

## Vegetative growth of tomato hybrids as influenced by fertigation levels grown under different soilless substrates in poly house conditions

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### ABSTRACT

Study was conducted to assess the effect of different NPK fertigation levels on three tomato hybrids *i.e.* Rakshita, Naveen 2000 plus, Avtar 7711 grown in two soilless substrates (vermicompost and cocopeat+vermicompost). Field experiments were laid under naturally ventilated polyhouse for two years *i.e.* 2017 & 2018. Amongst three hybrids tested, Naveen 2000 plus significantly improved the fruit yield with maximum of 1096.7 & 1220.1 kg 100m<sup>-2</sup> followed by 925.4 & 992 kg 100m<sup>-2</sup> in Rakshita with percent increase of 18.51 & 22.99 per cent. However, lowest yield was recorded under Avtar 7711 hybrid. Soilless media of cocopeat+vermicompost provided reliable results with highest fruits plant<sup>-1</sup> (25.7 & 27.4), fruit weight (67.2 & 69.3 g), fruit yield (967.7 & 1056.1 kg 100m<sup>-2</sup>) in 2017 & 2018, respectively. Crop fertigated @30gm<sup>-2</sup> NPK showed significant improvement with maximum fruit yield plant<sup>-1</sup> (1.99 & 2.14 kg plant<sup>-1</sup>) and fruit yield (1105 & 1178.5 kg 100m<sup>-2</sup>). Results also showed that all the variations in growth attributes were comparable in 2018 over 2017. Therefore, study identified the supplementation of NPK @30 gm<sup>-2</sup> to Naveen 2000 plus hybrid grown under cocopeat+vermicompost media as a prominent and promising treatment under polyhouse conditions ensuring significant production potential.

### 1. Introduction

The world's population is expected to reach around 9.6 billion by the 2050, to out accomplish the food demand, the agricultural production must have to be increased by 70 per cent. Improvement in crop production can be achieved by either promoting high yielding varieties or by maximizing the cropping intensity (Shubham *et al.* 2020). In Indian agriculture, vegetables production plays an important major role as it provides food, nutrition and economic security (Natrajan and Kothandaraman, 2018). Tomato (*Solanum lycopersicum* L.) is most consumed among vegetable crops and it belongs to family Solanaceae. It is one of the most important global vegetable crops because of its diversified uses, taste, color and high nutritive values (Rathore *et al.* 2021). It is considered as an important source of vitamin A, C and minerals (Ughade *et al.* 2016). Tomato lacks adaptability to varied environmental conditions as it is a warm season tropical crop. The crop productivity is adversely affected

when grown in open fields since it is subjected to varying temperatures, humidity levels, wind directions etc. (Sanwal *et al.* 2008). Hence the farmers can't opt for the cultivation of input sensitive and highly remunerative cash crops like vegetables. Extreme weather events force farmers to grow only one crop in a year with low levels of productivity. Therefore, in the present scenario of shrinking land holdings, coupled with perceptible changes in weather and climate, protected cultivation has emerged as the best alternative for using land and other resources efficiently.

Fertigation is another important component of protected cultivation in which application of fertilizer is done with irrigation water. In fertigation, nutrient use efficiency could be as high as 90 per cent compared to 40 to 60 per cent in conventional methods. The amount of fertilizer loss through leaching is as low as 10 per cent in fertigation, however, it is 50 per cent in the traditional system (Imamsaheb *et al.* 2011). Long-term application of chemical

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fertilizer in a consecutive monoculture system causes soil acidification or secondary salinization (Cai *et al.* 2015), which contribute strongly to the loss of microbial diversity (Rath and Rousk, 2015; Zhalnina *et al.* 2015). Increased use of chemical fertilisers results in decreased food quality and safety, such as nitrate buildup in vegetable products. (Ye *et al.* 2020) Therefore, the use of chemical fertilizers in combinations with organic manures is helpful for improving soil health and sustaining crop production and soil fertility (Ahamd *et al.* 2015). Besides, fertilizers there are several sources of plant nutrients such as FYM, vermicompost, neem cake, cocopeat and biodynamic manure which has a positive effect on crop production. These organic amendments can be used to improve soil fertility (Luo *et al.* 2018). Vermicompost, a kind of manure has received more attention because of its interesting physiochemical and biochemical properties (Singh and Singh, 2017).

Tomato is an important off-season crop of Himachal Pradesh with a production of 20,300 thousand metric tons in 831 thousand hectares area (Anonymous, 2022). The actual revolution in tomato cultivation has been brought about by hybrid tomato cultivars. Hybrids not only excel in high yield, tolerance to diseases, high adaptability to adverse environment, uniformity of produce and greater plant vigour but also has great potential to counter the challenge of high demand of fresh and processed products. However, there are production limitations restricting its growth, production, and produce quality. Therefore, shielded cultivation is viewed as a substitute for boosting tomato yield with higher fruit quality (Spehia *et al.* 2019). Protected cultivation of high value crops has become irreplaceable both from economic and environment points of view. It offers several advantages to grow high value crops with improved quality even under unfavorable and marginal environments (Kaushal and Singh, 2019). Keeping in view, a study was conducted to assess the effect of different growth media with varying fertigation levels on yield attributes of three different tomato hybrids under polyhouse conditions.

## 2. Materials and Methods

### Experimental Site

The research work was carried out in 2017 & 2018 at University's research and experimental farm, Department of Agronomy, CSK HPKV, Palampur, H.P., India. The region is characterized under the Sub-humid and Sub-tropical mid hill zone of Himachal Pradesh. The experimental site was located at 1250 amsl. Climatically mild summers and cool winters are the major characteristic features of Palampur.

### Experimental Details

For the study, twenty four treatment combinations

were made comprised of three hybrids (Avtar 7711, Rakshita and Naveen 2000 plus) grown under two growing medium (Vermicompost and cocopeat + vermicompost (1:1, v/v) and three levels of fertigation NPK @20, 25, 30 gm<sup>-2</sup>. The NPK content of vermicompost was found in range of 1.84, 1.49 & 1.93 per cent and cocopeat having 0.39, 0.47, 1.12 per cent, respectively. Naturally ventilated polyhouse of dimension 250 m<sup>2</sup> was selected. Mixture of soil less culture *i.e.* cocopeat, perlite and vermiculite were prepared in the ratio of 3:1:1 for nursery raising and seeds were sown in plastic plug trays in first week of February for both years. Seedlings took around 30 days for attaining 2-3 leaf stage suitable for transplantation. Before transplanting, soils were formalin-sterilized completely (1 litre of 40 % formalin + 7 liters of water). Then after, for seven days, black plastic sheets were used to cover the beds. The polyethylene sheet was removed after 7 days followed by soil raking to get rid of the formalin fumes for a week. After soil treatment, raised beds (1.8×1.2 m<sup>2</sup>) were prepared and filled with vermicompost alone and a combination of cocopeat and vermicompost in the growing media after excavating soil surface up to 15 cm depth. Drip system of irrigation was taken as source of irrigation. Plots for different treatments were aligned in factorial randomized block design.

Basal application of NPK through sources urea (21.5 g m<sup>-2</sup>), SSP (62.5 g m<sup>-2</sup>) and MOP (16.5 g m<sup>-2</sup>) were supplied for crop requirement of 100 kg NPK ha<sup>-1</sup>. Remaining doses of NPK were given through fertigation twice a week with Polyfeed (19:19:19) begins with the third week after transplanting and lasts up to 15 days before the final harvest. However, irrigation was maintained at regular basis and standard plant protection measures were also taken to ensure healthy plant stand. Plants were trained to 2 stems and finally nylon strands used as stakes after 30-35 days of transplantation. Data on plant attributes, number of fruits cluster<sup>-1</sup>, number of fruits plant<sup>-1</sup>, fruit weight (g), fruit length (cm), fruit breadth (cm), fruit shape index, fruit yield plant<sup>-1</sup> (kg plant<sup>-1</sup>) and fruit yield (kg 100 m<sup>-2</sup>) were recorded.

## 3. Results

### Number of fruits cluster<sup>-1</sup>

Data from Table 1 revealed that the maximum number of fruits cluster<sup>-1</sup> (5.8 in 2017 & 7.4 in 2018) were recorded under hybrid Naveen 2000 plus and the increase was significantly higher over the other hybrids tested. Moreover, significantly lowered fruits number (4.4 & 6 in 2017 & 2018) were associated with Avtar 7711 hybrid as compared to Rakshita. Crop fertigated with varying levels of fertilizers significantly affected the fruits number for both years of study. cursory glance of the data showed that NPK fertigation level (30 g m<sup>-2</sup>) significantly improved the fruits

number with maximum of 5.6 & 7.7 during study period. Similar response of tomato hybrids was observed by Kaushal *et al.* (2019). However, NPK@25g m<sup>-2</sup> also improved the fruit count with values 4.7 & 6.5 during 2017 & 2018, respectively. Results also showed that the fruit count was significantly increased in 2018 as compared to 2017. Crop grown on cocopeat+ vermicompost fruit production per cluster was highest possible (5.6 & 7 in 2017 & 2018) which was significantly higher than vermicompost. The results are in close proximity with the findings of Spehia *et al.*, 2019. Results showed that cultivation of hybrid Naveen 2000 plus fertigated with 30:30:30 g m<sup>-2</sup> NPK on cocopeat+ vermicompost provided superior and significant results. Higher fruit count in the treatment could be due to healthier plant growth bearing more branches and fruits. Accumulation of higher dry matter might have transformed better conditions for more fruit count. The findings were in close agreement with results of Kumar2009.

#### **Number of fruits plant<sup>-1</sup>**

Data enumerated in Table 1 showed that Naveen 2000 plus significantly improved number of fruits plant<sup>-1</sup> (29.2 & 30.5 in 2017 & 2018) than Rakshita and Avtar 7711. During the study time, the latter two hybrids also varied greatly. However, Avtar 7711 produced significantly lesser number of fruits plant<sup>-1</sup> (20.5 & 22.4 in 2017 and 2018) than Rakshita. Results also showed that crop fertigation with 30g m<sup>-2</sup> NPK attained maximum fruits plant<sup>-1</sup> with values 28 & 29.2 during study years. The per cent increase of 4.28 was found during 2018 over 2017 in fruit number and the results were impressive and encouraging. Moreover, result showed that growing media cocopeat+vermicompost proved itself superior with maximum fruits plant<sup>-1</sup> i.e. 25.7 & 27.4 in 2017 & 2018 and the count was significantly higher if compared to treatment of vermicompost alone. Supplementation of NPK @30 g m<sup>-2</sup> to Naveen 1200 plus hybrid grown under cocopeat+ vermicompost proved itself a significant treatment practice under polyhouse conditions. Improved fruit count plant<sup>-1</sup> under Naveen 2000 plus could be due to availability of essential nutrients which might have induced better vegetative growth with improved metabolism and higher rate of proteins, fats and carbohydrates synthesis. Moreover, the features of cocopeat and vermicompost include enhanced nutrient release capability, increased cation exchange capacity (CEC), better water holding capacity (WHC), soil aeration, low bulk density, ideal pH, and electrical conductivity. Similar response of organic sources on plant growth was reported by Chandra *et al.* 2003, Singh *et al.* 2005, Mishra *et al.* 2004 and Kumar, 2005.

#### **Fruit weight**

Data in Table 1 showed that compared to Rakshita and Avtar, Naveen 2000 plus returned significantly more fruit weight. In 2017 and 2018, Naveen 2000 Plus had a fruit weight increase of 22.1 and 17.98 percent above Rakshita, while the per cent increase over Avtar was 50.28 and 45.66 per cent in 2017 & 2018, respectively. Supplementation of NPK @30 g m<sup>-2</sup> as fertigation showed a significant rise in fruit weight with maximum of 71.1 g in 2017, furthermore the weight was found to be increased to 73.2 g during 2018 which showed 2.95 per cent increase. Fruit weight was comparably higher and significant under NPK @ 25 g m<sup>-2</sup> (66.1 & 68.1 g) over 20g m<sup>-2</sup> NPK treatment for both years. Hybrids grown on cocopeat + vermicompost showed significantly higher fruit weight with values 67.2 and 69.3 g in 2017 & 2018 in comparison to vermicompost treatment. Zhao *et al.* (2019) also found that in soils with 5 and 20 planting years, the tomato yield of the vermicompost treatments was significantly higher than that of chemical fertilizer. Overall results showed that hybrid Naveen 2000 plus fertigated with 30g m<sup>-2</sup> NPK on cocopeat+ vermicompost proved itself a potential cultivar in region with higher fruit weight. Increased rate of fertigation might have facilitated the plant with enough nutritional requirements and ultimately better vegetative growth brought fair fruit weight. The results were in conformity with Chandra *et al.* 2003; Sanwalet *et al.* 2008 and Mazur *et al.* 2012.

#### **Fruit length and breadth**

Data enumerated in Table 1 showed that Naveen 2000 plus hybrid to tomato excelled over the rest hybrids tested with maximum fruit length of 6.3 cm in 2017 and 6.6 cm in 2018 followed by Rakshita (5.9 & 6 cm in 2017 and 2018). Similarly higher fruit breadth was maintained with same treatment hybrid with values of 5.7 & 5.8 cm during study years. Fertigation level of NPK@ 30g m<sup>-2</sup> significantly improved the fruit length and breadth over other levels with a maximum of 6.3 & 6.5 cm fruit length, 6.1 & 6.3 cm breadth during 2017 & 2018, respectively. Highest values of fruit length and breadth were observed when the hybrid Naveen 2000 plus was grown on cocopeat+ vermicompost and fertilized with NPK@ 30g m<sup>-2</sup>. Similar results were observed by Ahirwar and Hussain (2015).

#### **Fruit yield plant<sup>-1</sup>**

Amongst all the various hybrids tested, Naveen 2000 plus recorded maximum fruit yield plant<sup>-1</sup> with significant values of 1.98 & 2.21 kg plant<sup>-1</sup> during 2017 & 2018, respectively (Table 2). Moreover, hybrid Naveen 2000 plus showed a per cent increase of 18.56 & 23.46 per cent over Rakshita and 53.48 & 53.47 per cent over Avtar 7711 on

fruit yield plant<sup>-1</sup> in 2017 and 2018, respectively. Fertilization level of NPK @30g m<sup>-2</sup> returned with highest values of yield of 1.99 and 2.14 kg plant<sup>-1</sup> which was 19.16 & 16.93 per cent, 55.46 & 45.57 per cent higher than NPK levels of 25 & 20 gm<sup>-2</sup>, respectively. Hybrid Naveen 2000 plus grown on cocopeat+ vermicompost returned highest fruit yield per plant over the treatment of vermicompost alone with a per cent increase of 12.25 per cent in 2017 & 11.04 per cent in 2018, respectively. One of the main factors in the greenhouse's increased tomato production is thought to be the fruit yield per plant. Our findings demonstrated that the fruit production per plant shown appreciable variations for growing media over both years.

It is possible to attribute hybrid Naveen 2000 plus's superior performance and higher fruit yield plant<sup>-1</sup> to its greater number of fruits per plant, greater number of fruits per cluster, higher fruit length, and fruit breadth. These factors outweigh hybrid Rakshita and Avtar. Khalid *et al.* 2002; Mishra *et al.* 2004 has also noted a significant difference in fruit output among several hybrids.

#### **Fruit yield 100m<sup>-2</sup>**

Data presented in Table 2 showed that with 1096.7 kg and 1220.1 kg 100m<sup>-2</sup>, Naveen 2000 plus recorded the maximum fruit yield followed by Rakshita hybrid (925.4 kg in 2017 and 992.0 kg 100m<sup>-2</sup>). However, the lowest was associated with Avtar 7711 hybrid with values 717.2 in 2017 and 800.5 kg 100m<sup>-2</sup> in 2018. A highest increase of 52.91 & 52.41 per cent was observed on fruit yield of Naveen 2000 plus over Avtar 7711 during 2017-18, respectively. Amongst the different fertigation levels, maximum fruit yield of 1105 & 1178.5 kg 100m<sup>-2</sup> were registered at NPK @ 30 g m<sup>-2</sup> which was significantly higher than NPK @ 25 and 20 g m<sup>-2</sup>. In 2017, it was discovered that fertigation of NPK @ 30 g m<sup>-2</sup> over NPK @ 25 and 20 g m<sup>-2</sup> increased fruit output by 20.34 and 54.30 percent, respectively. However, in 2018 the increase was 15.75 and 44.42 per cent. The maximum fruit yield for tomatoes planted in cocopeat+ vermicompost (1:1, v/v) was 967.7 and 1056.1kg 100m<sup>-2</sup> in 2017 and 2018, respectively, and was likewise noticeably greater than vermicompost. On per cent basis, treatment of cocopeat+ vermicompost registered an increase of 12.71 per cent in 2017 and 10.91 per cent in 2018 over vermicompost alone. Overall results showed that treatment combination of Naveen 2000 plus grown on cocopeat+vermicompost fertilized @30g m<sup>-2</sup>NPK showed promising results and recorded significantly highest fruit yield among all the different treatment combinations. The corresponding increase in yield and comparatively better performance of hybrid Naveen 2000 plus over hybrid Rakshita and Avtar could be ascribed to more number of fruits per plant, more number of fruits cluster<sup>-1</sup>, fruit yield

plant<sup>-1</sup>, higher fruit length and breadth. Moreover, the soilless growing media (Vermicompost+ cocopeat) tend to improve the soil conditions like improved WHC, CEC, aeration, nutrient availability, infiltration rate. Availability of all the feasible conditions might have increased the overall performance of crop. Similar results on positive interaction of soil conditions on growth have been reported by Kumar, 2005; Mazur *et al.* 2012; Hazarika and Phookan, 2006.

#### **4. Conclusion**

Amongst the hybrids tested, Naveen 2000 plus significantly increased the number of fruits per cluster, number of fruits per plant, fruit weight, fruit length, fruit breadth, fruit shape index, fruit yield per plant and fruit yield over the other hybrids. Fertigation level (NPK @ 30:30:30 gm<sup>-2</sup>) significantly increased yield and yield attributes. Significantly greater yield and yield qualities were seen in plants cultivated in growing media cocopeat:vermicompost (1:1 v/v) than in vermicompost alone. Therefore, study identified the supplementation of NPK @30 g m<sup>-2</sup> to Naveen 2000 plus hybrid grown under cocopeat+vermicompost media as a prominent and promising treatment under polyhouse conditions ensuring significant production potential.

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#### **6. Competing Interests**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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**Table 1.** Effect of different growth media and varying fertigation levels on plant yield attributes of tomato hybrids

Treatments	Number of fruits cluster <sup>-1</sup>		Number of fruits plant <sup>-1</sup>		Fruit length (cm)		Fruit breadth (cm)		Fruit shape index	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Tomato hybrids										
Rakshita	4.6	6.4	24.3	26.2	5.9	6.0	5.3	5.4	1.11	1.13
Naveen 2000 plus	5.8	7.4	29.2	30.5	6.3	6.6	5.7	5.8	1.11	1.14
Avtar (7711)	4.4	6.0	20.5	22.4	4.5	4.8	5.1	5.2	0.88	0.92
SE m ( $\pm$ )	0.1	0.1	0.4	0.4	0.1	0.1	0.1	0.1	0.02	0.02
CD (P=0.05)	0.4	0.4	1.1	1.1	0.3	0.3	0.2	0.2	NS	NS
Fertigation levels										
NPK @ 20: 20: 20 g/m <sup>2</sup>	4.5	6.2	21.0	23.1	4.9	5.1	4.7	4.9	1.04	1.04
NPK @ 25: 25: 25 g/m <sup>2</sup>	4.7	6.5	25.0	26.8	5.5	5.8	5.3	5.2	1.04	1.11
NPK @ 30: 30: 30 g/m <sup>2</sup>	5.6	7.1	28.0	29.2	6.3	6.5	6.1	6.3	1.03	1.03
SE m ( $\pm$ )	0.1	0.1	0.4	0.4	0.1	0.1	0.1	0.1	0.02	0.02
CD (P=0.05)	0.4	0.4	1.1	1.1	0.3	0.3	0.2	0.2	NS	NS

Growing media										
Vermicompost	4.3	6.2	23.6	25.4	5.3	4.9	5.1	5.3	1.04	1.04
Cocopeat+Vermicompost(1:1)	5.6	7.0	25.7	27.4	6.3	5.8	5.8	6.3	1.04	1.08
SE m ( $\pm$ )	0.1	0.1	0.3	0.3	0.1	0.1	0.1	0.1	0.01	0.01
CD (P=0.05)	0.3	0.3	0.9	0.9	0.2	0.1	0.1	0.2	NS	NS

**Table 2.** Effect of different growth media and varying fertigation levels on fruit weight and yield of tomato hybrids

Treatments	Fruit weight (g)		Fruit yield per plant (kg)		Fruit yield (kg/100 m <sup>2</sup> )	
	2017	2018	2017	2018	2017	2018
<b>Tomato hybrids</b>						
Rakshita	65.4	68.4	1.67	1.79	925.4	992.0
Naveen 2000 plus	79.8	80.7	1.98	2.21	1096.7	1220.1
Avtar (7711)	53.1	55.4	1.29	1.44	717.2	800.5
SE m ( $\pm$ )	0.3	0.2	0.02	0.02	12.5	13.3
<b>CD (P=0.05)</b>	<b>0.8</b>	<b>0.7</b>	<b>0.06</b>	<b>0.06</b>	<b>35.9</b>	<b>38.1</b>
Fertigation levels						
NPK @ 20: 20: 20 g/m <sup>2</sup>	61.1	63.1	1.28	1.47	716.1	816.0
NPK @ 25: 25: 25 g/m <sup>2</sup>	66.1	68.1	1.67	1.83	918.2	1018.1
NPK @ 30: 30: 30 g/m <sup>2</sup>	71.1	73.2	1.99	2.14	1105.0	1178.5
SE m ( $\pm$ )	0.3	0.2	0.02	0.02	12.5	13.3
<b>CD (P=0.05)</b>	<b>0.8</b>	<b>0.7</b>	<b>0.06</b>	<b>0.06</b>	<b>35.9</b>	<b>38.1</b>
Growing media						
Vermicompost	65.0	67.0	1.55	1.72	858.5	952.2
Cocopeat+ Vermicompost (1:1)	67.2	69.3	1.74	1.91	967.7	1056.1
SE m ( $\pm$ )	0.2	0.2	0.02	0.02	10.2	10.8
<b>CD (P=0.05)</b>	<b>0.7</b>	<b>0.6</b>	<b>0.05</b>	<b>0.05</b>	<b>29.3</b>	<b>31.1</b>