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Assessment of Tomato (*Solanum lycopersicon* L.) Hybrids for Fruit Quality and Yield Characters in the Hill Region of Utttarkhand

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Abstract: ***Twenty two hybrids of tomato were assessed for quality and yield characters at Vegetable Research Block College of Forestry, Ranichauri during summer- rainy season of 2014. In the analysis of variance, a high significant difference was found for almost all the quality characters suggesting a greater chance to explore variability mainly for the charcters viz., dry matter content, ascorbic acid and total soluble solid. Hybrid 'Azad T-6 x NDT-7' has obtained highest mean for dry matter content (12.33%) followed by ascorbic acid content (34.36 mg/100 g) and TSS (10.23^0 Brix) content. Maximum pH was found in hybrid 'CO-3 x Pusa Sadabahar' (6.16) which was significantly superior to the other hybrids. Highest titratable acidity (7.03%) was found in hybrid 'Punjab Chuhara x Pusa Uphar'. Hybrids under study, shows the fruit juice content ranged from 49.22 to 76.72 % with highest percentage recorded by hybrid 'Utkal Kumari x Utkal Uphar' (76.72 ml/100 g). Based on present investigation it may be suggested that hybrids viz. 'Utkal Urwasi x Gujrat Tomato-3', 'CO-3 x Pusa Sadabahar', 'Utkal Urwasi x Palam Pink', 'Azad T-6 x NDT-7' and 'Marglobe x Pusa Sadabahar' were the promising hybrids for producing desirable hybrids in future breeding programmes.***

Keywords: Tomato, *Solanum lycopersicon* L, variability, fruit quality and yield characters

1. Introduction

Tomato **(***Solanum lycopersicon* L.) with chromosome number 2n=24 is one of the most popular and widely grown vegetable in the world. It is popularly known as 'Love Apple'and commonly grown as vegetable in the kitchen and common gardens. It belongs to the family Solanaceae and is originated in a wild form in the Peru-Ecuador Bolivia region of the Andes in South America. Tomato was first introduced in Europe in the middle of sixteenth century and in India, it is introduced during seventeenth century probably by Portuguese (Kalloo, 1991). Tomato flower is normally perfect. There are four to eight flowers in each compound inflorescence. There is a light protective anther cone surrounding the stigma leading to self-pollination. In tomato, anthesis and dehiscence occur between 7.00-8.00 am and 9.00-11.00 am respectively, Pollen fertility is maximum on the day of anthesis and stigma is fully receptivity at 16 hrs before anthesis to the day of anthesis (Sindhu *et al*. 1980). The genetic variation present in the wild species has been investigated intensively for the specific traits and is being exploited in tomato breeding (Larry and Joanne, 2007). Advance in tomato breeding for resistant are due to the incorporation of major resistant genes identified from the *Lycopersicon* species (Rajdan and Mattoo, 2006).

It is a major source of vitamins and minerals perticularly vitamin C (31.0 mg), vitamin A (321 IU), protein (1.98g) moisture (93.1g), minerals (0.6 g), fibre (0.7g), sulphur (24 mg), chlorine (38 mg) and calcium (20 mg) per 100 g fresh weight. The pulp and juice are digestible mild aperients and blood purifier. It has antiseptic properties against intestinal infections.

India is the second largest tomato producing country in the world after China and contributes about 11.5 % to the global tomato production. As per NHB report 2015-16, in India, the tomato is grown in an area of 0.767 m ha with annual production of 16.385 m tonnes and productivity of 21.36 t/ha. Andhra Pradesh, Karnataka, Madhya Pradesh, Telangana and Odisha are the five major tomato growing states of the country (Anonymous, 2015).

The term genetic variability was he defined as 'the occurrence of a high degree of variation differences among individuals due to differences in their genetic composition and of the environment in which they are raised' (Falconer and Mackay 1996). The basic requirement for genetic improvement of a crop is to utilize the available or created genetic variability. In tomatoes, the wild species have a large genetic diversity, especially within the self- incompatible species like *L. chilense* and *L. peruvianum* (Rick, 1998) and the agro- climatic conditions of Uttarakhand hills are known for its variability, uncertainity and extremity. This region is 'hot-spot' of almost all the biotic and abiotic stresses, like early or late onset of mansoon, flush rains, erratic and unevenly distributed rainfall, leaf blight, bacterial wilt, fruit rot, fruit borer etc. With these cultivation of conventional varieties of tomato prone to be uneconomical enterprise. Hybrid have been found to be more suitable for ensured yield under such extreame agro-cological situation of hills. With the view to combat these problems, evaluation of hybrid in rain-fed temperate hills of Uttarakhand is indispensable for boosting the production of tomatoes in the state and such an experiment has been planned to evaluate the available hybrids of tomato for plant growth and quality characters.

2. Material and Methods

In the present investigation, hybrids for fruit yield and quality characters was carried out during the summer-rainy season (March-August 2014) at Vegetable Research Block, VCSG Uttarakhand University of Horticulture and Forestry,

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Ranichauri, Tehri Garhwal in summer rainy season during March-August in 2014. The experiment was laid out in a randomized block design having with 3 replications and 22 treatments. The thirty day old seedlings transplanted from nursery to the field keeping the plant-to-plant and row-to-row distances of 45 and 60cm, respectively. Observations were taken for different quality traits like dry matter content (%), ascorbic acid content (mg/100g), total soluble solid (^{0}Brix), pH, tritrable acidity, specific gravity (g/cm^2), fruit yield per plant (Kg), fruit juice content(ml/100g) from five randomly selected plant. Analysis of variance was calculated for RBD as given by Panse and Sukhatme (1985) for each of the characters separately. Quality characters like ascorbic acid content and titrable acidity was calculated by method given by Ranganna (1986) and Sharma and Nautiyal (2009), respectively.

3. Result and Discussion

The mean values of quality traits and fruit yield were observed, presented in Table 1. Highest mean value of dry matter content was observed in hybrid 'Azad T-6 x NDT-7'(12.33%) which was statistically *at par* with that in hybrid 'Marglobe x Pusa Sadabahar' (11.31%), 'Omnia' (11.26%) and 'Palam Pink x Pusa Sadabahar' (11.23%). Whereas, minimum mean value of dry matter content was recorded in hybrid 'Utkal Urwasi x Palam Pink' (5.36%). On the basis of fruit yield per plant and dry matter content, it could be noticed that the hybrids exhibiting higher fruit yield per plant had lower dry matter proving an inverse relation between these two traits. Comparatively, low dry matter content i.e. 3.7% to 6.15% have been realized by Cheema *et al*. (2013)[3] in tomato hybrids. Another character is ascorbic acid and mean value of ascorbic acid content ranged from 14.74 mg/100g to 34.36 mg/100g. Among the hybrids under study, 'Azad T-6 x NDT-7' possessed significantly higher amount of ascorbic acid content (34.36 mg/100 g). Lowest amount of ascorbic acid content was estimated in hybrid 'Utkal Urwasi x Palam Pink' (14.74 mg/100 g). A comparable results on variability in ascorbic content of tomato hybrids have also been reported by Bhatt *et al.* (2015), Singh *et al.* (2013) ,Shankar *et al*. (2013) and Cheema *et al*. (2013). Total soluble solid is an important character for preparation of processed product e.g. sauces, ketchups, powder and puri. The TSS is an estimate of the degree of dissolved sugars and minerals in fruit juice. About 50 to 65 % of TSS is sugars, glucose and fructose and their amount and proportion influenced the organoleptic quality of tomatoes. Hybrids 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 get higher recovery of processed products. Significant variation in TSS was realized across the hybrids. Maximum TSS was recorded in hybrid 'Azad T-6 x NDT-7' (10.23 ^{0} Brix), which was significantly higher than that occurred in rest of the hybrids. The other hybris with high TSS, 'Punjab Chuhara x Pusa Uphar' (9.40 ^{0}Brix). 'Gujrat Tomato-3 x Pusa Sheetal' and 'CO-3 x Utkal Urwasi' (9.0^0 Brix). Minimum TSS was registered by hybrid 'Utkal Urwasi x Palam Pink' (6.23^{0}Brix). While working on fruit quality characters of different hybrids of tomato, a comparable range of variability in TSS has also been reported by Purkayastha *et al*.(2011) 3.60 to 5.40 ºBrix, Durvesh and Singh (2006), reported that total soluble solids of the fruit ranged from 4.0 to 5.0 ºBrix, These results given by Singh *et al.* (2002) and Ara *et al.* (2009), Sekhar *et al.* (2009) from 3.80 to 5.60^0 Brix, Alam *et al.* (2010) from 3.0 to 4.39^0 Brix, Sharma *et al.* (2013) from 3.22 to 4.70 ^{0} Brix, Singh *et al.* (2013) from 5.60 to 7.53^0 Brix, Shankar *et al.* (2013) from 3.17 to 5.00^0 Brix, Ben *et al.* (2013) from 2.02 to 4.5^0 Brix and Said *et al.* (2014) from 3.6 to 6.4^0 Brix, and by Koutsos *et al.* (1994). Then pH value represents acidity in the fruits of the tomato. The fruit acidity in tomato is a valuable parameter to decide the quality of processed products to be prepared. Different tomato hybrids studied in the present investigation exhibited significant difference for fruit juice pH value. Maximum pH was found in 'CO-3 x Pusa Sadabahar' (6.16) which was significantly higher than that in other hybrids. As lower pH indicates higher acidity, the hybrids with lower fruit pH value should be esteemed. Minimum fruit pH was recorded in 'Gujrat Tomato-3 x Pusa Sheetal' (3.57). The other hybrids with lower fruit pH value were 'Palam Pink x Pusa Sadabahar' (3.98), 'Azad T-6 x NDT-7' (4.02) and 'Utkal Kumari x Utkal Uphar '(4.08). The population mean was 4.32. Comparable results on fruit pH of tomato have also been reported by Wahundeniya *et al.* (2001) from 3 to 4, Dar *et al.* (2012) from 3.41 to 4.45, Koutsos *et al*. (1994) and Hazarika *et al.* (2005) from 3.56 to 4.33. Ben *et al.* (2013) from 4.3 to 4.49 and Singh *et al.* (2014) from 4.90 to 7.98.

Tritratable acidity is quantification of acid content in fruit juice. There was significant difference among the hybrids in relation to titratable acidity. Highest titratable acidity (7.03 %) in 'Punjab Chuhara x Pusa Uphar' was significantly higher than that in the rest of hybrids. The minimum value of titratable acidity was found in 'Utkal Kumari x Utkal Uphar' (0.29 %). The population mean for this trait was noted as 2.21 %. These results were in accordance with those reported by Singh *et al.* (2013) from 0.70 to 0.84, Koutsos *et al.* (1994), Caliman *et al*. (2010), Shankar *et al*. (2013) from 0.27 to 0.77 and Cheema *et al*. (2013) from 0.35 to 0.75.

In addition to TSS, fruit pH, tritratable acidity along with the juice content in the fruits of tomato also decide suitability of the fruits for end use. The fruits with higher juice content are recommended for processing whereas those with low juice content or high pulp content are suitable for fresh consumption and distant transportation. The hybrids under study did not vary in relation to fruit juice content except Pusa Hybrid-1 with minimum value (49.22 %). The fruit juice content ranged from 49.22 to 76.72 %. Highest juice content was recorded in 'Utkal Kumari x Utkal Uphar' (76.72) ml/100 g. The population mean for this character was noted as 71.66 ml/100 g. It indicates that fruits of almost all the hybrids tested were suitable for preparation of processed product like puri, sauces, ketchups, chutney, Canned products and Powder. Comparable range of fruit juice content has also been reported by Sivakumar *et al.* (2002) from 72.26 % to 87.87 % and Huang *et al.* (2013) from 65.3 % to 67.4 % in tomato hybrids.

As far as fruit quality characters are concerned, 'Azad T-6 x NDT-7' contained maximum fruit dry matter content (12.33%), ascorbic acid content (34.36 mg/ 100g) and TSS

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(10.23 °Brix). Fruit pH, tritrable acidity and fruit juice content was highest in 'CO-3 x Pusa Sadabahar' (6.16), 'Punjab Chuhara x Pusa Uphar' (7.03%) and 'Utkal Kumari x Utkal Uphar' (76.72 ml/100g), respectively.

It is also evident from the results that the hybrids exhibiting better performance for fruit yield or its contributing characters were no way related to those promising for fruit quality traits. Therefore, an ideotype hybrid of tomato for fruit quality characters like dry matter content, ascorbic acid content, TSS, fruit juice content and acidity is different to that for fruit yield.

The fruit yield is supposed to be the ultimate economic trait in tomato as well as other fruit vegetables. Fruit yield per plant is an accurate assessment of potentiality of a particular hybrid at individual plant level. However, for a larger area individual plant yield may not lead to the figure which is actually realized. The data on fruit yield per plant exhibited a wide variability among the hybrids evaluated. Highest fruit yield per plant was observed in 'Utkal Urwasi x Gujrat Tomato-3' (6935.08 g) followed by statistically *at par* values in 'S-2 x Utkal Uphar' (6897.33 g) and 'Marglobe x Pusa Sadabahar' (6830.91 g). The F_1S 'VS-2853', 'Himshikhar' and 'Pusa Hybrid-1' exhibited comparatively lower fruit yield per plant *i.e.* 4721.04 g, 4740.49 g and 4787.49 g, respectively. The mean of population for this trait was 5628.84 g. The results indicated that certain hybrids developed from crosses between commercial grown open-pollinated varieties were more heterotic as compared to commercial F_1 hybrids developed by different organizations. The cumulative results of fruit weight, number of fruit per plant and fruit yield per plant proved that the hybrids exhibiting maximum number of fruits per plant 'Utkal Urwasi x Palam Pink' or maximum fruit weight 'Azad T-6 x NDT-7'did not have maximum fruit yield per plant. This was because of the fact that the hybrid with highest number of fruit per plant had lower fruit weight and *vice versa*. The hybrid having highest fruit yield per plant *i.e.* 'Utkal Urwasi x Gujrat Tomato-3' (6935.08 g) had comparatively higher number of fruits per plant (73.25) as well as heavier fruits (94.95 g). Therefore, an ideotype in tomato hybrids should contain number of fruits per plant and fruit weight above certain level for exhibiting higher fruit yield per plant and none of these two important component traits could raise the fruit yield alone. Variability in fruit yield per plant in tomato hybrids have also been reported by Sharma *et al.* (2013) from 681.00 to 1278.19 g, Singh *et al.* (2013) from 1000.36 to 1000.63 g, Saleem *et al.* (2013) from 1000.93 to 3000.72 g, Shankar *et al.* (2013) from 1000 to 3000.90 g. The yield results of present investigation agree with those of Sharma *et al.* (2009), Singh *et al.* (2005), and Satesh *et al.* (2007), who have also reported variation in yield ranging from 125.40 to 414.33 q/ha. Koutsos (1994) reported that there was strong variability among cultivars from year to year particularly in storage of fruit, as the storage in shade or in sun prolonged, all cultivar showed increase in pH or decrease in titrable acidity and in soluble solids.

4. Conclusion

In every concise way, it can be mentioned here that the progeny of the cross combinations *viz.*, 'Utkal Urwasi x Gujrat Tomato-3', 'Utkal Urwasi x Palam Pink', 'Azad T-6 x NDT-7', 'CO-3 x Pusa Sadabahar', 'Punjab Chuhara x Pusa Uphar' and 'Utkal Kumari x Utkal Uphar' proved to be promising for most of the fruit yield and quality characters in temperate hills of Uttarakhand.

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Table 1: Mean performance of tomato hybrids for different Fruit quality characters in open field condition

S.No.	Hybrids	Dry matter content (%)	Ascorbic acid content (mg/100g)	Total soluble solid (˚B)	pH	Tritratable acidity (%)	Fruit juice content (ml/100g)	Fruit Yield Per plant (g)
1.	Gujrat Tomato-3mx Swarna Lalima	9.31	17.29	7.23.	4.17	0.64	70.33	5784.59
2.	Azad T-6x Punjab Chuhara	7.31	19.06	8.90	4.32	1.27	71.72	5815.58
3.	CO-3 X Pusa Sadabahar	8.18	21.94	8.93	6.16	1.91	71.63	6224.77
4.	Azad T-6 X NDT-7	12.33	34.36	10.23	4.02	2.56	75.32	6578.77
5.	Utkal Kumari x Utkal Uphar	8.23	22.07	8.73	4.08	0.29	76.72	4825.53
6.	Pusa Uphar X Utkal Kumari	9.22	22.32	8.46	4.52	3.84	72.85	5281.16
7.	Marglobe x Palam Pink	10.28	15.24	8.00	4.27	4.48	69.10	6115.51
8.	Palam Pink x Pusa Sadabahar	11.23	20.87	8.00	3.98	5.12	73.16	5954.19
9.	Marglobe x Pusa Sadabahar	11.31	16.05	8.96	4.23	5.76	72.88	6855.91
10.	CO-3 X Utkal Urwasi	9.33	24.03	9.00	4.28	6.40	69.32	6017.21
11.	Utkal Urwasi x Gujrat Tomato-3	8.31	17.61	7.23	3.97	0.34	71.83	6935.08
12.	S-2 X Utkal Uphar	9.21	21.27	8.73	4.31	0.87	72.84	6897.33
13.	Utkal Urwasi x Palam Pink	5.36	14.74	6.23	4.25	0.97	73.25	5008.75
14.	Gujrat Tomato-3 x Pusa Sheetal	5.41	16.43	9.00	3.57	3.20	73.25	5310.38
15.	NDT-7 x S-2	5.37	15.26	7.56	4.30	0.99	68.04	5587.90
16.	Punjab Chuhara x Pusa Uphar	10.36	22.51	9.40	4.24	7.03	73.86	5713.04
17.	Abhilash	5.50	20.25	7.30	4.33	0.46	72.36	6075.94
18.	Pusa Hybrid-1	7.13	23.19	7.83	5.40	0.40	49.22	4787.49
19.	Himshikhar	9.13	23.05	7.16	4.08	0.46	75.43	4740.49
20.	Himsona	10.04	20.15	7.69	4.18	0.53	73.64	6130.97
21.	VS- 2853	10.27	23.48	7.69	4.27	0.46	74.53	4721.04

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22.	Omnia	11.26	20.87	8.06	4.18	0.79	75.32	5423.00
	'F'test	**	**	**	**	**	ns	**
	GM	8.864	19.57	8.109	4.325	2.21	71.66	5628.84
	SEM	0.676	0.131	0.253	0.740	.348	4.483	63.205
	CD at 5%	0.193	0.375	0.722	0.211	.995	12.79	180.38
	CV %	1.322	1.163	5.40	2.963	2.72	10.83	1.94

Table 2: Analysis of variance (ANOVA) for quantitative characters in Tomato (*Solanum Lycopersicon* L.)

S. No.	Source of variation	Mean sum of Square		
		Replication	Hybrid	Error
		2	29	58
1.	Fruit yield per plant (g)	6.0	61.0**	7.21
2.	Dry matter content (%)	6.7	9.9**	0.69
3.	Ascorbic acid(mg/100g)	.033	29.8*	.051
4.	Total Soluble Solid (TSS) (˚B)	.05	2.58**	.19
5.	Tritratable acidity (%)	.0043	14.79**	.36
6.	Fruit juice content (ml/100g)	58.33	89.44**	60.30
7.	pH	.032	.81**	.061

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