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Performance of Tomato (*Solanum lycopersicum* L.) Hybrids for Growth, Yield and Quality Inside Polyhouse under Mid Hill Condition of Uttarakhand

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ABSTRACT

A field experiment was conducted during kharif season 2011-2012 at the Vegetable Research Farm, Department of Vegetable Science, College of Forestry and Hill Agriculture, Hill Campus Ranichauri, Distt. Tehri Garhwal, Uttarakhand. The experiment was arranged in randomized complete block design with three replications and fourteen treatments (each hybrid representing one treatment). Tomato is considered as important and economic agricultural crop all over the world. For improving the yield and yield attributes, hybrids are often produced and evaluated under different growing conditions. In the study, presented morphological (growth and yield parameters) and biochemical properties of fourteen fresh tomato hybrids were evaluated inside polyhouse under mid hill condition of Uttarakhand. The experiment results revealed that hybrid Himraja performed extremely well under polyhouse condition with respect to growth, yield and quality parameters viz., number of flower cluster per plant (8.33), plant height (315.00 cm), fruit set percentage (84.09%), maximum marketable fruit yield per hectare (1046.80 q) and high TSS (7.98°Brix) when compared to all other hybrids. Besides, this hybrid also proved the best with respect to disease resistance and profitability.

Key words: Polyhouse, tomato hybrids, growth, yield and quality

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important members of nightshade family that are widely grown in many countries across the globe. Its origin and domestication started in Andean region of South America and in Mexico from the wild ancestor of *Lycopersicon esculentum* var. *cerasiforme* (Bai and Lindhout, 2007). Earlier, tomato were thought to be poisonous and long before it was considered fit to eat, it was grown only as an ornamental garden plant. Today, it is recognized as important commercial and dietary vegetable crops. Infact, it is the second most widely grown vegetable crop in the world after potato (Hanson *et al.*, 2001). Its cultivation has spread throughout the world occupying an area of 4.62 million ha with an annual production of 128.00 million ton (NHB, 2010). The major tomato growing countries in the world are China, India, USA, Italy, Turkey and Egypt. In India, it occupies an area of 0.63 million ha with an annual production of 12.43 million tones and productivity of 19.50 mt ha⁻¹.

Tomato occupies a prominent position among vegetables due to its export value. The agro-climate conditions of temperate region are well suited for its commercial production. Tomato production technology in greenhouse is not popularized yet in mid hill region of Uttarakhand, where there is a wide scope of expansion and production potential. In mid hill of Uttarakhand, tomato is cultivated as off-season during summer-rainy season when the crop does not grow well in open field due to unfavourable environmental conditions. Hence, there are great potentialities of evaluating different tomato hybrids during summer-rainy season under polyhouse condition. The present investigation was undertaken to study the performance of different tomato hybrids in terms of growth, yield and quality inside polyhouse of mid hill condition of Uttarakhand.

MATERIALS AND METHODS

The trial was conducted at Vegetable Research Block, Department of Vegetable Science, College of Forestry and Hill Agriculture, Hill Campus Ranichauri, Tehri Garhwal, Uttarakhand, India during summer-rainy season of 2011-2012. Fourteen tomato hybrids namely Lakshmi, Rupali, Snehalata, Apoorva, Hill Sona, Raja, No. 7711, Lucky, Jaya (AT-99), PS-61, Himraja and Calyx-111 and two standard check Heemsohna and Manisha were evaluated in the experiment. The experiment was laid out in Randomized Complete Block Design (RBD) with three replications under polyhouse. Raised nursery beds were first prepared and drenched with Captan (0.01%) before sowing the seeds in nursery beds. The seedlings were ready for transplanting after 40 days of sowing.

Land area inside the polyhouse was thoroughly dug to a depth of 20-25 cm, one week prior to planting. Weeds and stubbles were removed completely and the soil was brought to a fine tilth. The crop was raised by applying 20 t ha⁻¹ farm yard manure and 120:100:60 kg ha⁻¹ NPK and seedlings were transplanted at 50×50 cm spacing. Light irrigation was given soon after transplanting. Observation recorded as taken days to first flowering, number of flower clusters per plant, fruit set percentage, plant height, fruit diameter, pericarp thickness, marketable fruit yield per hectare, ascorbic acid, TSS, pH, titratable acidity, disease incidence and economics of five hybrids were recorded from five randomly selected plants in each replication for each hybrid. Regular irrigation, earthing up, fertilization, stacking and crop protection measures were adopted as per package of practices. For evaluation of quality parameters, ripe, firm and uniform tomatoes were taken. Economics of tomato production under polyhouse was also worked out by considering the present price of inputs and produce.

RESULTS AND DISCUSSION

Days taken to first flowering: The data was analyzed statistically, it revealed that the days taken to first flowering of tomato hybrids under greenhouse condition of Uttarakhand (Table 1). The mean number of days from transplanting to first flower initiation varied from 23.16-44.00. Among the different hybrids under study, the hybrid Lakshmi (23.16 days) and Apoorva (28.50 days) were earliest and statistically significant as compared to standard check Heemsohna (32.33 days) and Manisha (39.66 days). On the other hand, hybrids Snehalata, Hill Sona, Heemsohna and Himraja were statistically at par for this character. The earliest and late flowering is attributed as genotypic character and somewhat influenced by environmental factor of particularly growing areas. It is also considered to be economically important trait and therefore, assumes significance in crop improvement programmes since the early flowering hybrids and varieties with high yield are usually sought for the commercial cultivation. Flowering days of

Table 1: Growth and yield characters of different tomato hybrids under polyhouse condition

Hybrids	Days to 1st flowering	No. of flower clusters per plant	Fruit set (%)	Plant height (cm)	Fruit diameter (cm)	Pericarp thickness (cm)	Marketable fruit yield (q ha ⁻¹)
Lakshmi	23.16	7.83	80.50	211.66	4.13	3.10	540.30
Rupali	34.33	6.50	64.80	113.00	3.92	3.40	185.50
Snehalata	33.33	6.00	63.90	108.16	4.65	4.70	189.00
Apoorva	28.50	7.00	76.60	109.00	5.43	5.34	476.21
Hill sona	33.16	6.83	65.93	109.73	3.13	3.76	201.33
Raja	33.66	6.83	60.39	114.73	4.51	3.72	172.55
7711	32.50	7.33	70.90	106.00	4.94	5.89	445.70
Lucky	35.83	7.00	59.60	113.73	4.26	5.72	321.00
Jaya (AT-99)	34.50	6.66	56.52	113.66	4.12	5.26	163.75
PS-61	44.00	6.66	50.65	112.73	3.97	5.16	135.10
Himraja	32.33	8.33	84.09	315.00	4.44	4.26	1046.80
Calyx-111	41.66	7.33	66.30	118.73	4.00	5.37	396.10
Heemsohna (C)	32.33	7.16	58.91	113.33	4.87	4.65	126.77
Manisha (C)	39.66	6.50	65.38	113.73	3.16	4.71	146.33
CD at 5%	2.80	0.90	2.26	5.49	0.26	0.65	36.15
CV (%)	4.89	7.67	2.03	2.44	3.36	8.42	6.37

different varieties ranged from 25.00-30.25 days after transplanting was done by Amarananjundeshwara *et al.* (2008). Similar kind of findings for days to flower initiation on different hybrids of tomato were also reported by Hussain *et al.* (1990).

Number of flower clusters per plant: The differences among the hybrids on number of flower clusters per plant were highly significant (Table 1). The mean value for this trait ranged from 6.00-8.33. The maximum number of flower clusters (8.33) was produced by Himraja, whereas the minimum number of flower clusters (6.00) was produced by Snehalata which was statistically at par with the standard check Manisha (6.50). The varieties/hybrids having the maximum number of flower clusters also produce higher yield due to different genetic makeup of different tomato varieties/hybrids. Almost similar findings were also observed by Wahundeniya *et al.* (2005).

Fruit set percentage: The fruit set percentage was significantly affected by the tomato hybrids. It is evident from Table 1 that the range of fruit set percentage was 50.65-84.09%. Fruit set percentage on tomato hybrids is one of the important parameters for summer and rainy season tomato production which determines the resistance and tolerance of a hybrid to a particular temperature and environment. The highest fruit set (84.09%) was observed in the hybrid Himraja which was significantly higher than all the other hybrids tested in the present investigation. Hybrid PS-61 had the lowest fruit set percentage (50.65%). This finding is in conformity with Pandey *et al.* (2006) who reported the fruit set percentage ranging from 83.1-93.9%. The results revealed that the fruit set percentage was directly related to the fruit yield. Higher the fruit set, more would be the fruit yield.

Plant height: Plant height differed significantly among the hybrids at maturity stage due to varied genetic makeup of different tomato hybrids. The mean value for this trait ranged from 106.00-315.00 cm (Table 1). Among all the tomato hybrids, Himraja recorded maximum plant height of 315.00 cm followed by Lakshmi (211.66 cm) and Calyx-111 (118.73 cm), which were

found statistically significant as compared to standard check Heemsohna (113.33 cm) and Manisha (113.73 cm). The hybrid No. 7711 with mean plant height of 106.00 cm was dwarf among all the hybrids. Plant height is usually a good index of plant vigour, which may contribute towards greater productivity. Variation in height is attributed inherent genetic difference of the hybrids. It confirms the findings of Hazarika and Phookan (2005).

Fruit diameter (cm): The diameter of fruit ranged from 3.16-5.43 cm (Table 1). Maximum fruit diameter was recorded in hybrid Apoorva (5.43 cm) followed by Heemsohna (4.87 cm), while the standard hybrid Manisha had the minimum fruit diameter of 3.16 cm followed by Hill Sona (3.93 cm) and these hybrids were statistically at par with each other. The variation in fruit size in different tomato hybrids reported to inter varietal associated with the genetic makeup of cultivars and governed by the cell size and intercellular space of the flesh. Shaw and Cautliffe (2002), Rehman *et al.* (2000) and Golani *et al.* (2007) also obtained similar observation for fruit size.

Fruit pericarp thickness: The pericarp thickness ranged significantly from 3.10-5.89 cm (Table 1). Hybrid No. 7711 recorded the maximum pericarp thickness (5.89 cm) followed by Apoorva (5.34 cm) and Jaya (5.26 cm), while the minimum pericarp thickness was observed (3.10 cm) in Lakshmi. Variety/hybrid with thick pericarp is suitable for canning. Thick pericarp is a useful character in respect of postharvest handling of fruit during transportation. Since, pericarp cells contain number of starch grain, therefore the cultivars where accumulation of assimilates in the pericarp was more, the thickness was also maximum. Comparison of growth and yield performance among different cultivars of tomato for pericarp thickness was observed by Wahundeniya *et al.* (2005).

Marketable fruit yield: The difference among the hybrids on marketable fruit yield was highly significant. The fruit yield per hectare ranged from 135.10-1046.80 q ha⁻¹ (Table 1). Among all tomato hybrids the maximum fruit yield per hectare was observed in hybrid Himraja (1046.80 q ha⁻¹), which was significantly superior over all the other hybrids followed by Lakshmi (540.50 q ha⁻¹) and Apoorva (476.21 q ha⁻¹). The hybrid PS-61 gave the lowest marketable fruit yield (135.10 q ha⁻¹) followed by check Heemsohna (126.17 q ha⁻¹) and Manisha (146.33 q ha⁻¹). Both these hybrids were statistically at par to each other for fruit yield. The mean fruit yield per hectare found to be highest in hybrid Himraja succeeded by Lakshmi and Apoorva in comparison to check Heemsohna and Manisha due to its good plant growth and quality parameters. Such kind of genetic differences for marketable fruit yield and other plant characters in different tomato genotypes had also been reported by Hussain *et al.* (1990), Hussain *et al.* (2001), Singh *et al.* (2006, 2009) and Mansour *et al.* (2009). These findings suggested that medium sized and large number of fruits per plant will probably produce more yield than the hybrids bearing large sized fruits but few in number.

Ascorbic acid content: The ascorbic acid content varied significantly among all the tomato hybrids. The ascorbic acid content ranged from 12.65-15.63 mg/100 g (Table 2). The hybrid Heemsohna had the highest vitamin C content (15.63 mg/100 g) followed by Calyx-111 (15.05 mg/100 g) and Jaya (AT-99) (15.00 mg/100 g), however, statistically these were at par to each other. Hill Sona had the least, with a value of 12.65 mg/100 g. Because tomato is mainly consumed in the processed form, using cultivars with high vitamin C content is preferable and it

Table 2: Quality parameters and disease incidence of different tomato hybrids under polyhouse condition

Hybrids	Ascorbic acid	TSS	pH of juice	Titrateable acidity	Disease incidence (%)
Lakshmi	14.75	6.50	4.00	0.310	11.25
Rupali	13.20	5.00	3.60	0.623	20.00
Snehalata	14.80	5.33	5.00	0.511	15.00
Apoorva	14.50	5.25	3.56	0.257	13.40
Hill Sona	12.65	5.36	4.10	0.512	28.75
Raja	14.40	5.80	3.90	0.386	30.00
7711	14.86	6.94	4.00	0.588	15.00
Lucky	14.00	7.19	4.50	0.323	20.00
Jaya (AT-99)	15.00	6.65	3.53	0.578	26.25
PS-61	14.15	5.35	3.62	0.593	38.00
Himraja	13.95	7.98	3.50	0.258	5.00
Calyx-111	15.05	6.10	4.00	0.548	17.50
Heemsohna (C)	15.63	4.90	4.50	0.449	35.00
Manisha (C)	14.00	7.50	3.21	0.303	21.00
CD at 5%	0.89	0.59	0.19	0.120	3.54
CV (%)	3.72	5.74	2.92	1.650	11.71

is an important character that determines the nutritious value of tomato hybrids/cultivars. The ascorbic acid contents of the fruits analyzed in this study are in agreement with Bhatt *et al.* (1998).

Total soluble solids: The TSS content varied between 4.90-7.98°Brix (Table 2) was observed in the trial. The maximum total soluble solids were found in hybrid Himraja (7.98°Brix) followed by Manisha (7.50°Brix) and Lucky (7.19°Brix) whereas, the hybrid Heemsohna had the minimum TSS (4.90°Brix) followed by Rupali (5.00°Brix). Total soluble solids content is one of the most important quality parameters in processing tomato cultivars, having higher TSS content are better suited for the preparation of processed products like tomato powder, canned products, ketchup, sauce and chutney. High TSS is desirable to yield higher recovery of processed products. Purkayastha and Mahanta (2011) also reported that the total soluble solids content ranged from 3.60 to 5.40°Brix.

pH of juice: Significant differences were noticed among tomato hybrids for pH content (Table 2). The mean value for this trait ranged from 3.21-5.00. The maximum pH value was found in hybrid Snehalata (5.00) followed by Heemsohna and Lucky (4.50), while the minimum pH value was recorded in hybrid Manisha (3.21) followed by Himraja (3.50) and Jaya (3.53). The hybrid Snehalata was statistically significant as compared to all other hybrids. These values agree with those of Hazarika and Phookan (2005) who reported that pH of the tomato cultivars ranged from 3.56-4.33.

Titrateable acidity: The titrateable acidity of tested hybrids significantly ranged from 0.257-0.623%. The maximum titrateable acidity was observed in hybrid Rupali (0.623%), which was statistically significant as compared to standard check. Whereas, the minimum acidity was found in Apoorva (0.257%) followed by Himraja (0.258%) and Manisha (0.303%), however, these hybrids were statistically at par to each other. These findings related to titrateable acidity are in accordance with the result of Caliman *et al.* (2010).

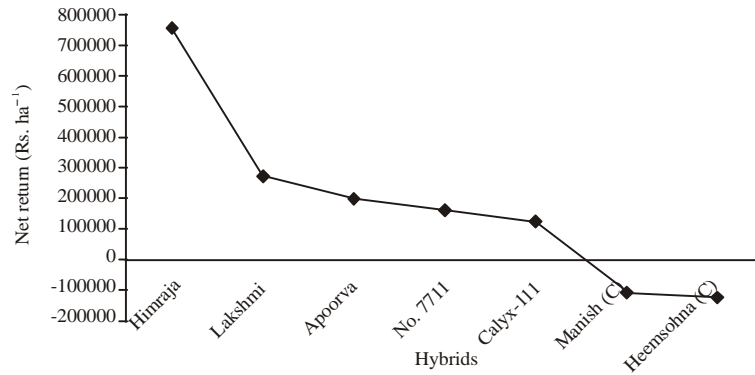


Fig. 1: Net return of best five tomato hybrids including standard check Manisha and Heemshna (Rs. ha⁻¹)

Table 3: Economics of best five tomato hybrids including standard check Manisha and Heemsohna

Hybrids	Cost of cultivation (Rs. ha ⁻¹)	* Gross return (Rs. ha ⁻¹)	Net return (Rs. ha ⁻¹)	B:C
Himraja	3,25,525.00	10,80,000.00	7,54,475.00	3.31
Lakshmi	2,86,525.00	5,60,000.00	2,73,475.00	1.95
Apoorva	2,80,525.00	4,80,000.00	1,99,475.00	1.71
No. 7711	2,77,525.00	4,40,000.00	1,62,475.00	1.58
Calyx-111	2,74,525.00	4,00,000.00	1,25,475.00	1.45
Manisha (C)	2,55,715.00	1,49,200.00	-1,06,515.00	-0.58
Heemsohna (C)	2,54,485.00	1,32,800.00	-1,21,685.00	-0.52

*Selling price of the production: Rs. 1000.00 per quintal

Disease incidence: Evaluation of these hybrids was also done for disease incidence under polyhouse condition and data is presented in Table 2. All the hybrids significantly differed in relation to disease incidence percentage and the mean value for this trait exhibited a range of 5.00-38.00%. Among all the hybrids, Himraja recorded only 5.00% disease incidence followed by Lakshmi (11.25%) and Apoorva (13.40%). These hybrids were statistically significant as compared to standard check Heemsohna (35.00%) and Manisha (21.00%), while the maximum disease incidence was observed in hybrid PS-61 (38.00%). In the present study, Himraja and Lakshmi were found as disease resistant which could be ascribed due to the variation in the genetic makeup of these hybrids. Disease incidence is directly related to the fruit yield. Hybrids which showed less incidence of disease produced higher yield. Similarly, Chellemi *et al.* (1994) studied the performance of tomato hybrids in relation to disease incidence and reported that the incidence of bacterial wilt disease ranged from 0.00-83.00%.

Economics: Economics return from the seven hybrids showed in Table 3 and Fig. 1. Comparative economics revealed that the highest gross return (Rs. 10,80,000.00 ha⁻¹) was from the hybrid Himraja which gave the maximum net return (Rs. 7,54,475.00 ha⁻¹). The highest B-C ratio (3.31) was also obtained in the hybrid Himraja. On the basis of economic return, it is apparent that the hybrid Himraja was more profitable than the standard check Heemsohna and Manisha. Findings of Alam *et al.* (2010) also support the results of present trial.

CONCLUSION

Based on the present findings, it could be concluded that hybrid Himraja, Lakshmi and Apoorva are more suitable for growing commercially inside the polyhouse under mid hill condition of Uttarakhand, as they not only possess the desirable marketable fruit shape, size and colour for fresh consumption but also have high yield potential and resistance to various biotic/abiotic stresses.

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