

Evaluation of Tomato (*Solanum lycopersicum* L.) Hybrids for Morphological and Qualitative Traits under Protected Environment

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ABSTRACT

Ten hybrids of tomato (*Solanum lycopersicum* L.) were obtained from public and private sectors were evaluated to performance of genotype on various characters like Days to flowering, Days to fruiting, Number of cluster per plant and Number of flower per cluster, Number of fruit per cluster, Total number of fruit per plant and Plant height (cm), Fruit length, diameter of fruit, Number of locule per fruit, Pericarp thickness of fruit, Total soluble solids (brix), Standard fruit weight (g), Yield per plant (kg), For qualitative traits fruit shape, Immature fruit color and Mature fruit color, Foliage coverage, Stem pigmentation, pulpiness and plant habits and fruit firmness inside the polyhouse at Department of Agriculture Guru Nanak College, Budhlada during *kharif* 2020-21. The experiment was layout in RBD with three replications. Analysis of variance revealed significant difference among the genotype for all the characters under study, which is representing the survival of

sufficient heritable variation among the genotypes. Days to flowering and days to fruiting were early in the Himshikher and NS 4266 hybrids. Highest fruit length and diameter was exhibit by Abhinav and Himshikher respectively. The highest yield per plant was exhibited by Himshikher, Polyana and Lakshmi in under protected environment.

Keywords Fruit yield, Fruit color, Fruit shape, Mean performance, Polyhouse, Tomato.

INTRODUCTION

The tomato is botanically known as *Lycopersicon esculentum* belongs to the family Solanaceae is being widely cultivated under protected conditions and gives higher profits. The fruits are harvested as red for consumption. It has prominent place in human food. It is native of South America, but is now grown worldwide for its edible fruits with thousands of cultivars have been selected with varying fruit types and for optimal growth in conflicting growth conditions. It is a popular vegetable the entire over the world because of its high nutritive value and rich source of vitamin A and C and eaten as salad and cooked as vegetable.

Tomato is the world's largest vegetable crop after potato and onion. India ranks are second in respect of area and production after china. Specially in India, Madhya Pradesh is leading state in production followed by Karnataka, Andhra Pradesh, Tamil Nadu and Gujarat.

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Protected cultivation is a distinguishing and specific form of agriculture in which the micro climate surrounding the plant is controlled partially or fully, as per the necessity of the plant grown during their growth period. The main objective is to cultivate crops where or else they could not survive by modifying the normal atmosphere to prolong the harvest time often with in advance maturity, increase yield, get better quality and improve the stability of production and create commodities available when there is no outside production. Tomato is a hot season crop and required a comparatively long growing season and fairly high temperature (22-28°C). It ensures that the optimum fruit setting is at night temperature and the optimum range is 15°-20°C. In Haryana and Punjab winter planted crop is most successful one and gives a very high yield, but distributed over a small time span of less than two month. During peak harvesting season there is glut in the market and there price crash, while during rest part of the year it is in short supply and the price rises beyond the reach of common man. Recently, to overcome these environmental conditions and pesticide residue problem protected farming of vegetables, particularly protected cultivation of tomato, brinjal, cucumber and capsicum, lettuce has been recommended by Punjab Agricultural University, Ludhiana, CCS HAU Hissar and state government's bodies.

Protected farming of tomato offers distinguishing advantages of earliness, high productivity and quality mainly chemical residue free produce, moreover higher income to growers. Being an important vegetable crop, research on every aspect of tomato cultivation to improve the productivity becomes essential. India has entered into the area of greenhouse vegetable cultivation more recently only. India being a huge country with different and great agro-climatic conditions, the protected vegetable cultivation technology can be utilized for season and off-season production of high value, low quantity vegetables, production of disease free quality seedlings, quality hybrid seed production and as a device for disease resistance breeding programs (Wani *et al.* 2011). In the current situation of continuous require of vegetables and significantly decrease land holdings in the country, it is the best substitute and labor less approach for using land and other resources more competently. In Punjab and

Haryana, the thrust is now being given for protected cultivation using hybrids. This is so more in the case of tomato, especially indeterminate types. Keeping these in view, the present experiment is undertaken to identify superior and promising tomato hybrids with respect to yield, disease resistance and quality of produce under protected conditions in Guru Nanak College campus Budhlada.

MATERIALS AND METHODS

The current study was conducted in polyhouse at experimental farm Department of Agriculture, Guru Nanak College Budhlada during 2020-21 to identify superior tomato hybrids for polyhouse cultivation. Ten tomato genotypes were obtained from local and private sectors. The seedlings were raised in portrays filled with the potting mixture. The experiment was laid out in Randomized Block Design (RBD) with three replications with spacing 60×60 cm in raised bed transplanting. The polyhouse is provided micro irrigation system with fogger unit to control temperature and humidity. The observation were recorded on the basis of five randomly selected plants from each treatment in each replication and calculate mean value for morphological traits such as Days to flowering, Days to fruiting, Number of cluster per plant and Number of flower per cluster, Number of fruit per cluster, Total number of fruit per plant and plant height (cm), Fruit length and diameter, Number of locule per fruit and Pericarp thickness of fruit, Total soluble solids (brix), Standard fruit weight (g), Yield per plant (kg), For qualitative character fruit shape, Immature fruit color and Mature fruit color, Foliage coverage, Stem pigmentation, pulpiness and plant habits and final fruit firmness. All values of the data were used for further statistical analysis. ANOVA was analyzed as suggested by (Panse and Sukhatme 1985) model.

RESULTS AND DISCUSSION

Analysis of variance revealed that mean sum of squares for all the hybrids were significant (Table 1) for Days to flowering, Days to fruiting, Number of cluster per plant and Number of flower per cluster, Number of fruit per cluster, Total number of fruit per plant and plant height (cm), Fruit length and diameter,

Table 1. ANOVA for 14 morphological traits of 10 genotypes of tomato. *, ** significant at 5% and 1% level, respectively.

Source of variation	DF	Days to flowering	Days to fruiting	No. of cluster/ plant	Number of flower/cluster	Number of fruits/cluster	Total number of fruits/ plants	Plant height
Replication	2	11.03	27.74	3.23	1.95	1.29	31.73	19.59
Treatment	9	213.25**	65.01**	6.01**	3.70**	1.12**	246.91**	3762.08**
Error	18	1.36	4.96	0.20	0.14	0.05	1.60	6.38
Total	29	67.79	25.17	2.21	1.37	0.47	79.81	1172.86

Source of variation	DF	Fruit length	Fruit diameter	Number of locule/fruit	Pericarp thick- ness of fruit	TSS (brix)	Average fruit weight	Yield/plant
Replication	2	0.27	0.080	0.342	0.006	0.075	13.17	0.037
Treatment	9	1.66**	0.952**	0.948**	0.016**	2.382**	129.94**	0.252**
Error	18	0.08	0.128	0.024	0.001	0.013	3.20	0.013
Total	29	0.58	0.380	0.333	0.006	0.753	43.22	0.089

Number of locule per fruit and Pericarp thickness of fruit (mm), Total soluble solids (brix), Average fruit weight (g), Fruit yield per plant (kg), Fruit shape, Immature fruit skin color and Mature fruit skin color, leaf /foliage coverage, Stem pigmentation, pulpiness and plant habits and final fruit firmness which show the sufficient of genetic variability exists in the genotypes. Thus there is profuse scope for selection of promising genotypes. Similar finding were also reported by Hasan *et al.* (2016), Kumar *et al.* (2017) and Panchbhaiya *et al.* (2018).

Morphological character

The mean performance of morphological characters for 10 hybrids of is presented (Table 2). The average performance of diverse genotype shows that the Himshikher (27.67) was most primitive days to flowering while local check (54.50) took maximum days to flowering. The genotype US 3383 (28.43 days) were statistically at average with Himshikher (Sharma and Singh 2015). Genotype Shaktiman (33.87), Abhinav (34.43) and US 1083 (34.43), NS 4266 (33.60) recorded as earliest days as compared to local check. Three genotypes like NS 585 (45.0), Lakshmi (44.23) and Polyana (42.43) observed as late flowering days as followed by Himshikher and US 3383. The early flowering may be due to natural genetic potential, superior growing conditions in the polyhouse which may activate the hormonal activity of plant for flower production.

The early fruiting was observed for Himshikher (78.13 days) followed by local check (92.0) and US 1083 (78.40), US 3383 (83.17). Whereas highest days to first fruiting was recorded in Lakshmi (86.37) and Polyana (86.30) similar results also obtained by Pandey *et al.* (2006), Anuradha *et al.* (2020). Days to early flowering and days to fruiting is very significant for getting fruit thus fetches higher price from market.

The genotypes Himshikher (10.67) and NS 4266 (10.30) exhibited maximum in number of cluster per plant whereas least amount number of cluster per plant was noticed in local check (6.00). Genotypes Polyana (9.30) and US 3383 (8.47) showed maximum number of cluster per plant as compared local check. The least number of cluster per plant recorded in NS 585, Abhinav and Shaktiman as compared to lakshmi and US 1083.

For the character number of flower per cluster and number of fruit per cluster were recorded maximum in genotypes Himshikher and NS 4266 followed by local check. Whereas, genotype Polyana and US3383 were observed highest number of flower per cluster, number of fruit per cluster as compared to NS 585, US 1083 and other hybrids. The variation in these characters may be due to interaction between genetic factor and the environmental conditions (Temperature, light, humidity) and other climatic factors existing in the polyhouse during the growing period.

The number of fruits per plant ranged from min

Table 2. Average performance of 14 morphological characters for 10 genotypes of tomato.

Sl. No.	Hybrids/genotypes	Days to flowering	Days to fruiting	No. of cluster/ plant	No. of flower/ cluster	No. of fruits/ cluster	No. of fruits/ plants	Plant height
1	Himshikher	27.67	78.13	10.67	8.27	4.40	44.33	202.53
2	NS 4266	33.60	81.27	10.30	7.17	3.60	35.80	106.40
3	Polyana	42.43	86.30	9.30	6.40	3.47	30.97	107.47
4	NS-585	45.00	81.27	8.07	6.03	2.83	21.23	99.53
5	US 1083	34.43	78.40	8.33	6.50	2.77	24.00	99.07
6	US 3383	28.43	83.17	8.47	6.90	3.43	25.30	103.97
7	Abhinav	34.43	81.40	6.97	6.00	3.07	19.70	105.67
8	Shaktiman	33.87	76.60	7.67	5.53	2.83	20.20	103.70
9	lakshmi	44.23	86.37	8.33	5.07	2.43	20.53	164.27
10	Local	54.50	92.00	6.00	4.33	2.40	13.53	95.47
	Mean	37.86	82.49	8.41	6.22	3.12	25.56	118.81
	Min	27.67	76.60	6.00	4.33	2.40	13.53	95.47
	Max	54.50	92.00	10.67	8.27	4.40	44.33	202.53
	SE(d)	0.95	1.82	0.36	0.31	0.19	1.03	2.06
	CD at 5%	2.02	3.85	0.77	0.65	0.40	2.19	4.37
	CV%	3.08	2.70	5.28	6.00	7.34	4.95	2.13

Table 2. Continued.

Sl. No.	Hybrids/genotypes	Fruit length	Fruit diameter	No. of locule/ fruit	Pericarp thickness of fruit	TSS (brix)	Av fruit weight	Yield/ plant
1	Himshikher	5.69	5.70	3.23	0.793	5.080	95.40	2.12
2	NS 4266	5.37	4.94	2.70	0.770	4.563	82.43	1.63
3	Polyana	5.30	3.88	2.93	0.687	3.543	74.17	1.96
4	NS-585	4.92	4.78	2.47	0.680	3.153	71.87	1.45
5	US 1083	5.70	5.42	3.80	0.577	3.107	85.40	1.64
6	US 3383	5.68	4.69	2.83	0.590	3.100	77.60	1.27
7	Abhinav	5.98	4.52	2.50	0.583	2.830	83.07	1.24
8	Shaktiman	5.40	4.59	3.70	0.673	2.497	82.37	1.63
9	lakshmi	4.71	4.39	2.29	0.650	2.567	77.73	1.81
10	Local	3.40	4.02	2.17	0.680	2.393	82.83	1.37
	Mean	5.21	4.69	2.86	0.670	3.28	81.29	1.61
	Min	3.40	3.88	2.17	0.580	2.39	71.87	1.24
	Max	5.98	5.70	3.80	0.79	5.08	95.40	2.12
	SE(d)	0.23	0.29	0.13	0.021	0.094	1.46	0.09
	CD at 5%	0.49	0.62	0.27	0.043	0.199	3.10	0.20
	CV%	5.47	7.61	5.42	3.760	3.513	2.20	7.06

13.53 to max 44.33. Genotype Himshikher had higher number of fruit per plant and NS 4266 genotype was statistically at same level with Himshikher. Whereas, lowerest value of fruit per plant was observed in Abhinav hybrid and local check. The increase or decreased in size and weight of fruit influenced number of fruit per plant. Small sized fruit and early fruiting might be tends to produce large number of fruits per plant. Earlier researchers was reported (Prajapati *et al.* 2015, Meena and Bahadur 2015, Kumar and Singh 2016,

Thapa *et al.* 2016, Lekshmi and Celine 2017).

Plant height ranged from 95.47 cm (Local check) to 202.53 (Himshikher) with a mean value of 118.81 cm. The high plant height exhibited by the genotype Himshikher (202.53 cm), lakshmi (164.27cm), as compared to the general mean. The other genotypes were shorter as compared to the general mean. In polyhouse, plant expected lower light intensity which might be assisting in cell elongation and intermodal

Table 3. Performance of qualitative characters of 10 genotypes of tomato.

Hybrids/ genotype	Fruit shape	Immature fruit skin color	Mature fruit skin color	Leaf/ foliage cover	Stem pig- mentation	Fruit firmness	Pulpiness	Plant habit
Himshikher	Flat round	Green	Red	Moderate	Green	Medium	Juicy	Indetermi- nate
NS 4266	Heart	Green	Red	Moderate	Green	Medium	Juicy	Determinate
Polyana	Flat round	Dark green	Dark red	Excellent	Green	Firm	Pulpy	Indeterminate
NS-585	Flat round	Dark green	Red	Moderate	Green	Firm	Juicy	Determinate
US 1083	Flat round	Green	Red	Moderate	Green	Medium	Pulpy	Determinate
US 3383	Oval round	Dark green	Red	Excellent	Green	Firm	Juicy	Semi-determi- nate
Abhinav	Heart	Light green	Dark red	Excellent	Green	Medium	Pulpy	Semi-determi- nate
Shaktiman	Oval	Light green	Dark red	Moderate	Green	Firm	Juicy	Determinate
Lakshmi	Flat round	Green	Red	Excellent	Green	Medium	Juicy	Indeterminate
Local check	Oval	Light green	Red	Moderate	Green	Soft	Pulpy	Determinate

length which show the way to increase plant height. The similar findings was recorded by (Biyyala and Pradeep 2021 and Kanchhi Maya *et al.* 2021).

Fruit length (cm) maximum (5.98) and minimum (3.40) was recorded in Abhinav and local check respectively with an overall mean value of (5.21). The genotypes namely Himshikher (5.69), NS 4266 (5.37), Polyana (5.30) and US 1083 (5.70), US 3383 (5.68) had long fruits whereas, the genotypes Lakshmi (4.71cm) and NS 585 (4.92 cm) were having short fruit also noticed similar deviation for equatorial diameter of fruit. Dissimilarity in fruit shape was may be due to genetic structure of the genotypes (Sharma and Singh 2015).

The highest diameter of fruit was observed in Himshikher (5.70) after that US 1083 (5.42) while Polyana (3.88) indicate was lowest diameter of fruit. The genotypes namely NS 4266 (4.94), NS 585 (4.78) and US 3383 (4.69) exhibited high value as compared the overall mean. The variation in mean value for fruit diameter was 3.88 to 5.70 cm reported by (Dhyani *et al.* 2018 and Biyyala and Pradeep 2021).

The average performance of the character number of locules per fruit was recorded ranged from 2.17 to 3.80. The highest number of locules was observed for genotype US 3383(3.80) as compared Shaktiman (3.70), Himshikher (3.23). Other genotypes exhibited lowest number of locules per fruit as compare local

check except Polyana (2.93). Similar findings was observed by (Dar *et al.* 2012) and (Dhyani *et al.* 2018). For seed production and table (salad) purpose more number of locules per fruit is prefer whereas, for processing purpose less number of locules per fruit is perfect.

Pericarp thickness of fruit is a very important parameter in tomato fruit, as thicker pericarp is desirable for longer shelf life and transportation. Genotype Himshikher indicated higher pericarp thickness (0.793) whereas minor pericarp thickness was recorded in US1083 (0.577). The four genotype namely NS 4266 (0.770), Polyana (0.687) and NS 585 (0.680), Shaktiman (0.673) was showed higher thickness as compared to overall general mean. For transportation of long distance and post harvest handling, thick Pericarp is preferred. Thick Pericarp is also suitable for canning. Similar deviation was observed by (Kanchhi Maya *et al.* 2021).

Higher TSS are a desirable quality attribute for tomato in processing as well as for fresh consumption. Highest Total Soluble Solid was found in Himshikher (5.080⁰B) and NS 4266 (4.563⁰B) as compared other genotypes but showed high brix followed by local check. The differences in total soluble solids were due to variations in genotypes and environmental conditions that prevailed during the growing crop seasons. Similar results was reported by (Meena and Bahadur 2015, Mitul *et al.* 2016, Rai *et al.* 2016,

Prakash *et al.* 2019).

The highest standard fruit weight (g) was observed in Himshikher (95.40) after that US 1083 (85.40) while Polyana (74.17) and NS 585, Lakshmi (77.73) was show the lowest fruit weight as compared overall general mean. The genotypes namely NS 4266 (82.43), Abhinav (83.07) and Shaktiman (82.37), exhibited high fruit weight as compared the overall mean. Fruit weight is inversely related with number of fruit per plant although both of these traits are basic yield contributing characters. Variation in standard fruit weight might be due to relations between genetic factor and environmental conditions survive during flowering stage, fruit set, fruit growth and development stage (Cheema *et al.* 2013, Anuradha *et al.* 2020).

Yield per plant means ranged from 1.24 to 2.12 kg with an overall mean value of 1.61 kg. The significantly highest yield per plant was recorded in hybrid Himshikher (2.12 kg) and Polyana (1.96 kg) as compared to local check (1.37 kg). The genotypes namely NS 4266 (1.63 kg), US1083 (1.64 kg) and Shaktiman (1.63 kg) showed maximum yield per plant as followed by over all general mean and local check. Yield trait depending upon various yield contributing characters such as number of fruit per plant, average fruit weight, number of flower per cluster, number of fruit per cluster and plant height, number of nodes per plant. The atmosphere inside the polyhouse favor early flowering which results in early fruit set and thereby, increase yield per plant. (Dhyani *et al.* 2018, Anuradha *et al.* 2020, Venkadeswaran *et al.* 2020).

Qualitative character

Different type of fruit shape was indicated by the genotype (Table 3) flat round shaped fruit found in five genotypes, three genotypes show oval round, round shaped fruit and two genotype were found heart shaped fruit. Immature fruit skin color, Four genotypes was found in green, Dark green color showed three genotypes and light green skin color show three genotypes. In case of mature fruit skin color cauterized red and dark red color. The seven genotypes including local check was found in red color. Five

genotypes had moderate and four genotypes excellent coverage of leaf and foliage. All the genotypes showed green stem pigmentation. Five genotypes showed medium firmness and four genotype found as firm, local check showed soft firmness in fruit. All the genotype was found juicy type except Polyana, US 1083 and Abhinav, local check also showed pulpy nature fruit. Three genotype was found indeterminate and five genotypes determinate including check and two genotype semideterminante of plant growth habit. The diversity in fruit shaped, fruit color at maturity and pigmentation on stem of tomato hybrids was may be due to variation in their genetic performance and environmental condition in the polyhouse.

CONCLUSION

On the basis of above findings concluded that huge range of genetic variability are present in set of study genetic material. Thus there is profuse scope for selection of promising genotypes. Among the genotypes/hybrids namely, Himshikher and Polyana, Lakshmi were acknowledged for higher yield under protected cultivation.

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