



Standardisation of Population Density and Training Levels for Maximizing Growth and Yield of Tomato under Protected Conditions

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(Received 2 June, 2016; accepted 4 July, 2016)

ABSTRACT

The present investigation was carried out during kharif 2012 under semi controlled polyhouse at Vegetable Experiment Farm, Division of Vegetable Science, SKUAST-Kashmir, Shalimar. Two indeterminate hybrids of tomato namely Shalimar Tomato Hybrid-1 and Shalimar Tomato Hybrid-2 released by SKUAST-Kashmir were planted at two spacings viz., 60 cm x 30 cm and 60 cm x 45 cm and the three levels of trainings viz. no training, one shoot plant⁻¹ and two shoots plant⁻¹ were followed resulting in twelve treatment combinations. The observations were recorded on various yield and yield attributing traits. Among all the treatment combinations, T₅ i.e., Shalimar Tomato Hybrid-1 with wider spacing of 60 cm x 45 cm and one shoot plant⁻¹ recorded the highest fruit length of 4.98 cm, fruit diameter of 5.67 cm, flesh thickness of 8.83 mm, average fruit weight i.e., 89.36 g and the maximum fruit yield plant⁻¹ viz., 8.13 kg. The highest number of fruits plant⁻¹ was recorded in T₇ i.e., Shalimar Tomato Hybrid-2 + Spacing 60 cm x 30 cm + No training viz., 133. The fruit yield per square meter and fruit yield obtained from a polyhouse was recorded to be highest in treatment combination Shalimar Tomato Hybrid-1 + Spacing 60 cm x 30 cm + One shoot plant⁻¹ viz., 47.100 kg and 35.325 quintals.

Key words: Protected cultivation, spacing, tomato, training

In Kashmir valley, the consumption of tomatoes is very high. Here tomato is grown as a summer crop and the availability of fresh tomatoes is limited to a few months only. Despite its economic importance, growers are not in a position to produce good quality tomatoes with high productivity due to various biotic and abiotic stresses experienced under open field conditions. To obtain higher yields of good quality produce, to increase the longevity of the crop and to enable production during off season, cultivation of tomato hybrids under polyhouses is gaining importance. However the rampant growth under polyhouses makes the crop unmanageable. Hence training of plant and maintaining of plant density are very important in order to check plant growth and optimize plant spacing per unit area for greenhouse cultivation of tomatoes.

So far no work has been done on greenhouse cultivation of tomatoes under Kashmir conditions and its response to varying plant populations. Hence there is an urgent need to assess the optimum plant density for its cultivation in greenhouse under valley conditions. Pruning the plants to a single stem or two stems will not only facilitate easy training operation, but also permit closer planting, early ripening of fruits and get higher yields of larger sized fruits. However, the pruning

methods vary with different growth habits of tomato cultivars and for different plant densities. Keeping all these perspectives under view, an investigation was initiated to find out the suitable plant spacing and optimum training level for harnessing higher yield in tomato under protected conditions.

MATERIALS AND METHODS

The present investigation was carried out during *kharif* 2012 under semi controlled polyhouse (Table1) at Vegetable Experiment Farm, Division of Vegetable Science, SKUAST-Kashmir, Shalimar. Two indeterminate hybrids of tomato namely Shalimar Tomato Hybrid-1 and Shalimar Tomato Hybrid-2 released by SKUAST-Kashmir were planted at two spacings *viz.*, 60 cm x 30 cm and 60 cm x 45 cm and the three levels of trainings *viz.* no training, one shoot plant⁻¹ and two shoots plant⁻¹ were followed resulting in twelve treatment combinations. The observations on various yield and yield attributing traits were recorded from five randomly selected plants from each treatment in every replication at the appropriate time and their average was worked out for the statistical analysis. The data was statistically analyzed using the standard procedure given by Gomez and Gomez (1984).

Table 1: Details about the polyhouse utilized for present investigation

Details	Dimensions (m)	Area (m ²)
Total area	15 x 8	120
Central Path	15 x 1	15
Buffer land and Gaps	15 x 2	30
Land under actual cultivation	15 x 5	75

RESULTS AND DISCUSSION

Effect of hybrids, spacing and training on growth parameters and yield attributing traits has been presented in Table 2. The experimental results of present investigation revealed that the treatment combination T₁₁ *i.e.*, Shalimar Tomato Hybrid-2 with wider spacing 60 cm x 45 cm and training level of one shoot plant⁻¹ produced the maximum plant height *i.e.*, 4.15 m. The increase in plant height in trained plants is due to the fact that pinching of axillary shoots at the time of their emergence diverted the flow of all nutrients and manufactured food material towards the apical growing point that resulted in increased plant height. The pinching of side shoots also led to greater exposure of plants to light resulting in higher photosynthetic activities, as the trained plants were able to present all its leaves before sun. The results are in conformity with the finding of Ibrahim *et al.* (1996) and Thakur *et al.* (2005).

The highest number of nodes plant⁻¹ *i.e.*, 576 was recorded in T₁₀ *viz.*, Shalimar Tomato Hybrid-2 with wider spacing 60 cm x 45 cm and no training and significantly lower number of nodes plant⁻¹ was recorded in Shalimar Tomato Hybrid-2 with closer spacing of 60 cm x 30 cm and plants trained to one shoot plant⁻¹ *viz.*, 81 nodes. The increase in number of nodes plant⁻¹ in control (no training) plants is due to higher number of branches plant⁻¹. In trained plants since the growth is restricted to one shoot plant⁻¹ and the internodal length is increased as compared with no training plants.

Among all the treatment combinations, T₅ *i.e.*, Shalimar Tomato Hybrid-1 with wider spacing of 60 cm x 45 cm and one shoot plant⁻¹ recorded the highest fruit length of 4.98 cm, fruit diameter of 5.67 cm, flesh thickness of 8.83 mm and average fruit weight *i.e.*, 89.36 g. The increased fruit

Table 2: Influence of spacing and training on yield and yield attributing traits of tomato (*Solanum lycopersicum* L.) under protected conditions

S. No	Treatment combinations	Plant height (m)	Number of nodes plant ⁻¹	Fruit length (cm)	Fruit diameter (cm)	Flesh thickness (mm)	Average fruit weight (g)	Number of fruits plant ⁻¹
1.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 30 cm + No Training (T ₁)	2.39	388.66	3.91	4.48	6.30	45.06	125.00
2.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 30 cm + One shoot plant ⁻¹ (T ₂)	3.95	82	4.85	5.52	8.20	82.00	96.00
3.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 30 cm+Two shoots plant ⁻¹ (T ₃)	3.26	125.33	4.42	5.00	6.10	64.86	105.33
4.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 45 cm + No Training (T ₄)	2.48	412	4.27	4.60	7.90	52.60	126.00
5.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 45 cm + One shoot plant ⁻¹ (T ₅)	3.87	82	4.98	5.67	8.83	89.36	93.00
6.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 45 cm+Two shoots plant ⁻¹ (T ₆)	3.33	118	4.28	5.33	8.16	70.73	100.33
7.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 30 cm + No Training (T ₇)	2.99	434	3.50	4.58	6.33	44.86	133.00
8.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 30 cm + One shoot plant ⁻¹ (T ₈)	4.05	81	4.42	5.50	8.43	78.66	84.00
9.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 30 cm+Two shoots plant ⁻¹ (T ₉)	4.11	150	3.94	5.16	6.66	61.80	109.00
10.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 45 cm + No Training (T ₁₀)	3.48	576	3.66	4.50	7.93	50.80	125.00
11.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 45 cm+One shoot plant ⁻¹ (T ₁₁)	4.15	83	4.44	5.45	8.23	84.66	87.00
12.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 45 cm+Two shoots plant ⁻¹ (T ₁₂)	3.94	142	4.14	5.10	8.13	67.46	107.00
C.D.(p<0.05)		0.23	17.68	0.16	0.16	0.55	3.56	12.150

characteristics resulted due to better exposure of plants to light because of training of plants to one shoot, assimilation of more carbohydrates and proteins due to less competition between plants when planted at wider spacing and translocation of more photosynthates from source to sink. Enhanced cell division and cell enlargement might have attributed to increased fruit size. The results are in agreement with the finding of Ahmad and Singh (2005), Thakur *et al.* (2005), Machado *et al.* (2007), Muhammad and Singh (2007b), Ulukap *et al.* (2009) and Azevedo *et al.* (2010). It was also observed that fruit weight increased linearly with increase in inter plant spacing, being maximum at wider spacing. Highest average fruit weight was recorded with wider spacing and one shoot plant⁻¹ due to availability of adequate supply of metabolites to the limited number of fruits, more uptake of nutrients and build up of sufficient photosynthates enabling the increase in fruit size which ultimately results in increased fruit weight.

The highest number of fruits plant⁻¹ was recorded in T₇ i.e., Shalimar Tomato Hybrid-2 + Spacing 60 cm x 30 cm + No training *viz.*, 133 and lowest number of fruits plant⁻¹ *viz.*, 84 was recorded in T₈ *viz.*, Shalimar Tomato Hybrid-2 + Spacing 60 cm x 30 cm + One shoot plant⁻¹. Due to large number of branches and nodes in no training plants, the number of fruits plant⁻¹ also increased. In the present study, it was observed that the treatment combinations with no trained plants recorded significantly higher number of fruits plant⁻¹ followed by those with two shoots plant⁻¹ and one shoot plant⁻¹. These results are in agreement with the findings of Muhammad and Singh (2007a) and Charlo *et al.* (2007). It was also observed that number of fruits plant⁻¹ was higher at closer spacing. The results are in accordance with the finding of Muller and Wamser (2009).

Fruit yield plant⁻¹ is one of the most important factors contributing to total yield per unit area. Improvement in yield of fruits is a deciding factor for the practical utility of adopting different training systems in combination with varying plant population per unit area. Table 3 depicts the effect of spacing and training on fruit yield of tomato (*Solanum lycopersicum* L.) under protected conditions. In the present investigation there was a marked influence of training and spacing on fruit yield plant⁻¹. Plants trained to one shoot plant⁻¹ with wider spacing exhibited the highest fruit yield plant⁻¹. The maximum fruit yield plant⁻¹ viz., 8.13 kg was recorded in T₅ i.e., Shalimar Tomato Hybrid-1 + Spacing 60 cm x 45 cm + One shoot plant⁻¹. This is because pinching of plants and availability of more space has a promotive effect on fruit yield plant⁻¹, due to less competition for nutrients, more assimilation of carbohydrates and proteins and good exposure of plants to light. These results are in tune with the finding of Singh and Kumar (2005) and Mantur and Patil (2008).

Table 3: Influence of spacing and training on yield and yield attributing traits of tomato (*Solanum lycopersicum* L.) under protected conditions

S. No	Treatment combinations	Fruit yield plant ⁻¹ (kg)	Fruit yield m ⁻² (kg)	Fruit yield per polyhouse (q)
1.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 30 cm + No Training (T ₁)	5.560	34.020	25.515
2.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 30 cm + One shoot plant ⁻¹ (T ₂)	7.920	47.100	35.325
3.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 30 cm + Two shoots plant ⁻¹ (T ₃)	6.850	41.520	31.140
4.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 45 cm + No Training (T ₄)	6.500	26.400	19.800
5.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 45 cm + One shoot plant ⁻¹ (T ₅)	8.130	34.116	25.587
6.	Shalimar Tomato Hybrid-1 + Spacing 60 cm x 45 cm + Two shoots plant ⁻¹ (T ₆)	6.850	27.360	20.520
7.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 30 cm + No Training (T ₇)	6.140	38.213	28.660
8.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 30 cm + One shoot plant ⁻¹ (T ₈)	6.700	40.230	30.172
9.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 30 cm + Two shoots plant ⁻¹ (T ₉)	6.740	39.266	29.450
10.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 45 cm + No Training (T ₁₀)	6.475	26.553	19.915
11.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 45 cm + One shoot plant ⁻¹ (T ₁₁)	7.300	30.213	22.660
12.	Shalimar Tomato Hybrid-2 + Spacing 60 cm x 45 cm + Two shoots plant ⁻¹ (T ₁₂)	7.060	29.390	22.040
C.D. (p<0.05)		1.010	3.680	2.76

For efficient utilization of area in protected structures, plant density plays a key role. In present study, the fruit yield per square meter and fruit yield obtained in a polyhouse (with 75 m² net cultivated area) was recorded to be highest in treatment combination i.e., Shalimar Tomato Hybrid-1 + Spacing 60 cm x 30 cm + One shoot plant⁻¹ (T₂) viz., 47.100 kg and 35.325 quintals. The closer spacing accommodated more plants per square meter and one shoot plant⁻¹ trained plants resulted in maximizing fruit size and weight that resulted in higher marketable yields. Similar findings have also been reported by Cruz *et al.* (2003) and Mantur and Patil (2008).

Conclusion: In the present investigation it was found that the treatment combination Shalimar Tomato Hybrid-1 when planted at the spacing of 60 cm x 30 cm and trained to one shoot gave profitable results in terms of yield per square meter and yield per polyhouse as compared with other treatment combinations.

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