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Growth and yield of tomato in soilless media under naturally ventilated polyhouse

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ABSTRACT

The present study explored the possibility of substrate/ growing media other than soil which can support good crop growth accompanied by water saving and get rid of some soil-borne diseases under protected cultivation. The experiment aimed to identify suitable indeterminate tomato cultivars for Punjab in soilless cultivation and standardize management practices for growing tomatoes in soilless (coco peat) media with different fertigation levels under protected cultivation. The treatments comprised two indeterminate tomato cultivars, 'Punjab Sartaj' (PAU) and 'Heemshikahar' along with 'NS 4266' and three levels of fertigation as F1 = 70% of RDF, F2 = 85% of RDF and F3 = 100% of RDF. Results showed that maximum fruit yield (6.10 and 6.68 kg plant-1) was obtained during respective years with application of 100 per cent RDF, which was statistically at par with 85% RDF (5.70 and 6.20 kg plant-1) but significantly higher than 70% RDF (4.94 and 5.62 kg plant-1) application. Among the cultivars with 100% RDF, 'NS 4266' recorded significantly higher fruit yield (6.68 kg plant-1), which was 22.8 and 29.7 per cent higher than 'Heemshikahar' and 'Punjab Sartaj', respectively. During the second year, 'Punjab Sartaj' produced fruit yield statistically at par with 'Heemshikahar' but significantly lower than 'NS 4266'.

Keywords: Cultivars, Drip-fertigation, *Lycoperiscon esculentum* L., Soilless media, SPAD

INTRODUCTION

Advanced agriculture technologies like hydroponics, aeroponics and soil less cultivation uses nutrient solution in water or substrate for growing crops holds promise for crop production. It has been proven that soil is not necessarily required for crop production; it only provides nutrients (Pradhan and Deo, 11). In soilless method of growing crops, the plant roots grow either in a porous media called substrate with frequent application of nutrient solution (substrate culture) or directly in nutrient solution without any solid phase (water culture/ hydroponics). The commonly used substrates are peat, coir (also known as coir dust and coco peat), soft-wood pine bark, wood fiber and composted organic wastes (Barrett, 4). Soilless cultivation can support year round production of crops (Brechner and Both, 3) and results in higher water and nutrient use efficiencies (Van Os, 15; Savvas,14; Barrett, 4). Besides a number of advantages of soilless cultivation like high yields, elimination of soilborne diseases and high water use efficiency. It has been reported that for production of one kilogram of tomato, soilless cultivation uses 35 l of water while soil cultivation uses 78 l of water for producing similar quantity of the produce (Massa *et al*., 7).

Tomato is the second most consumed vegetables in the world, while India is the second largest producer of tomatoes. As compared to open field crop, greenhouse crop of tomato results in better growth especially in the early stage and results in early and more yield (Phookan and Saikia, 12). Tomato plants grown in soilless system under protected cultivation develop faster with higher total yield as compared to crop grown in soil under greenhouse. Shifting from soil to soilless cultivation can also help in eliminating soil-borne plant diseases (Olympios, 9). Under Punjab conditions, many greenhouse structures have been abandoned by farmers because of increased /severe problem of nematodes and other soil borne diseases. The scope of further enhancing the productivity under greenhouse is widened by adopting soilless cultivation (Raviv and Lieth, 13; Nejad and Ismaili, 8; Barrett, 4). Mabokoa *et al*. (6) and Luitel *et al*. (5) recommended cocopeat as potential growing substrate for tomato cultivation to increase its yield and fruit quality characters. Very little work has been done on soilless cultivation of tomato under subtropical environment like Punjab. Hence, the present study was carried out to identify suitable indeterminate tomato cultivars in soilless cultivation and to standardize management practices for growing tomato in soilless (coco peat) medium with different fertigation levels under protected cultivation.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* season 2016-17 and 2017-18 in a poly net house at the research farm, department of Soil and Water

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Engineering, (30°-56' N, 75°-56' E and 247 m above mean sea level) Punjab Agricultural University, Ludhiana. A poly net house (25 m × 8 m) oriented in east-west direction, having centre height 3 meter and side height 2 m with provision for top ventilation by providing 7 windows each of size 95 cm × 90 cm was used for growing indeterminate tomato. The area of poly net house was divided into two halves keeping centre path 2.30 m wide. The first longitudinal strip (trench) was 1.0 m away from the side wall and the second longitudinal strips were 1.55 m away from the first trench towards the central path. The trenches of 15 × 20 cm were dug along the centre line of each strip longitudinally. The trenches were given a slope of 1% towards the length of the trench. The soil excavated while digging trenches was placed around the trenches in such a way so as to create an inward slope towards the trench such that all the leachate / nutrient solution falling over each strip drains into the trench dug at each strip. The entire surface area of poly net house floor was then covered with old plastic sheets (thickness 200 µm) to prevent any infiltration of leachate or water into the soil/ ground. For collection of leachate, PVC pipes having diameter 64 mm with 140 holes per m length, leaving 1/3rd area at the base without holes and surface area of pipe was wrapped in 30 mesh net and placed at the bottom of the trenches. These pipes were then packed with gravel of 2-4 mm size. The entire surface area of the polyhouse floor was covered with weed mat to avoid any weed emergence. Coco-peat slabs were placed directly above weed mat along the trenches.

During the first year, the nursery of two indeterminate tomato cultivars 'Punjab Sartaj' (PAU) and 'Heemshikahar' was sown on 6th September, 2016 in the plug trays, while in second year nursery sowing was done on 23rd August, 2017 and another promising cultivar-'NS 4266' was added to the treatments. The trays were filled with coco peat based medium, which was saturated with nutrient solution for 24 h before planting of the seed. The plug trays were placed on 2-2.5 feet raised platform/stand. After sowing the seed, nutrient solution was sprinkled over the plug trays using sprinkling can to meet the irrigation and fertigation needs of the growing seedlings. The seedlings were raised under polynet house provided with white coloured shade net. On each coco-peat slab, three square holes of 7.5 cm × 7.5 cm were made with sharp edged knife, keeping a 30 cm spacing between any two adjacent holes. First hole was made in the centre of the slab. The slabs were saturated with nutrient solution before transplanting for at least 24 h. After saturation a coco-peat slab expands and attains dimensions of 100 cm × 15 cm × 10 cm. The seedlings were transplanted in coco peat slabs. Three plants were planted in each slab. In total 288 plants of tomato were planted in 200 m^2 polyhouse. During first year each treatment included 24 plants, while during second year plants were reduced to 18 plants (Fig.1). The treatments comprised of two indeterminate tomato cultivars *viz.* 'Punjab Sartaj' (PAU) and 'Heemshikahar' during first year and three tomato cultivars including 'NS4266' along with three levels of nutrient solution *viz*. F_1=70 % of RDF, F_2=85 % of RDF and F_3=100 % of RDF. Different dosages of nutrient solution applied for growing tomato under climate controlled polyhouse in soilless media are presented in Table 1. The experiment was conducted in completely randomized design, replicated twice. After transplanting of seedlings in each slab about 2" slanting cut was made on alternate sides towards the end with a sharp knife/blade for draining excess nutrient solution. The plants were drip fertigated with single strength nutrient solution prepared by dissolving required quantity of different fertilizers in 1000 l tank. The pH of nutrient solution was maintained between 5.8-6.5 by addition of commercial grade phosphoric acid.

The pH and EC of coco peat slabs was also monitored on daily basis. After transplanting of seedlings for 30 days irrigation with nutrient solution was provided for 5-7 min., three times in a day. Thereafter, irrigation interval was increased to 10 minutes and frequency was 4 times a day. During the peak fruiting period, irrigation interval was increased to 12-15 minutes keeping weather conditions in view and frequency of drip-fertigation increased to five times a day. Other package of practices were followed as recommended by Punjab Agricultural University. The plants were trained to single stem by removing side shoots and using nylon rope with roller hooks and trellising system within a week after transplanting. Plant stems were secured to plastic twine with clips every 10-15 cm, allow for 10-12 m unwind on hook. The lower leaves up to 30 cm height from the base were pruned

Fig. 1. Tomato crop planted in coco peat based soilless media.

Table 1. Nutrient dose (ppm) recommended (RDF100%) for raising nursery and tomato crop in soilless media under climate controlled greenhouse.

Crop Stage	N	NH_{4+}	P	K	Ca	Mg	Fe	Mn	Zn	B	Cu	Mo	S*
Nursery raising	200	10	50	253	247	75	0.8	0.55	0.33	0.5	0.05	0.05	120
Normal feed for crop	210	22	50	370	190	75	0.8	0.55	0.33	0.5	0.05	0.05	120

* = No specific requirement for sulphur.

15 day after transplanting. At later stages leaves were pruned after fruit picking and growing tip remains at the top of the canopy, but the stem is lowered and trails along the base of the plants. It has advantages like maximum light interception, by young leaves with increased aeration and labour efficiency resulting from easier removal of leaves and fruit at the lower part of the plant stem. The stem was leaned, lowered and rotated in clock wise direction, along the row. The data on growth parameters like vine length, stem diameter, SPAD readings were recorded at periodic interval from three tagged plants selected at random in each plot. The 5th, 10th and 15th node were counted from tip of the plant at each observation. For recording number of fruits per plant three tagged plants in each plot were selected and recorded the fruit data at each picking. The data on fruit length, fruit diameter and single fruit weight was recorded three times (early, mid and late) during the crop cycle and average value was recorded for each of the parameters. The fruits were picked in 23 pickings starting from 9th January, 2017 till 22 May, 2017 during first year and in 25 pickings during second year starting from 28 November, 2017 till 23 April, 2018. The data was statistically analysed using Analysis of Variance technique and results were compared at 5 per cent level of significance.

RESULTS AND DISCUSSION

During first year, at 30 days after transplanting (DAT), plants of 'Punjab Sartaj' recorded the highest vine length (175.5,182.0 and 184.8 cm) followed by 'Heemshikahar' at different levels of recommended dose of fertilizer (RDF) applied during the first year (Table 2). However, during the second year it was not significantly influenced. Within the same cultivar the varied fertilizer dose had no significant effect on vine length. At 60 and 90 DAT also there was no significant difference in vine length of different tomato cultivars or varied levels fertilizer dose. This may be because of reason that during this period most of plant metabolites were available for vegetative growth and only little portion was diverted towards reproductive parts in the form of flowers or fruits. During first year from 120 DAT till maturity of the crop, among the cultivars the highest vine length was recorded in 'Punjab Sartaj' (523-587 cm) and it was followed by 'Heemshikahar' (494.5-496 cm). In second year also the highest vine length was recorded in 'Punjab Sartaj' (528-555.2 cm) and it was followed by 'Heemshikahar' (431.5-508.4 cm) and lowest vine length was recorded in NS 426 (436.3-491.2 cm). During first year various fertigation levels failed to significantly influence the vine length of a variety except 'Punjab Sartaj' with

Table 2. Vine length of tomato as influenced by fertigation levels and cultivars.

Treatment	Vine length (cm)											
	30 DAT		60 DAT		90 DAT		120 DAT		150 DAT		Maturity	
	2016	2017	2016	2017	2017	2018	2017	2018	2017	2018	2017	2018
T_1:70% RDF*- 'Punjab Sartaj'	175.5	126.9	240.8	235.0	322.5	297.4	379.2	348.3	493.9	410.7	523.0	528.0
T_2:70% RDF- 'Heemshikahar'	154.5	124.2	185.5	224.2	268.9	263.0	330.8	301.9	387.3	335.5	494.5	431.5
T_3:70% RDF- NS 4266	--	140.2	--	236.8	--	276.6	--	312.5	--	370.2	--	436.3
T_4: 85% RDF- 'Punjab Sartaj'	182.0	129.3	244.0	239.7	319.7	300.3	397.6	354.2	495.7	422.2	557.0	539.0
T_5:85% RDF- 'Heemshikahar'	163.3	126.4	208.5	224.3	271.5	272.5	332.0	309.9	401.4	353.7	496.0	466.9
T_6:85% RDF- NS 4266	--	142.7	--	245.5	--	288.4	--	325.7	--	371.7	--	470.7
T_7:100% RDF- 'Punjab Sartaj'	184.8	136.2	247.2	245.2	311.9	303.7	413.0	366.7	503.5	421.3	587.0	555.2
T_8:100% RDF- ' Heemshikahar'	164.5	126.2	212.2	242.4	274.2	294.0	338.0	337.8	414.3	382.5	494.5	508.4
T_9:100% RDF- NS 4266	--	139.7	--	246.5	--	297.2	--	335.0	--	379.0	--	491.2
$LSD_{(0.05)}$	15.9	NS	NS	NS	NS	NS	27.2	24.1	53.7	NS	40.9	50.4

*RDF = Nutrient dose recommended for climate controlled polyhouse

Table 3. SPAD value of tomato as influenced by fertigation levels and cultivars

Treatment	SPAD value (60 DAT)						SPAD value (90 DAT)						SPAD value (120 DAT)					
	5th Node		10th Node		15th Node		5th Node		10th Node		15th Node		5th Node		10th Node		15th Node	
	2016	2017	2016	2017	2016	2017	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T_1	54.0	50.7	52.7	50.5	51.4	49.5	50.5	54.2	48.1	47.9	50.7	48.2	56.8	52.6	56.2	50.9	68.1	62.9
T_2	50.3	44.9	52.0	46.5	49.1	40.0	46.6	52.3	48.4	44.0	48.5	41.0	54.4	49.6	57.6	47.1	59.7	52.5
T_3	--	41.7	--	47.7	--	43.9	--	41.4	--	40.1	--	46.8	--	52.8	--	51.9	--	53.2
T_4	55.4	50.8	54.9	53.1	52.3	51.9	50.0	56.9	50.0	57.2	54.2	55.8	57.1	56.8	55.7	66.8	70.4	61.4
T_5	53.0	56.6	53.0	60.0	51.6	49.5	47.3	49.8	52.9	48.8	53.6	48.0	54.8	58.9	58.5	57.4	61.4	58.8
T_6	--	46.9	--	49.4	--	46.7	--	43.7	--	45.5	--	45.7	--	50.6	--	49.2		55.0
T_7	57.7	53.4	55.2	55.8	54.9	52.2	50.2	55.9	52.8	52.0	55.8	51.4	59.8	53.9	59.2	57.6	77.3	61.0
T_8	54.7	52.1	57.9	54.4	52.5	50.6	47.4	55.4	53.0	50.1	55.6	51.4	59.1	52.3	53.9	58.1	69.8	64.3
T_9	--	47.1	--	52.6	--	49.4	--	47.1	--	45.5	--	46.6	--	53.4	--	52.4	--	54.9
$LSD_{(0.05)}$	NS	5.76	NS	4.65	NS	NS	NS	6.45	NS	8.82	NS	NS	NS	NS	NS	NS	NS	NS

*RDF = Nutrient dose recommended for climate controlled polyhouse

70% RDF recorded significantly lower vine length at 120 DAT and at maturity. However, during the second year the fertigation levels had no significant influence on vine length except in 'Heemshikahar' with 70% RDF (301.9 cm), which recorded significantly lower vine length as compared to 100% RDF (337.8 cm) at 120 DAT and at maturity while under 'NS 4266' only at time of maturity 70% RDF (431.5 cm) was significantly lower than 100% RDF (491.2). This varied behavior of vine length during two years may be attributed to physiological behavior of plant according to length of vegetative phase, as during first year first picking was obtained about 86 DAT while during second year first picking was obtained 70 DAT. Thus, when plants enter early into reproductive phase the overall length of the vine may be shorter.

The Chlorophyll content in the leaves of tomato was measured by using non destructive method based on SPAD values using SPAD 502 meter. The SPAD values showed non- significant differences among the different treatments during the first year (Table 3). However, during second year at 60 DAT leaves at 5th node of 'Punjab Sartaj' (50.7) applied with 70 % RDF dose recorded significantly higher SPAD value than 'Heemshikahar' (44.9) or 'NS4266' (41.7). This may be attributed to the fact that 'Heemshikahar' and 'NS 4266' gave relatively higher quantity of early fruit yield as compared to 'Punjab Sartaj' (data not given). But fertigation at 85 % RDF dose leaves of 'Punjab Sartaj' (50.8) recorded SPAD values statistically at par with 'Heemshikahar' (56.6) as well as 'NS 4266' (46.9), however 'Heemshikahar' recorded significantly higher SPAD values than 'NS 4266'. At 10th node SPAD values did not differ significantly among different cultivars at 70 or 100 % RDF fertigation levels. However, at 85 % RDF level 'Heemshikahar' (60.0) recorded significantly higher SPAD value than 'Punjab Sartaj' (53.1) or NS 4266 (49.4). At 15th node SPAD values did not differ significantly either among cultivars or among different ferigation doses. During second year at 90 DAT, SPAD values recorded at 5th node in leaves of 'Punjab Sartaj' (54.2 or 55.9) and 'Heemshikahar' (55.9 or 55.4) with 70 or 100 % RDF application were statistically at par with each other but significantly higher than 'NS 4266' (41.4 or 47.1).

However, with 85% RDF fertigation SPAD readings were significantly higher in 'Punjab Sartaj' as compared to 'Heemshikahar' or 'NS 4266', but later two cultivars recorded SPAD values statistically at par with each other. With 85% RDF fertigation level early fruiting was higher in 'Heemshikahar' and 'NS 4266'. Though, slight increase was observed in SPAD values with increased level of fertigation dose. At 10th node SPAD values did not differ significantly among the cultivars at 70 and 100% RDF fertigation levels.

But at 85% RDF level 'Punjab Sartaj' (57.2) recorded significantly higher SPAD value than 'NS 4266' (45.5), while it was statistically at par

'Heemshikahar' (48.8). At later stages of crop growth (120 DAT) SPAD values recorded at 5th, 10th or 15th node did not differ significantly either because of cultivars or fertigation doses. Stem diameter recorded at 5th node, 60 days after transplanting (DAT) in 'Punjab Sartaj' cultivar (13.2 mm) with fertigation applied at 85% RDF was significantly higher than 'Heemshikahar' cultivar fertigated with 70% RDF (11.0 mm) and 85 % RDF (11.4 mm). However, at 100% RDF(14.7& 15 mm) stem diameter was statistically at par in both the cultivars but it was significantly higher than70 (12.9 & 12.7 mm) and 85% RDF (13.8 & 13.7 mm) fertigation dose in both the cultivars. Further, stem diameter recorded at 10th node was significantly higher with 100% RDF applied through fertigation as compared to 70% RDF, but it was statistically at par with fertigation done at 85% RDF. Stem diameter recorded at 15th node was not significantly influenced by different levels of RDF applied as fertigation or cultivars during both the years. The stem diameter measured at 5th, 10th or 15th node showed non-significant differences with varied levels of RDF or cultivars at 90 and 120 DAT (Table 4). This indicates that after the start of fruit setting the stem diameter in tomato did not vary with applied fertilizers.

Fruit length of tomato was not significantly influenced by different fertigation levels or different cultivars during both the years. However, the fruits of 'Punjab Sartaj' (4.73 & 4.85 cm) were slightly long as compared to 'Heemshikahar' (4.58 & 4.59 cm) or NS 4266 (4.65 & 4.72 cm). The fruits of 'Punjab Sartaj' and NS 4266 were round in shape, while 'Heemshikahar' were slightly more boarder as compared to their length. Similarly, fruit diameter was not significantly influenced by different fertigation levels or cultivars. Parvej *et al.* 2010.,10 also reported that fruit length and fruit diameter was not significantly influenced by different cultivars. The number of fruits plant^{-1} was significantly influenced by fertigation levels during both the years of study. During first year for cultivar 'Heemshikahar' fertigated with 100% RDF recorded maximum number of fruits plant^{-1} (72.3), which was statistically at par with 85% RDF (68.2) fertigated plants but significantly higher than plants applied with 70% RDF (61.1) (Table 5). However, number of fruits plant^{-1} in 'Punjab Sartaj' (54.8, 56.2 & 57.6) did not differ significantly among different levels of RDF applied as fertigation. At 85 and 100% RDF (72.3) application of fertilizer 'Heemshikahar' recorded significantly higher fruit number/vine as compared to 'Punjab Sartaj'. During the second year also number of fruits plant^{-1} were significantly influenced by fertigation levels among

Table 4. Stem diameter (mm) of tomato as influenced by fertigation levels and cultivars.

Treatment	Stem diameter (60 DAT)						Stem diameter (90 DAT)						Stem diameter (120 DAT)					
	5th Node		10th Node		15th Node		5th Node		10th Node		15th Node		5th Node		10th Node		15th Node	
	2016	2017	2016	2017	2016	2017	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T_1	12.0	8.7	12.9	10.3	15.0	10.1	10.7	10.4	11.8	11.8	14.4	11.9	10.6	8.7	11.8	10.6	11.5	10.5
T_2	11.0	9.8	12.7	10.8	12.9	10.9	9.2	9.6	12.2	10.9	13.0	13.7	9.4	8.4	11.4	11.7	10.7	13.2
T_3	--	10.7	--	11.7	--	11.1	--	10.6	--	9.4	--	10.4		7.9	--	9.1	--	9.7
T_4	13.2	9.9	13.8	10.3	14.5	10.6	10.2	9.8	11.5	10.1	13.8	12.5	9.7	10.6	12.8	11.7	11.5	11.5
T_5	11.4	10.9	13.7	11.3	13.5	12.1	10.4	8.6	13.1	11.7	14.4	12.4	10.2	8.7	12.4	9.8	10.9	10.3
T_6	--	8.4	--	9.4	--	9.7	--	7.3	--	8.9	--	11.8		13.1	--	8.6	--	9.2
T_7	15.0	11.5	14.7	10.5	15.3	9.4	10.7	10.4	12.4	10.9	15.2	13.2	9.4	8.5	11.8	9.4	11.1	11.9
T_8	14.2	6.6	15.0	11.4	14.2	12.3	10.2	9.4	12.5	12.1	13.9	12.8	9.8	9.8	11.2	12.6	10.3	12.6
T_9	--	9.6	--	10.9	--	11.4	--	8.0	--	10.7	--	12.4		8.8	--	11.1	--	13.0
LSD (0.05)	1.34	NS	1.45	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

RDF *= Nutrient dose recommended for climate controlled polyhouse

different cultivars except for 'Punjab Sartaj', which did not recorded significant increase in number of fruits per vine with increased dose of fertigation. The cultivar 'NS 4266' (77.3) and 'Heemshikahar' (70.1) with 100% RDF applied as fertigation recorded significantly higher number of fruits plant^{-1} as compared to 70% RDF dose (63.5 & 68.3) , however it was statistically at par with 85 % RDF dose (67.6 & 72.1). Among the cultivars 'NS 4266' recorded maximum number of fruits plant^{-1} (77.3), it was significantly better compared to 'Heemshikahar' (70.1) or Punjab Sartaj (54.7) with 100% RDF application. This was because of lower number of fruits per cluster in 'Punjab Sartaj' (5-6 fruits/cluster) as compared to 'Heemshikahar' (8-9 fruits/cluster) and 'NS 4266' (8-10 fruits/cluster-data not given).The results showed that cultivars with large sink capacity respond better under increased dose of fertigation.

The single fruit weight was not significantly influenced by fertigation levels during both the years of study (Table 5). Plants applied with 100% RDF recorded maximum single fruit weight 100.8, 99.6 g in 'Punjab Sartaj' and 90.9, 83.9 g in 'Heemshikhar', which was statistically at par with 85% RDF (100.6, 93.2 g and 90.8, 81.2 g) and 70% RDF (87.4, 86.1 and 85.0, 76.1 g) for above said cultivars in respective order during both the years of study. 'NS 4266' recorded fruit weight of 76.0 to 89.7 g which was lower than 'Punjab Sartaj'. Cultivar 'Punjab Sartaj' as well as 'Heemshikahar', per plant fruit yield of tomato increased significantly with increase in nutrient dose from 70 % RDF (4.93, 4.94 kg plant^{-1}) to 85 % RDF (5.44, 5.70 kg plant^{-1}) (Table 5). However, further increase in nutrient dose to 100% RDF (5.45, 6.10 kg plant^{-1}) did not result in significant increase in the fruit yield. Among the two cultivars up to 85% RDF nutrient dose the differences in fruit yield were non-significant. But at 100% RDF application in 'Heemshikahar' resulted in 7.02 per cent increase in fruit yield as compared to negligible increase of 0.2 per cent in 'Punjab Sartaj', indicating better response to higher dose of applied fertilizer in 'Heemshikahar'. It may be attributed to difference in sink capacity of two cultivars as indicated by number of fruits per cluster. During the second year of study, similar results were reported with different fertigation levels in a cultivar. However, among the cultivars maximum fruit yield was recorded in NS '4266' (5.62, 6.20 and 6.68 kg plant^{-1}) at different levels of RDF applied as fertigation. 'Heemshikahar' (4.56, 5.30 and 5.44 kg plant^{-1}) recorded fruit yield statistically at par with 'Punjab Sartaj' at 4.27, 5.30 kg & 5.15 kg plant^{-1} with 100% RDF application as fertigation.

From the above results, it is clear that under Punjab conditions transplanting of tomato in polyhouse should be done in mid September to get higher yield as compared to mid October planted crop. The mid October sown crop attains fruit bearing around Mid December and temperature during that period is quite low, the developed fruits attain large size but do not develop/change colour due to low temperature. While crop planted in mid September it gave first picking by end of November and fruits attain desired colour up to mid-December, only after that period the plants that set flowers and fruit will grow and mature by end of January due to low temperature. During later part of crop season in the months of April & May air temperature inside the polyhouse during the day becomes very high resulting in poor fruit setting in tomato. The night temperature in polyhouse is also high resulting in photorespiration by plants. The fruit size is also very small when temp becomes very high during night.

Table 5. Tomato yield attributes and fruit yield as influenced by fertigation levels and cultivars.

Treatment	Fruit length (cm)		Fruit diameter (cm)		No. of fruits/ Plant		Single fruit weight (g)		Yield (kg/plant)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
T_1	4.81	4.56	5.20	5.05	54.8	54.9	87.4	86.1	4.93	4.27
T_2	4.63	4.50	5.40	5.35	61.1	63.5	85.0	76.1	4.94	4.56
T_3	--	4.58	--	5.00	--	68.3	--	76.4	--	5.62
T_4	4.88	4.73	5.25	5.30	56.2	57.6	100.6	93.2	5.44	4.84
T_5	4.82	4.58	5.50	5.65	68.2	67.6	90.8	81.2	5.70	5.30
T_6	--	4.65	--	5.30	--	72.1	--	86.1	--	6.20
T_7	5.04	4.85	5.25	5.20	57.6	54.7	100.8	99.6	5.45	5.15
T_8	5.02	4.59	5.65	5.65	72.3	70.1	90.9	83.9	6.10	5.44
T_9	--	4.72	--	5.65	--	77.3	--	89.7	--	6.68
$LSD_{(0.05)}$	NS	NS	NS	NS	10.6	6.62	NS	NS	0.51	0.49

*RDF = Nutrient dose recommended for climate controlled polyhouse

Further, it can be concluded from the results that indeterminate tomato cultivars 'Heemshikahar', 'NS 4266' having high sink capacity (8-10 fruit clusters/ plant) and having large fruit number per cluster are good for higher level (100% RDF) of fertigation. The cultivars having low genetic potential ''Punjab Sartaj'' can be applied with less/lower amount of fertilizer dose (85% RDF) thus saving the fertilizer without significant reduction in fruit yield, while high yielding cultivars 'Heemshikahar' or 'NS 4266' could respond well up to 100 RDF dose. Albaho and Mazidi (1) also observed that fruit yield among different cultivars varied from 2.85 to 5.04 kg plant^{-1} in gravel based soilless media.

AUTHORS' CONTRIBUTION

Conceptualization of research (KGS, AS); Designing of experiments (KGS, AS), Contribution of experimental material (KGS, AS); Execution of field experiments and data collection (AS, KGS); Analysis of data and interpretation (AS, KGS); Preparation of Manuscript (AS, KGS).

DECLARATION

The authors do not have conflict of interest.

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REFERENCES

1. Albaho, M. and Mazidi, K.A. 2005. Evaluation of selected tomato cultivars in soilless culture in Kuwait. *Acta Hortic*. **691**:113-16.

2. Baiyeri, K. P. and Mbah, B. N. 2006. Effects of soilless and soil-based nursery media on seedling emergence, growth and response to water stress of African breadfruit (*Treculia africana* Decne). *African J. Biotech*.**5**: 1405-10.

3. Brechner, M. and Both, A.J. 2014. *Hydroponic Lettuce Handbook*. Cornell Controlled Environment Agriculture. Cornell University. http://www.cornellcea.com/ attachments / Cornell CEA Lettuce Handbook.pdf (Accessed 2 December 2014).

4. Barrett, G.E. 2016. Achieving environmentally sustainable growing media for soilless plant cultivation systems – A review *Sci. Hortic.* **212**: 220-34.

5. Luitel, B.P., Adhikari, P. B. ,Yoon, C. S. and Kang, W.H. 2012. Yield and fruit quality of tomato (*Lycopersicon esculentum* Mill.) cultivars established at different planting bed size and growing substrates. *Hortic. Env. Biotech.* **53**: 102-07.

6. Mabokoa, M.M., Du Plooy, C.P. and Bertling I. 2009. Comparative performance of tomato cultivars in soilless vs. In-soil production systems. *Acta Hortic*. 843: 319-26.

7. Massa, D., Incrocci, L., Maggini, R., Carmassi, G., Campiotti, C. A. and Pardossi, A. 2010. Strategies to decrease water drainage and nitrate emission from soilless cultures of greenhouse tomato. *Agric. Water Manage.* **97***:* 971-80.

8. Nejad R. A. and Ismaili A. 2014. Changes in growth, essential oil yield and composition of geranium (*Pelargonium graveolens* L.) as affected by growing media. *J. Sci. Food Agric*. **94**: 905-10

9. Olympios, C.M., 1995. Overview of soilless culture; Advantage, constraints and perspectives for its uses in Mediterranean countries. *Cahies Options Mediterranean*, **31**: 307-24.

10. Parvej, M.R., Khan M.A.H. and Awal, M.A. 2010. Phenological development and production potentials of tomato under polyhouse climate. *J. Agric. Sci*. **5**: 19-31.

11. Pradhan, B. and Deo, B.2019. Soilless farming – the next generation Green Revolution *Curr. Sci.***16**:728-32.

12. Phookan, D.B. and Saikia, S. 2003. Vegetable production under naturally ventilated plastic house cum rain shelter. **In**: Satapathy, K K, Kumar A. (Eds.), *Plasticulture Intervention for Agriculture Development in North Eastern region*, pp.127-142

13. Raviv, M. and Lieth, J. H. 2008. Significance of soilless culture in agriculture. *Soilless Culture*, pp. 1-12.

14. Savvas, D. 2002. Automated replenishment of recycled greenhouse effluents with individual nutrients in hydroponics by means of two alternative models. *Biosyst. Engg.* **83**: 225-36.

15. Van O S E.A. and Benoit, F. 1999. State of art of the Dutch and Belgian greenhouse horticulture and hydroponics. *Acta Hortic*. **481**: 765-67.

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