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Short communication

Comparison of substrate hydroponic systems for soilless tomato production

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ABSTRACT

The growth and fruit yield of tomato plants grown under wick type self-suction and drip substrate hydroponic systems was compared. Tomato plants were cultivated under these two substrate hydroponic systems in summer and winter seasons. Four nutrient solutions having different proportions of N and K for vegetative and reproductive stages were applied to plants raised under both the hydroponic systems in both the seasons. Total fruit yield was higher in winter crop raised under wick substrate hydroponic system supplied with nutrient solution containing N:K in the ratio of 1.4:3 during vegetative stage and 1.7:3.5 during reproductive stage.

Key words: *Solanum lycopersicum*, soilless culture, wick, yield.

Tomato is a major horticultural crop with immense nutrition benefits. It is a warm season crop and requires a relatively long growing season with plenty of sunshine and moderate day temperature of 20°C. Fruit set is poor when the temperature is relatively low or high. In Punjab, extremely low and high temperatures restrict the production of tomatoes. Consequently, there is fluctuation of price of tomatoes in the market. Further, under field conditions, yield is limited due to numerous biotic (pest and diseases), abiotic (temperature, relative humidity, rainfall and light intensity) and plant factors (flower and fruit drop).

The cultivation of greenhouse crops and the procurement of high yield and good quality of fruits are achievable with hydroponics due to the proper control of plant nutrition and all other growing conditions (Adams, 1). Tomato plants require nutrients at varying amounts at different stages of growth and development. Tomato yields are associated with the application of nitrogen and potassium in appropriate ratios at specific growth stages of plants (Passam *et al.,* 7) In the present study, growth and yield of tomato crop under two hydroponic systems, supplied with four levels of N and K were compared during summer and winter season.

Experiments were conducted during the years 2014-15 and 2015-16.The nursery of tomato var. Punjab Varkha Bahar 1 was raised at field area of department of Vegetable Science, Punjab Agricultural University, Ludhiana as per recommended practices (Anonymous, 2). For winter crop, the nursery was sown in 2nd week of July and transplanted in mid-August. For summer crop, nursery was planted during last week of October and transplanted in first week of December.

The crops were transplanted to improvised substrate hydroponic systems (Bhullar *et al.,* 3) at the Department of Mechanical Engineering, Punjab Agricultural University, Ludhiana. Substrate medium comprising a mixture of cocopeat, vermiculite and perlite (3:1:1) was contained in plastic pots (height 28 cm and diameter approximately 30 cm). For wick type self-suction hydroponic system, four cotton wicks of suitable thickness and length were selected and inserted through holes drilled in the base of the pot. The pots were placed on plastic buckets (6 litre capacity) that contained the respective nutrient solution (5 litres). The solution was drawn into the growing substrate medium by capillary action through the wick providing sufficient water and nutrients to the plants. For drip substrate hydroponic system, the nutrient solution was contained in plastic drum and was supplied to each pot (containing growing substrate) through a plastic pipe attached with drippers. The nutrient solution was pumped and later circulated back into the drum after wetting the substrate medium of each pot using an electrical motor.

Under both the substrate hydroponic systems, 4 nutrient solution treatments as per Kaur *et al*. (6) were applied during both the growing seasons. Treatments comprised N and K supplied in four different ratios at vegetative and reproductive stages respectively. A commercially available formulation of micronutrients was used. The hydroponic systems were placed inside a polyhouse. The environment inside the polyhouse was monitored and maintained by using heaters and coolers in winters and summers respectively. In summer, the average maximum day

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temperature ranged between 23°C - 29°C and in winter, the range was between 21°C - 27°C. A green net was used for shading the polyhouse in the months of August and September.

The plants were staked to maintain upright growth. The crop growth and yield data were recorded throughout the crop cycle of tomato. The axillary buds were pruned regularly. The main stem of each plant (each replication) was measured from ground level up to the tip of growing bud using a metre scale. Total number of flowers per cluster and clusters per plant were counted from the plant from each treatment and replication till maturity of plant and average number was calculated. Total numbers of fruits harvested from each picking from each plant were added to calculate the total number of fruits harvested per plant during the entire harvesting season. Three fully matured fruits were selected at random from each replicated treatment for measurement of diameter (cm). Total fruit weight from all the pickings was added to calculate total fruit yield.

CRD factorial design was used to analyse the data. The fertilizer treatments (N:K ratios) were considered as the main plot, hydroponic systems as the sub-plot and growing seasons as the sub-sub plot.. Means of the treatments and systems were compared using the Tukey test at a significance level of 0.05.

Plant height is a selection criterion for screening vigorous plants at early growth stages. In the current study, the maximum plant height was recorded in winter crop supplied with nutrient solution containing higher proportion of N and K (i.e. treatment T4) under wick type substrate hydroponic system. Bhullar *et al.* (3) also compared the growth response of tomato plants raised under wick type and pumping type substrate hydroponic systems and reported that with the application of 2.5 gm nutrients per litre of water, the height of plants grown under wick type system was more than that of plants raised under pumping type system. Irrespective of the season or hydroponic system, the fruit yield was higher in plants supplied with nutrient solution T4 but the composition of nutrient solution did not affect diameter of individual fruit (Table 2). Similar results have been reported by Genuncio *et al*. (5) wherein N:K ratios in the fertilizers did not affect the average diameter of marketable fruits. During each season, diameter of fruit was not affected by hydroponic systems. In tomato, high levels of K improves yield (Bidari and Hebsur, 4). Nitrogen deficiency can result in stunted growth and decrease fruit number and size. Overall, maximum total fruit yield was obtained in crop raised under wick type substrate hydroponic system in winter crop (Table 1). The enhanced yield in winter crop is attributed to traits such as number of flower clusters per plant, total number of fruits and total yield were higher under wick system (Table 1). However, in summer crop, these traits were higher in the drip substrate hydroponic system.

The yield is determined by plant development during early stages. Wick system was more effective in establishment of winter crop because during transplanting stage (mid-August) crop faced more evapo-transpiration losses which the drip system was not able to compensate. Further, wick type substrate hydroponic system gave better yield because wicks established a direct contact with nutrient solution and the act as capillaries to absorb water along with nutrients in an adequate amount whenever needed by the plant. Even some of the roots established direct contact with the nutrient solution and were able to compensate rapidly for evapo-transpiration losses experienced during early growth period of winter crop. As winter crop has more vigorous vegetative growth, the leaves were able to accumulate more photoassimilates which were subsequently translocated to fruits contributing to

Table 1. Mean of yield contributing parameters and total yield of tomato under wick and drip substrate hydroponic systems in winter and summer crop.

Parameter	Winter crop		Summer crop	
	Wick system	Drip system	Wick system	Drip system
Plant height (cm plant^{-1})	168.36 ^{a}	133.99 ^{c}	130.18 ^{d}	151.15 ^{b}
Flower clusters (plant^{-1})	10.75 ^{a}	9.08 ^{b}	8.83 ^{b}	10.00 ^{ab}
Flowers per cluster (plant^{-1})	7.63 ^{a}	6.83 ^{a}	6.94 ^{a}	7.50 ^{a}
Total number (fruit plant^{-1})	72.33 ^{a}	51.50 ^{d}	57.42 ^{c}	68.00 ^{b}
Fruit diameter (cm)	5.82 ^{a}	5.18 ^{ab}	4.93 ^{b}	4.83 ^{b}
Total yield (Kg plant^{-1})	8.15 ^{a}	5.21 ^{d}	5.79 ^{c}	7.53 ^{b}

For both crop growth seasons, mean corresponded to 4 treatments combining different N:K ratios (N=4). Values followed by a same superscript in a row are not statistically different (Tukey test).

Table 2. Effect of composition of nutrient solution on total yield and diameter of fruit in tomato crop raised wick and drip substrate hydroponic systems in winter and summer crop.

Treatments (Nutrient Solutions)	Yield (Kg/plant)	Diameter (cm)
Winter crop, Wick system		
T1 (N:K= 1.2:2; N:K= 1.5:2.5)	2.36 [d]	5.37 [a]
T2 (N:K= 1.2:3; N:K= 1.5:3.5)	5.31 [b]	5.43 [a]
T3 (N:K= 1.4:2; N:K= 1.7:2.5)	4.34 [c]	5.53 [a]
T4 (N:K= 1.4:3; N:K= 1.7:3.5)	20.61 [a]	6.97 [a]
Winter crop, Drip system		
T1 (N:K= 1.2:2; N:K= 1.5:2.5)	1.65 [d]	4.57 [a]
T2 (N:K= 1.2:3; N:K= 1.5:3.5)	3.88 [b]	4.77 [a]
T3 (N:K= 1.4:2; N:K= 1.7:2.5)	2.31 [c]	4.80 [a]
T4 (N:K= 1.4:3; N:K= 1.7:3.5)	13.01 [a]	6.56 [a]
Summer crop, Wick system		
T1 (N:K= 1.2:2; N:K= 1.5:2.5)	1.17 [d]	4.57 [a]
T2 (N:K= 1.2:3; N:K= 1.5:3.5)	3.77 [b]	4.30 [a]
T3 (N:K= 1.4:2; N:K= 1.7:2.5)	3.19 [c]	4.43 [a]
T4 (N:K= 1.4:3; N:K= 1.7:3.5)	15.01 [a]	6.43 [a]
Summer crop, Drip system		
T1 (N:K= 1.2:2; N:K= 1.5:2.5)	2.00 [d]	4.33 [a]
T2 (N:K= 1.2:3; N:K= 1.5:3.5)	5.03 [b]	4.17 [a]
T3 (N:K= 1.4:2; N:K= 1.7:2.5)	4.20 [c]	4.36 [a]
T4 (N:K= 1.4:3; N:K= 1.7:3.5)	18.88 [a]	6.47 [a]

Values followed by a same superscript in a column and within a cropping system are not statistically different (Tukey test, $P<0.05$).

higher yield and quality. However, in summer crop, drip substrate hydroponic system gave better yield (Table 1).

Overall higher yield was obtained from winter crop which may be attributed to more vigorous vegetative growth and more number of flower clusters and number of fruits per plant. Among the nutrient solution, treatments with higher proportion of N and K (T4) increased the total fruit yield in both the substrate hydroponic systems in both the seasons. Plants grown under wick substrate hydroponic system produce higher fruit yield in winter crop.

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