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Response of Soilless Coloured Capsicum under Different Irrigation Strategies in Greenhouse

Ravindra D Randhe[1*], Murtaza Hasan[2], D.K. Singh[3], S. Naresh Kumar[4], Pramod Kumar[5] and Wasi Alam[6]

[1]Division of Agricultural Engineering, ICAR-IARI, New Delhi 110 012, India
[2] Centre for Protected Cultivation Technology, ICAR-IARI, New Delhi 110 012, India
[3] Division of Agricultural Engineering, ICAR- IARI, New Delhi 110012, India,
[4] Division of Environmental Sciences, ICAR- IARI, New Delhi 110 012, India
[5]Division of Agricultural Economics, ICAR-IARI, New Delhi 110 012, India
[6]ICAR-IASRI New Delhi 110 012, India

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ABSTRACT

Experiment was conducted to evaluate the weight based fertigation strategies in soilless coloured capsicum under greenhouse. Weight based sensing system was developed to continuously monitor water loss from grow bag and plants by transpiration for fertigation scheduling. The experiment was conducted using treatments comprised of T1, where the weight loss of growing media and plants by transpiration was fully replenished by nutrient solution; T2, T3 and T4, which received 10% 20% and 30% less amount of nutrient solution, respectively as compared to T1 treatment. The plant height (104 cm) and leaf area (3353.352 cm^2) was observed significantly higher in the treatment (T1) which received 100% fertigation against the weight loss. Dry biomass and root parameters were found higher in the T1 treatment. Significantly higher capsicum yield (61.716 t/ha), and kg of fruit/plant (1.543 kg/plant) were observed in T1 treatment compared to other treatments. Water use efficiency was found significantly higher in treatment T1 (296.23 kg/ha mm) and lowest (199.954 kg/ha mm) in case of T4 treatment. Fertigation strategy which received the 100% nutrient solution against the weight loss without drainage, allowed the plant to grow with maximum yield and water use efficiency (WUE). Therefore, the 100% or more nutrient solution against weight loss could be a suitable strategy for controlling the fertigation scheduling through the weight based sensing system.

***Key words**: Fertigation scheduling, Soilless cultivation, Grow bag, Capsicum, Weight*

Introduction

Coloured capsicum (sweet pepper or bell pepper) is one of the valuable horticultural crop usually grown in the climate control greenhouses where the micro-climate can be precisely monitored (Ngouajio *et al.*, 2008). Capsicum is ideal for greenhouse growing due to its optimal plant size, canopy cover, and flower settings and fruit production at a lower temperature (Singh *et al.*, 2011). The aim of protected cultivation of capsicum is to achieve a high yield, good quality, improved shelf life, year-round availability of pepper and protect against the biotic and abiotic stress. But continuous production of crops from same land throughout many years has resulted in poor soil fertility and in addition soil borne pathogen problems are posing a serious threat to the protected cultivation. Furthermore, continuous and

([1*] Ph.D. Research Scholar, [2] Principal Scientist, [3] Prof., [4] Prof., [5] Principal Scientist, [6] Principal Scientist)

rapid climate changes, as well as the biotic and abiotic stresses are posing a severe threat to global agricultural productivity (Raza *et al.,* 2019). Therefore, soilless farming under protected structures has emerged as a promising alternative technique for soil-based production to overcome such agricultural limits. Solid substrate culture is commonly used in horticultural crop cultivation inside the greenhouse (Hasan *et al.,* 2018). However, fertigation is the important process of preparing and delivering fertilizer through micro irrigation in soilless cultivation because the crop does not receive nutrients from the substrate culture (Jones, 2016). Crop variety, crop growth stage, environmental circumstances and growing season, and substrate culture type are all elements that influence fertigation treatment (Sonneveld and Voogt, 2009).

In soilless cultivation, fertigation scheduling is calculated based on crop transpiration according to the climatic model, one or more sensors used to calculate water content, use of the plant's response parameter, and any combination of the above methods. Fertigation strategies in soilless cultivation affects crop growth parameters, water and nutrient use, yield and quality of capsicum were studied by Jovicich *et al*., 2003.

Many efforts have been made in the past to control of fertigation in substrate soilless cultivation based on leach out concentration (Jovicich *et al.,* 2003), transpiration measurement (Shin and Son, 2015b), weighing type lysimeters (Ehret *et al.,* 2003) and climatic and physiological parameters (Shin *et al.,* 2014). Among the different irrigation control strategies, weight loss strategy is the best (Saha *et al.,* 2008). Keeping in view above facts, fertigation scheduling was applied, based on the output of newly developed weight based control system in terms of amount of water loss from the substrate soilless grow bag with plants. The developed control system was evaluated to study the effects of different level of fertigation strategies without drainage on growth parameters and yield of soilless coloured capsicum inside the greenhouse and consequently developing efficient fertigation scheduling for soilless coloured capsicum.

Materials and Methods

Experimental Site

The experiment was conducted at the Centre for Protected Cultivation Technology, Indian Agricultural Research Institute, New Delhi, during 2019-20 (October to March) under climate controlled greenhouse (200m^2). The mean daily temperature in the greenhouse was 18-24^{o}C. Coco-peat grow bags (100cm x 20cm x 15cm) were used for cultivation. Some physical properties of coco-peat substrate were presented in Table 1. Capsicum seedlings of yellow colour (cv. Orobelle) were transplanted into coco-peat grow bag at a density of 4 plants/m^2 (25 x 100 cm). Plants were trained around separate strings and supported by overhead wires. Fertilizer along with each irrigation were applied by using drip system with stakes dripper spacing of 25 cm and dripper discharge of 2 l/h. Weight based sensing system was developed to monitor the combined weight loss of grow bag with four plants and controlled the irrigation scheduling.

The experiment was laid out in completely randomized design with three replications. The fertigation treatments were imposed from 15 days after transplanted (DAT). The treatments comprised of T1: 100% of nutrient solution (NS) applied, which means the weight loss of growing media and plants (by transpiration of crop) was fully replenished by fertigation; T2, T3 and T4, which received 10% 20% and 30% less amount of nutrient solution, respectively as compared to T1 treatment. The nutrient solution was applied to all treatments at the same time, when T1 treatment get trigger to start the fertigation by weight based sensing system. Plants were fertilized by nutrient solution containing macro and micronutrients as per Sonneveld and Voogt, (2009): NO_3-N 236.8 ppm, P 38.59 ppm, K 239.15ppm, Ca 212.44 ppm, Mg 35.89 ppm, S 55.1ppm, Fe 1.68 ppm, Cu 0.32ppm, Mn 0.55 ppm, Zn 0.33ppm, B 0.06 ppm, and Mo 0.05 ppm with maintaining the EC between 2-3.5 dS m^{-1} and pH in the range of 5.5-6.5.

During the course of investigation, three sample plants were randomly selected and labeled properly from each of the treatments to measure the yield and growth parameters. Plant height was measured using a flexible measuring tape. Leaf area was measured by using leaf area meter (Model: LI3100C). Three plants were collected from each treatment for the determination of dry biomass of shoot and root. These samples were first air dried before final drying in a hot air oven at 60 °C for 48 h and then final constant weight was measured. The same methods were applied to the root, before that the fresh root samples were used for the determination of root length, surface area, root volume and average diameter by using root scanner. Root diameter less than 0.5mm was considered as fine root for calculation of percent contribution of fine root parameters over the respective total root parameters. Number of fruits/ plant and fresh weight of harvested capsicum fruits was recorded per treatment after each harvesting. The cumulative yield (kg/ha) of the entire harvests and kg of fruits/plant was calculated. Water use efficiency (WUE) was estimated by dividing the yield (kg/ha) with the amount of water consumed by the crop (mm) during its growth period under different treatment.

The statistical software SPSS (v.16.0) was used for the statistical analysis of the data on different parameters for both the seasons. Further, least significant difference among the different treatments was noted using post-hoc tests.

Results and Discussion

Plant height and Leaf area

The results revealed that plant height was significantly highest (104 cm) under treatment T1, as compared with the treatment T2, T3 and T4 (Table 2). Moreover, among the treatments, lower plant height was recorded under the T4 treatment. Leaf area per plant was not statistically different among the fertigation treatments. Highest leaf area per plant (3353.352 cm^2) was recorded under the T1-treatment. It was found that sufficient nutrients were available in the 100% level of fertigation for vegetative growth. It was observed that higher the level of fertigation applied, higher the growth of the plant and leaf area. The plants remained underdeveloped under less amount of fertigation in comparison to the full amount requirement; similar result was reported by Biwalkar *et al.*, 2015. Jovicich *et al.*, 2003 also obtained similar result as plant growth was significantly reduced as fertigation levels were reduced.

Dry matter of shoot and root

Dry matter of shoot and root was significantly ($p<0.05$) affected under different treatment of fertigation strategies. In T1 treatment, dry matter of the shoot was higher whereas it was lower in the T3 treatment. No significance difference was observed between the T3 and T4 treatment (Table 2). The highest dry matter of root was recorded under the T1 treatment followed by T3, though they were at par. Lowest dry matter of root was observed under the T4 treatment. It was found that the T3 treatment significantly decreased the dry matter of shoot and increased the dry root biomass of the plants. Dry matter of shoot and root of capsicum plants responded similarly to fertigation strategies, according to Sabli, (2012).

Root parameter

Root length, projected area and surface area of capsicum plants was not significantly ($p<0.05$) affected by the fertigation strategies (Table 3). Root volume, average diameter and percent contribution of fine root length to total root length and fine root surface area to total root surface area was found signifi-

Table 1. Physical properties of the coco-peat grow bag used in the experiment

Media	Water Holding Capacity (%)	Porosity (%)	Bulk Density (g/cm^3)	pH	EC (ds/m)
Coco-peat	87	90	0.11	5.7	0.6

Table 2. Effect of different treatments on growth parameters of greenhouse capsicum

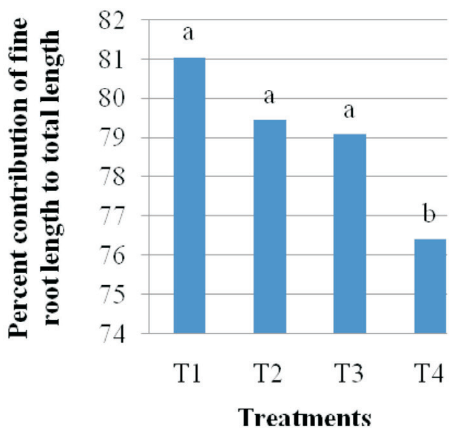
Treatments	Plant height(cm)	Dry biomass of shoot (g)	Dry biomass of root (g)	Leaf area (cm^2)
T1	104.00a	48.223a	5.940ab	3353.352a
T2	97.50bc	41.290b	5.447b	3256.875a
T3	99.75b	34.227c	6.463a	3289.418a
T4	96.00c	34.980c	4.580c	3079.008a
SEM	0.9386	1.7996	0.2376	71.2155
F value	8.863	22.521	9.162	0.608

Values within columns followed different letters are statistically different at $p < 0.05$

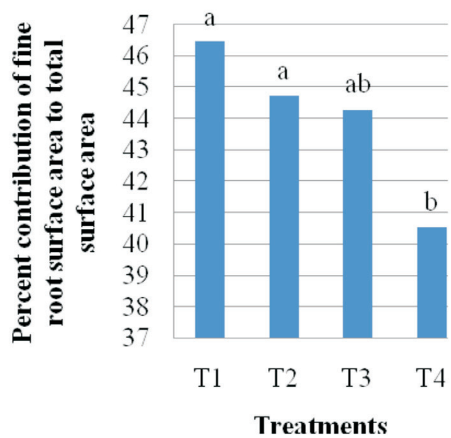
cantly different among the fertigation treatment at last stage (Fig. 1). Reduced nutrient and water availability under T1 and T2 treatments resulted in increased root length and root surface area in plant. Moreover, it was found that average root diameter of T1, and T2 treatment were observed lower compared to T4 treatment. Due to this, the plants in T1 and T2 treatment were able to acquire more water and nutrients from the smaller roots. It may, however, aid in the establishment of nutritional balance in the root zone. In line with the findings of Saha *et al*., (2008), the treatment with the least amount of nutrient leaching showed enhanced root growth and the plant had more fine roots than the treatment with the most fertigation.

Yield parameters

Fertigation treatments significantly (p<0.05) affected the coloured capsicum yield parameters such as number of fruits per plant, kg of fruits per plant and yield in t/ha. The highest capsicum yield (61.716 t/ha), number of fruits per plant (8.75) and kg of fruit/



(a)



(b)

Fig. 1. (a) Percent contribution of fine root length to total root length and (b) Percent contribution of fine root surface area to total root surface area (Bars graph with different letters are statistically different at $p < 0.05$)

Table 3. Effect of different treatments on root parameters of capsicum

Treatments	Root Length (cm)	Projected Area (cm^2)	Surface Area (cm^2)	Root Volume (cm^3)	Average Diameter (mm)
T1	31042a	1198a	3763a	36.341b	0.387b
T2	31897a	1247a	3917a	38.311ab	0.392b
T3	23689b	928b	2914b	28.538c	0.393b
T4	29606a	1269a	3985a	42.694a	0.428a
SEM	1238	48.417	152.1	1.689	0.00548
F value	4.167	7.027	7.027	12.682	11.706

Values within columns followed by different letters are statistically different at $p < 0.05$

Table 4. Effect of different treatments on yield parameters and water use efficiency of greenhouse capsicum

Treatments	Number of fruits per plant	kg of fruits per plant	Yield (t/ha)	IWUE (kg/ha-mm)
T1	8.75a	1.543a	61.716a	296.234a
T2	8.25a	1.111b	44.438b	237.002ab
T3	6.50a	0.849bc	33.972bc	203.830b
T4	6.75a	0.729c	29.160c	199.954b
SEM	0.41802	0.9101	3.64044	14.250
F value	2.156	14.534	14.534	3.819

Values within columns followed by different letters are statistically different at $p < 0.05$

plant (1.543 kg/plant) was obtained under the T1 treatment (Table 4). In T4 treatment, yield parameters were observed lowest and it was at par with the treatment T3. The lowest fruit weight (0.729-0.849 kg) per plant was observed in the treatments receiving 70 and 80 % less fertigation as compared to T1 (100% received fertigation against the weight loss) indicates more fertigation amount increased yield of capsicum. Water use efficiency was found significantly highest in treatment T1 (296.23 kg/ha mm), it was at par with T2 (237.002 kg/ha mm) and lowest was 199.954 kg/ha mm in case of T4 treatment. The yield of capsicum higher in 100% of fertigation strategies due to the fact that nutrients were more easily available and therefore drainage is not occurred in this strategy. It may induce the imbalance of nutrient concentration in the root zone without drainage, due to this lower yield obtained. Similarly, Aminifard *et al.*, 2012 reported capsicum yields in the range of 1.2 to 2.3 kg per plant for the same plant density. Sabli, (2012) reported yield of 1.65-2.36 kg/plant for capsicum cultivated in soilless culture inside a greenhouse. The results of yield (Table 4) from the experiment were similar with the report of Sabli, (2012) who reported higher leaf area and total dry matter production were associated with higher yield.

Conclusion

Results revealed that weight-based fertigation can support capsicum growth, and farmers will be more confident in applying fertigation based on water loss. Furthermore, 100 percent fertigation approach might be used to boost water availability, reduce nutrient imbalance, and allow more nutrients to reach the plant root zone area. The fertigation control strategy of applying 100 percent of the nutrient and water to the growing system against weight loss due to crop transpiration reduces nutrient loss and improves crop production and related crop parameters. It should be used as a fertigation strategy to promote weight-based fertigation scheduling for capsicum production in soilless grow bag systems.

References

Aminifard, M.H., Aroiee, H., Ameri, A. and Fatemi, H. 2012. Effect of plant density and nitrogen fertilizer on growth, yield and fruit quality of sweet pepper (*Capsicum annum* L.). *African Journal of Agricultural Research*. 7(6) : 859-866.

Biwalkar, N., Singh, K.G., Jain, A.K., Sharda, R., Jindal, S.K., Singh, K. and Chawla, N. 2015. Response of coloured sweet pepper (*Capsicum annuum* L. var. grossum) to fertigation and irrigation levels under naturally ventilated greenhouse. *Agricultural Research Journal*. 52(1) : 19-25.

Ehret, D.L., Helmer, T. and Bittman, S. 2003. Greater accuracy from direct crop measurements. *Fruit and veg tech.* 3 : 9-11.

Hasan M, Sabir N, Singh A K, Singh MC, Patel N, Khanna M, Rai T and Pragnya P. 2018. *Hydroponics Technology for Horticultural Crops*, Pp. 30, Tech. Bull. TB-ICN 188/2018. ICAR-IARI, New Delhi, India.

Jones, J.B. 2016. *Hydroponics: a Practical Guide for the Soilless Grower.* CRC press.

Jovicich, E., Cantliffe, D.J., Stoffella, P.J. and Vansickle, J.J. 2003. Reduced fertigation of soilless greenhouse peppers improves fruit yield and quality. *Acta Horticulturae*. (609) : 193–196.

Ngouajio, M., Wang, G. and Goldy, R.G. 2008. Timing of drip irrigation initiation affects irrigation water use efficiency and yield of bell pepper under plastic mulch. *Hort Technology*. 18 : 397–402.

Raza, A., Razzaq, A., Mehmood, S.S., Zou, X., Zhang, X., Lv, Y. and Xu, J. 2019. Impact of climate change on crops adaptation and strategies to tackle its outcome: A review. *Plants.* 8(2) : 34.

Sabli, M.Z. 2012. *Fertigation of bell pepper (Capsicum annuum L.) in a soil-less greenhouse system: effects of fertilizer formulation and irrigation frequency*. Ph.D. Thesis, Newcastle University, UK.

Saha, U.K., Papadopoulos, A.P., Hao, X. and Khosla, S. 2008. Irrigation Strategies for Greenhouse Tomato Production on Rockwool. *Hort Science Horts.* 43(2) : 484-493.

Shin, J.H., Park, J.S. and Son, J.E. 2014. Estimating the actual transpiration rate with compensated levels of accumulated radiation for the efficient irrigation of soilless cultures of paprika plants. *Agricultural Water Management*. 135 : 9–18.

Shin, J.H. and Son, J.E. 2015b. Development of a real-time irrigation control system considering transpiration, substrate electrical conductivity, and drainage rate of nutrient solutions in soilless culture of paprika (*Capsicum annuum* L.). *Europ. J. Hort. Sci.* 80(6) : 271-279

Singh, A.K., Singh, B. and Gupta, R. 2011. Performance of sweet pepper (*Capsicum annuum*) varieties and economics under protected and open field conditions in Uttarakhand. *Indian Journal of Agricultural Sciences*. 81(10) : 973-975.

Sonneveld, C. and Voogt, W. 2009. Nutrient solutions for soilless cultures. In C. Sonneveld, & W. Voogt (Eds.), Plant Nutrition of Greenhouse Crops (pp. 257-275). Springer.