45	8	30	0.930	20	0.375
3	Flower initiation to fruit development stage	46 to 77	7	20	0.625	20	0.375
4	Fruit development to final stage	78 to 153	20	40	0.526	50	0.395
		Total					

One month old seedlings were transplanted on raised beds in a paired row pattern in 50%, tape type green shade net. Coloured capsicum seeds were sown in protrays on 1st August 2018 and one month old seedlings were transplanted on 1st September 2018 in a zig zag manner in a paired row pattern on raised beds. Irrigation was scheduled at 0.8 E pan based on evaporation data of USWB class A pan evaporimeter. The total water applied equally to all the treatments through drip at 0.8 E pan was 555 mm, which includes the water applied for nursery including special operations (16 mm). The total water used during the crop growth period was 608.2 mm including effective rainfall (53.2 mm). The capsicum (bell-pepper) crop faced a severe nematode infestation which include *Meloidogyne incognita*, *M. javanica* (root-knot nematodes), and *Rotylenchulus reniformis* (reniform nematode). This nematode problem escalated to alarming levels, resulting in significant crop loss up to 50% in our experimental fields. To combat this issue, we implemented an organic solution comprising *Pseudomonas fluorescens* and *Trichoderma harzianum*. This formulation was applied to the plants through alternating sprays and drip drenching, with a concentration of 5g lit^{-1} or 5ml lit^{-1} at regular 20-day intervals. This approach effectively managed the nematode infestation within the shade net.

Results and Discussion

Effect of fertigation on yield traits, fruit yield and water productivity of coloured capsicum hybrids

The capsicum fruit length ranged from 8.52 cm to 9.02 cm, fruit width from 7.41 to 7.61 cm and fruit weight between 72.53 to 78.91 g due to various fertigation levels. Maximum values were recorded at highest fertigation level (F_{125}) and lowest values with $F_{50.}$ However, none of these three attributes were significantly affected by graded levels of fertigation. These results were in agreement with that of Rajendra Kumar *et al.* (2017) [16] and Gill (2018) [7] who hypothesised that K fertigation played an important role in maintaining favourable osmotic balance which in turn provided conducive

environment for better fruit length. On the contrary, F_{125} (9.55) was found to be significantly superior to rest of the fertigation levels in no. of fruits plant^{-1} as it resulted in 12.9%, 20.7% and 70.2% more fruits plant^{-1} over F_{100}, F_{75} and F_{50}.

The total fruit yield of capsicum improved gradually with increment in the N and K fertigation level reaching highest value at 125% RDNK. The highest fruit yield (Table 2) obtained due to fertigation @ F_{125} (15.00 t ha^{-1}) was onpar with F_{100} (13.69 t ha^{-1}) and both were significantly superior to F_{75} (11.58 t ha^{-1}) and F_{50} (8.96 t ha^{-1}). Application of F_{125} has produced 9.6, 29.5 and 67.4% higher fruit yield over F_{100}, F_{75} and F_{50}, respectively. This might be owing to continuous delivery of necessary nutrients in the root zone of the crop, which fostered favourable conditions for growth and development by enhancing metabolic processes in the plant system. Our results were in agreement with that of earlier studies by Shilpa *et al*., (2019) [19] and Dubey *et al*. (2017) [6] on capsicum under shade net conditions. Further, according to Ughade *et al.* (2016) [20] the lowest fruit yield was witnessed with least amount of fertiliser (60% RDF) used for growing the crop. The water productivity went on increasing with graded levels of fertigation and reached highest F_{125} (2.47 kg m^3) which was found to be at par with F_{100} (2.25 kg m^3) and both were significantly higher than that of F_{75} (1.90 kg m^3) and F_{50} (1.47 kg m^3).

Effect of coloured capsicum hybrids on yield traits, fruit yield and water productivity

The fruits of Indra (V_1) were measured to be significantly longer (8.91 cm) than Bombey (8.68 cm) but at par with that of Orobelle (8.82 cm). Further, significantly greater no. of fruits were reported in green hybrid followed by Orobelle and Bombey. Among the hybrids, Bombey (V_3) recorded the highest mean fruit width (7.62 cm), but, it did not differ significantly from that of Indra (V_1) (7.52 cm) and Orobelle (V_2) (7.46 cm). Similarly, fertigation levels failed to show significant influence on fruit weight as the values were more or less similar for three hybrids evaluated. It was observed that rise in N and K fertigation levels, improved number of fruits which might be because of a more favourable microclimate and greater photosynthetic translocation to the productive areas, which leads to the development of more blooms and, ultimately, more fruits the results are in line with Sanchita *et al*. (2014) [17] and Ningoji *et al.* (2023) [14]. The hybrid Bomby recorded higher fruit weight in a naturally ventilated polyhouse, according to Shilpa *et al.* (2019) [19] these results are in conformity with the findings from the studies on coloured capsicum hybrids in shade net condition by Rajendra Kumar *et al*. (2017) [16], Gill (2018) [7]. Similar results on increased fruit yield with increase in the dose of fertilizers were reported by Hegazi *et al*. (2017) [8], Sanchita *et al*. (2014) [17], Bhuvaneswari *et al.* (2013) [4] and Malik *et al.* (2011) [11].

Substantial variation was observed among hybrids for the total fruit yield. The Indra (V_1) (17.17 t ha^{-1}) with 67.8 and 80.4% higher yield, has significantly outyielded Orobelle (V_2: 10.23 t ha^{-1}) and Bombey (V_3: 9.52 t ha^{-1}), respectively. The results are in line with Shilpa *et al.* (2019) [19].

The Indra hybrid was found to be efficient utilizer of water as it produced significantly greater yield per unit water consumed (V_1: 2.82 kg m^3) and was significantly superior to Orobelle (V_2: 1.68 kg m^3) and Bombey (V_3: 1.56 kg m^3) hybrids. This might be due to higher yield following better availability of N and K supplied through drip fertigation and efficient utilization of applied water. Similar results were published earlier by Shilpa *et al.* (2019) [19] who reported that an increase in WUE was caused by enhanced fruit production following crop nourishment by fertigation @ 125% N, P, and K.

Effect of interaction of fertigation levels and coloured capsicum hybrids on yield traits, fruit yield and water productivity

None of the yield traits *viz*., fruit length, width, weight and no. of fruits besides fruit yield and water productivity were significantly influenced by either different N and K fertigation levels and three different hybrids of capsicum.

Table 2: Mean fruit length, fruit width, total number of fruits plant-1 and average fruit weight of coloured capsicum hybrids as influenced by different N and K fertigation levels under shade net (*rabi* 2019-20)

Treatments	Mean fruit length (cm)	Mean fruit width (cm)	Total number of fruits plant^{-1}	Average fruit weight (g)	Total fruit yield (t ha^{-1})	Water Productivity (kg m^{-3})
Main – Fertigation						
F_{50} - 50% RDF of N and K	8.52	7.41	5.61	72.53	8.96	1.47
F_{75} - 75% RDF of N and K	8.75	7.51	7.91	73.24	11.58	1.90
F_{100} - 100% RDF of N and K	8.91	7.60	8.46	77.85	13.69	2.25
F_{125} - 125% RDF of N and K	9.02	7.61	9.55	78.91	15.00	2.47
SEm±	0.07	0.05	0.21	2.13	0.42	0.07
C.D (P=0.05)	NS	NS	0.82	NS	1.65	0.27
Sub – Hybrids						
V_1 – Indra (Green variety)	8.91	7.52	9.66	73.82	17.17	2.82
V_2 – Orobelle(Yellow variety)	8.82	7.46	7.02	75.08	10.23	1.68
V_3 – Bomby (Red variety)	8.68	7.62	6.96	78.00	9.52	1.56
SEm±	0.08	0.11	0.21	3.26	0.67	0.11
C.D. (P=0.05)	0.25	NS	0.63	NS	1.99	0.33
Interaction						
Hybrids at same fertigation level						
SEm±	0.14	0.18	0.37	5.64	1.16	0.19
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Fertigation at same or different hybrids						
SEm±	0.14	0.17	0.38	5.33	1.09	0.18
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

Note: Mean fruit length (cm), fruit width (cm) and average fruit weight (g) is a mean of first, second and third picking

Conclusion

Cultivation of green hybrid capsicum and application of 125% recommended dose of N and K (126 and 75 kg N, P_2O_5 ha^{-1}) through fertigation on every fourth day starting from 10 DAT to 153 DAT were found to be beneficial under 50% shade net conditions during *rabi* season due to realisation of higher productivity and profitability.

References

1. Agostini F, Tei F, Silgram M, Farneselli M, Benincasa P Aller M. Decreasing nitrate leaching in vegetable crops with better N management. In Genetic Engineering, Biofertilisation, Soil Quality and Organic Farming. Springer: Berlin, Germany; c2010. p. 147-200.
2. Anonymous. apeda.gov.in; c2022(a)
3. Anonymous. (b), IIHR technical bulletin on Capsicum, IIHR, Bangalore, Karnataka, India; c2022.
4. Bhuvaneswari G, Sivaranjani R, Reet S, Ramakrishnan K. Application of nitrogen and potassium efficiency on the growth and yield of chilli (*Capsicum annuum* L). International Journal of Current Microbiology and Applied Science. 2013;2(12):329-337.
5. Dimple SB, Lakhawat S, Kothari M. Determination of crop water requirement of drip irrigated capsicum crop inside naturally ventilated polyhouse. Indian National Committee on Surface Water (INCSW)-CWC Ambassador Ajanta, Aurangabad, India; c2019 Jan 16-18. Publishers: Ivy League Systems. com,259.
6. Dubey AK, Singh D, Rajput PS, Kumar Y, Verma AK, Chandraker SK. Effect of NPK on plant growth, yield and quality of capsicum (*Capsicum annum* L.) cultivar Swarna under shade net condition. International Journal of Current Microbiology and Applied Science. 2017;6(3):1085-1091.
7. Gill DS. Performance of sweet pepper (*Capsicum annuum* L.) cultivars and economics under protected structures in Punjab. Ph. D Thesis. Lovely Professional University, Punjab, India; c2018.
8. Hegazi AM, El-Shraiy AM, Ghoname AA. Growth, yield and nutritional quality of sweet pepper plants as affected by potassium and phosphate fertilizers varying in source and solubility. Current Science International. 2017;6(2):445-457.
9. Jayasurya P, Chatterjee S, Biswas A, Viswanath M, Roy A. Low cost protected structures for off-season vegetable production: A review. The Pharma Innovation Journal. 2021;10(7):778-783.
10. Kapoor R, Kumar A, Kumar S, Sandal Sharma A, Raina R, Thakur KS. Water and nutrient economy in vegetable crops through drip fertigation and mulching techniques: A review. Journal of Plant Nutrition. 2022;45(15):2389-2403.
11. Malik AA, Chattoo M, Sheemar G, Rashid R. Growth, yield and fruit quality of sweet pepper hybrid SH-SP-5 (*Capsicum annuum* L.) as affected by integration of inorganic fertilizers and organic manures (FYM). Journal of Agricultural Technology. 2011;7(4):1037-1048.
12. Manjunatha MK, Babu BM, Ramesh G, Reddy GVS, Rajkumar R. Impact of different colour low tunnel shade nets and mulches on water use efficiency and nutrient use efficiency in Chrysanthemum. International Journal of Environment and Climate Change. 2022;12(11):2148-2158.
13. Nemera DB, Zur N, Lukyanov V, Shlizerman L, Ratner K, Shahak Y, *et al*. Top photoselective netting results in improved microclimate, productivity, physiological performance and water-use efficiency in citrus. International Syposium on New Tecnologies and Management for Greenhouse, 19-23 July, Evora, Portekiz; c2015.
14. Ningoji SN, Thimmegowda MN, Mudalagiriyappa Vasanthi BG, Sanam T, Shivaramu HS. Influence of Automated Sensor-Based Irrigation and Fertigation on Fruit Yield, Nutrient Utilization and Economics of Capsicum (*Capsicum annuum* L.). Communications in Soil Science and Plant Analysis; c2023. p. 1-19.
15. Palevitch D, Craker LE. Nutritional and medical importance of red pepper (*Capsicum* spp.). Journal of herbs, spices & medicinal plants. 1996;3(2):55-83.
16. Rajendra Kumar J, Singh AK, Narendra K. Performance of capsicum (*Capsicum annum* L.) cultivars grown under shade net and open field in arid ecosystem of Rajasthan. Environment and Ecology. 2017;35(1A):290-294.
17. Sanchita B, Luchon S, Hazarika TK, Pankaj B. Response of capsicum (*Capsicum annum* var. *grossum*) to different levels of N and K fertigation under Assam conditions. Progressive Horticulture. 2014;46(1):80-84.
18. Serra S, Borghi S, Mupambi G, Camargo-Alvarez H, Layne D, Schmidt T, *et al*. Photoselective protective netting improves "Honeycrisp" fruit quality. Plant. 2020;9:1708.
19. Shilpa K, Uma Devi M, Avil Kumar K, Sridevi S. Effect of N and K fertigation levels on yield attributes, yield and water productivity of coloured capsicum (*Capsicum annuum* var. *grossum*) hybrids under shade net. The Journal of Research, PJTSAU. 2019;47(4):33-37.
20. Ughade SR, Tumbare AD, Surv US. Impact of environmental factors on tomato under fertigation frequency in controlled atmosphere condition. The Ecoscan An International Quarterly Journal of Environmental Sciences. 2016;(9):243-249.
21. www.Indiastat.com
22. Zaman S, Shen J, Wang S, Wang Y, Ding Z, Song D, Wang H, *et al*. Effects of shading nets on reactive oxygen species accumulation, photosynthetic changes, and associated physiochemical attributes in promoting cold-induced damage in *Camellia sinensis* (L.) Kuntze. Horticulture. 2022;8:637.