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Evaluating the yield and quality characters of cherry tomato [*Solanum lycopersicum* (L.) var. *cerasiforme* Mill.] genotypes

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Abstract
An experiment was conducted to evaluate the cherry tomato genotypes for yield and quality traits under shade net condition. The study consisted of 24 cherry tomato genotypes collected from various research institutes across the country were evaluated for mean performance for yield and quality traits. The highest fruit yield plant^{-1} (1572.36 g) and yield hectare^{-1} (31.45 tonnes) were found in genotype LE 1223. The genotype ATL-01-19 recorded the highest fruit firmness (1.65 kg sq. cm^{-1}) followed by LE 1223 (1.21 kg sq. cm^{-1}). Pericarp thickness (2.22 mm) and shelf life (32.50 days) were highest in the genotype LE 1223. The genotypes IIHR 2753 and Pant Cherry Tomato 1 registered the highest for total soluble solids (6.19 °Brix) and total sugars (2.05 mg 100 g^{-1}). The genotype IIHR 2754 registered the lowest ascorbic acid (25.17 mg 100 g^{-1}) while, Pant Cherry Tomato 1 and Pusa Cherry Tomato 1 registered the lowest titrable acidity (0.10 percent). The highest lycopene (8.22 mg 100 g^{-1}) was recorded in the genotype IIHR 2753 whereas IIHR 2754 registered the highest total carotenoids (18.13 mg 100 g^{-1}) and total antioxidant (1.94 µ mol. AA g^{-1}). The highest total phenol content in leaf (0.54 mg 100 g^{-1}) was recorded in the genotype LE 87 and IIHR 2754. The broad phenotypic variability observed in the evaluated genotypes favours the potential selection and breeding of cherry tomato for traits associated with fruit production and quality.

Keywords: Cherry tomato, *Cerasiforme*, evaluation, genotypes, quality and yield

Introduction
Cherry tomato [*Solanum lycopersicum* (L.) var. *cerasiforme* Mill.] is a popular, table purpose tomato with small fruits with a bright red colour resembling a cherry and having an excellent taste (Charlo *et al.,* 2007) [11], which is consumed as fresh vegetable as well as raw material for processed products such as juice, ketchup, sauce, canned fruits, puree, paste and unripe green fruits are used for preparation of pickles and chutney. In addition, cherry tomato is used for the preparation of tomolive and tomatina, which are having more industrial value. Cherry tomato is the probable ancestor of the cultivated tomato; its fruits are consumed more as a fruit rather than as a vegetable. The wild cherry tomato was first found throughout tropical and subtropical America and then propagated in the tropics of Asia and Africa (Gharezi *et al*., 2012) [17]. They are becoming popular in the retail chains and marketed at a premium price compared to regular tomatoes. This is a warm season crop and required long growing periods to reap more harvests and is the most promising crop under protected structures (Vidyadhar *et al.,* 2014) [50]. Cherry tomatoes, one of the promising wild types of *Solanum*, in breeding programs offers great potential because of their valuable characteristics in terms of genetic diversity for selection of parental material and their broad geographic range. Cherry tomato adaptation provides high possibilities for inclusion in breeding programmes, using their valuable characteristics for selecting parents, together with their large geographical diversity (Medina and Lobo, 2001) [30]. In order to produce high quality fruits with enhanced productivity, cherry tomato could be grown under shade houses. The shade net house protects the crop from adverse climatic conditions (Mantur *et al.,* 2014) [28]. From the nutritional point of view, quality is considered to be as an important factor in any vegetable crop. Cherry tomato often called 'salad tomato' and being high content of antioxidant and phytochemical compounds, it is needless to emphasis the importance of quality parameter for fresh and processed produce. Quality parameters in cherry tomato emphasizes on attributes for fresh market and processing.

The cherry tomatoes developed for fresh market and processing should have distinct quality characteristics (Kumar *et al.,* 2014) [24]. Therefore, the aim of the present study is to evaluate the cherry tomato genotypes for yield and quality characters under shade net conditions in order to evaluate their potential for breeding programs.

Materials and Methods

The experiment was conducted during 2016-17 in the university orchard, Department of Vegetable crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. Twenty four cherry tomato genotypes were collected from various research institutes across the country *viz.,* Indian Institute of Horticultural Research, Bengaluru, Indian Agricultural Research Institute, New Delhi, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar and Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in a Randomized Block Design and was replicated thrice. The seeds were sown in the protrays using sterilized and enriched coco-peat as growing media. The main field was prepared to a fine tilth and FYM @ 25 t ha^{-1} was applied at the time of last ploughing. The cherry tomato seedlings were planted on beds in a paired row system under shade net house condition. All the other cultural practices as recommended (Crop production techniques of horticultural crops, 2013) [14] were followed as in tomato. Fruit yield and quality characters were recorded from five plants in each replicated entry selected randomly and were tagged. The quality parameters *viz.*, fruit firmness (Dhatt and Singh, 2004) [16], pericarp thickness, shelf life of fruits (Abound, 1974) [1], total soluble solids, total sugars (Hedge and Hofreiter, 1962) [19], ascorbic acid (Horwitz, 1975) [20], titrable acidity (Horwitz, 1975) [20], lycopene (Ranganna, 1979) [40], total carotenoids (Roy, 1973) [44], total phenol (Bray and Thorpe, 1954) [8] and total antioxidant (Umamaheswari and Chatterjee, 2008) [49] were studied. The estimates of mean, variance and standard error were done as per Panse and Sukhatme (1967) [35].

Results and Discussion

The *per se* performance of cherry tomato genotypes for different traits like yield and quality parameters were presented in Table 1. Genotypes differed significantly among themselves for fruit yield $plant^{-1}$ and was found to be highest in the genotype LE 1223 (1572.36 g) followed by PAV 2373 (1483.76 g), VGT 89 (1350.11 g) and IIHR 2753 (1348.79 g). The genotype VR 35 recorded the lowest fruit yield $plant^{-1}$ of 723.90 g. Totally thirteen genotypes recorded more fruit yield than the grand mean (1073.61 g). The increased yield may be due to the increased major growth and yield contributing characters under shade net house condition. The high yielding potential of any genotype will serve as the good parents for further crop improvement programme. Thus, the present result correlates with the outcomes of Samadia *et al.* (2006), Mehta and Asati (2008), Manna and Paul (2012) and Reddy *et al.* (2013) [45, 31, 27, 42] in tomato and Kumar *et al.* (2014), Prema *et al.* (2011), Silva *et al.* (2011), Ceballos-Aguirre and Vallejo-Cabrera (2012), Renuka *et al.* (2014) and Ramya *et al.* (2016) [24, 36, 46, 10, 43, 38] in cherry tomato. Among the twenty four genotypes of the study, the genotype LE 1223 registered the highest yield $hectare^{-1}$ of 31.45 tonnes followed by PAV 2373 (29.68 tonnes), IIHR 2753 (26.97 tonnes) and LE 13 (26.00 tonnes). The lowest yield $hectare^{-1}$ of 12.25 tonnes was noted in IIHR 2876. Similar results were also observed by Renuka *et al.* (2014) and Ramya *et al.* (2016) [43, 38] in cherry tomato.

Firmness in cherry tomato fruit is an indirect measure of keeping quality after harvest of fruits. Firm fruited types stay well for longer period and fruit firmness decreases as ripening progress. Among the genotypes of cherry tomato, the genotype ATL-01-19 registered the highest fruit firmness (1.65 kg sq. cm^{-1}) followed by LE 1223 (1.21 kg sq. cm^{-1}). The least value of fruit firmness was recorded by LE 315 (0.76 kg sq. cm^{-1}). For shipment, fruits should be smooth and firm enough to withstand transportation Prema *et al.* (2011) [36]. The flesh thickness is determining the fruit shape and firmness. This is probably due to diversion of photo assimilates from the formation of locule walls towards pericarp formation thereby increasing the fruit firmness. Kaur and Cheema (2005) [22] reported that varieties with more fruit firmness in tomato fruits and Prema *et al.* (2011) [36] in cherry tomato fruits. Improvement of pericarp thickness in cherry tomato could help to obtain enhanced shelf life of fruits with quality traits. Pericarp thickness was recorded as the highest in the genotype LE 1223 (2.22 mm) followed by ATL-01-19 (2.16 mm), LE 13 (2.01 mm) and VRCT 155 (2.01 mm) while the genotype IIHR 2876 recorded the least value of pericarp thickness of 1.22 mm. Tomatoes with thicker pericarp would stand for long distance transport and keeps well. The pericarp thickness also important character for more storability which in turn indirectly helps in getting more market price (Bhutani and Kalloo, 1991) [7]. Increased pericarp thickness in cherry tomato also observed by Prema *et al.* (2011), Renuka *et al.* (2014) and Ramya *et al.* (2016) [36, 43, 38] in cherry tomato. However, the very thin pericarp thickness of some genotype may be due to genetic character of particular genotype of small fruited tomato (Kumar *et al.,* 2014) [24]. The firm fruited genotypes generally have longer shelf life due to thicker pericarp. Higher pericarp thickness and firmness also improve the shelf life of fruit Prema *et al.* (2011) [36]. Among the twenty four genotypes, shelf life was the longest in the genotype LE 1223 (32.50 days) followed by ATL-01-19 (31.00 days) and LE 13 (30.50 days) while, the genotype LE 89 reported the least shelf life (23.00 days). Similar results were noted by Olivier (2011) [34] in cherry tomato.

The total soluble solids content is the most important character for processing cherry tomatoes. The flavour of cherry tomato products also depends on the total soluble solids of fruits. Genotypes differed significantly among themselves for total soluble solids. The genotypes IIHR 2753 and Pant Cherry Tomato 1 registered the highest for total soluble solids (6.19 °Brix) followed by LE 1223 as 6.17 °Brix and LE 13 as 6.15 °Brix, while the genotype PAV 2373 recorded the least total soluble solids value of 4.72 °Brix. High total soluble solids and low acidity are the major factors considered for manufacture of processed products. One percent increase in total soluble solids content of fruits results in 20 percent increase in recovery of processed product (Berry *et al.,* 1988) [6]. The Brix values were increased as the colour changed from green to red, may be due to physiological transformation in the genotypes ascribed by David and Philip (2001) [15]. These results were in consonance with the findings of Nu *et al.* (1997), Marquez and Cano (2005), Stommel *et al.* (2005), Juarez-Lopez *et al.* (2009), Macua *et al.* (2009), Kumar *et al.* (2014), Prema *et al.* (2011), Silva *et al.* (2011), Ceballos-Aguirre and Vallejo-Cabrera (2012), Gharezi *et al.* (2012), Kavitha *et al.* (2014), Rai *et al.* (2014), Renuka *et al.* (2014) and Ramya *et al.* (2016) [33, 29, 47, 21, 26, 24, 36, 46, 10, 17, 23, 37, 43, 38] in cherry tomato. The highest total sugars content (2.05

mg 100 g^{-1}) was recorded in the genotypes IIHR 2753 and Pant Cherry Tomato 1 followed by LE 1223 (2.04 mg 100 g^{-1}) and LE 13 (2.03 mg 100 g^{-1}) while, the lowest content was recorded in the genotype PAV 2373 (1.56 mg 100 g^{-1}) and similar results were noted by Al-Aysh *et al.* (2012) [5] in tomato genotypes.

Table 1: *Per se* performance of cherry tomato genotypes for yield and quality characters

Genotypes	Yield plant^{-1} (g)	Yield hectare^{-1} (tonnes)	Fruit firmness (kg sq. cm^{-1})	Pericarp thickness (mm)	Shelf life of fruits (days)	Total soluble solids (°Brix)	Total sugars (mg 100 g^{-1})
ATL-01-19	1296.51	25.93	1.65	2.16	31.00	5.01	1.66
HAT 20	1077.61	21.55	1.18	1.92	30.00	5.08	1.68
LE 13	1300.28	26.00	1.11	2.01	30.50	6.15	2.03
LE 87	1183.50	23.67	1.11	1.68	27.50	5.81	1.92
LE 89	1073.92	21.48	1.13	1.13	23.00	5.35	1.77
LE 315	926.97	18.54	0.76	1.26	23.50	5.66	1.87
LE 338	881.25	17.62	0.90	1.50	27.00	5.28	1.75
LE 598	1055.65	21.11	0.92	1.52	27.00	5.11	1.69
LE 887	945.36	18.91	1.06	1.82	29.50	5.41	1.79
LE 1223	1572.36	31.45	1.21	2.22	32.50	6.17	2.04
PAV 2373	1483.76	29.68	1.06	1.85	29.50	4.72	1.56
VGT 89	1350.11	27.00	1.20	1.78	28.50	5.63	1.86
VGT 90	779.46	15.59	0.81	1.44	24.00	5.04	1.67
VGT 95	957.14	19.14	0.78	1.68	28.50	5.13	1.70
VR 35	723.90	14.48	1.20	1.54	27.50	4.94	1.63
VRCT 17	1265.89	25.32	1.00	1.65	28.00	5.76	1.90
VRCT 155	1148.01	22.96	1.09	2.01	30.00	5.23	1.73
IIHR 2753	1348.79	26.97	1.13	1.52	27.50	6.19	2.05
IIHR 2754	1054.03	21.08	1.19	1.33	24.00	6.01	1.99
IIHR 2871	697.92	13.96	0.80	1.27	24.50	5.87	1.94
IIHR 2873	634.85	12.70	0.87	1.24	24.00	5.79	1.91
IIHR 2876	612.45	12.25	1.03	1.22	24.00	5.64	1.86
Pant Cherry Tomato 1	1183.21	23.67	1.18	1.40	25.00	6.19	2.05
Pusa Cherry Tomato 1	1213.78	24.28	1.09	1.46	24.00	6.07	2.01
Mean	1073.61	21.47	1.06	1.61	27.10	5.55	1.83
SEd	44.389	0.888	0.055	0.070	0.397	0.071	0.023
CD (0.05)	126.178	2.525	0.155	0.198	1.129	0.201	0.065

Table 1: (Continued…)

Genotypes	Ascorbic acid (mg 100 g^{-1})	Titrable acidity (percent)	Lycopene (mg 100 g^{-1})	Total carotenoids (mg 100 g^{-1})	Total phenol (mg 100 g^{-1})	Total antioxidant (µ mol. AA g^{-1})
ATL-01-19	43.85	0.30	5.03	8.12	0.41	0.87
HAT 20	43.97	0.31	5.14	7.92	0.51	0.85
LE 13	28.55	0.15	7.73	10.05	0.53	1.08
LE 87	29.87	0.17	6.15	7.83	0.54	0.84
LE 89	27.18	0.20	6.92	7.49	0.40	0.80
LE 315	36.37	0.12	5.02	7.43	0.51	0.80
LE 338	37.04	0.21	5.19	8.25	0.52	0.88
LE 598	43.22	0.24	5.42	6.74	0.43	0.72
LE 887	28.49	0.23	6.03	9.26	0.46	0.99
LE 1223	28.11	0.11	6.13	7.17	0.51	0.77
PAV 2373	45.19	0.32	4.82	6.77	0.50	0.73
VGT 89	32.85	0.18	6.11	7.67	0.48	0.82
VGT 90	42.10	0.30	6.13	7.22	0.42	0.77
VGT 95	44.09	0.33	6.04	6.48	0.41	0.69
VR 35	44.33	0.34	5.02	7.23	0.53	0.77
VRCT 17	36.07	0.13	3.62	8.10	0.46	0.87
VRCT 155	37.19	0.12	5.60	7.89	0.49	0.85
IIHR 2753	28.45	0.16	8.22	12.88	0.47	1.38
IIHR 2754	25.17	0.16	8.17	18.13	0.54	1.94
IIHR 2871	28.66	0.18	7.02	9.28	0.38	0.99
IIHR 2873	29.18	0.18	6.93	10.13	0.39	1.09
IIHR 2876	29.13	0.18	6.86	9.20	0.37	0.99
Pant Cherry Tomato 1	28.11	0.10	8.18	11.34	0.52	1.22
Pusa Cherry Tomato 1	27.87	0.10	8.16	11.11	0.50	1.19
Mean	34.38	0.20	6.24	8.90	0.47	0.95
SEd	0.549	0.013	0.086	0.139	0.016	0.030
CD (0.05)	1.559	0.037	0.244	0.394	0.046	0.084

Among the 24 genotype used in the study the genotype IIHR 2754 registered the lowest ascorbic acid content (25.17 mg 100 g^{-1}) followed by LE 89 (27.18 mg 100 g^{-1}) and Pusa Cherry Tomato 1 (27.87 mg 100 g^{-1}) while, PAV 2373 recorded highest ascorbic acid content with 45.19 mg 100 g^{-1}. These results were in concurrence with the earlier findings of Juarez-Lopez *et al.* (2009), Adalid *et al.* (2010), Crisanto-Juarez *et al.* (2010), Prema *et al.* (2011), Adalid *et al.* (2012) and Ceballos-Aguirre *et al.* (2012) [21, 3, 13, 36, 4, 9]. The high amount of ascorbic acid and acidity might be due to result of more number of locules which were in agreement with the findings of Manna and Paul (2012) and Rathod (2014) [27, 41]. Among the cherry tomato genotypes evaluated, the genotype Pant Cherry Tomato 1 and Pusa Cherry Tomato 1 registered the lowest titrable acidity (0.10 percent) followed by LE 1223 (0.11 percent) and LE 315 (0.12 percent) while, VR 35 recorded highest titrable acidity content with 0.34 percent. The lower acidity of the fruits grown in the protected environment may be a result of the lower photosynthetic activity of the plant (shading in protected environment) in this environment and lower carbohydrate accumulation in the fruits. The low values of titratable acidity were because of red tomato fruits used for analysis (Rana *et al*., 2014) [39] and same trends has also been observed by Juarez-Lopez *et al.* (2009), Kumar *et al.* (2014), Prema *et al.* (2011), Ceballos-Aguirre and Vallejo-Cabrera (2012), Gharezi *et al.* (2012), Rai *et al.* (2014) and Kavitha *et al.* (2014) [21, 24, 36, 10, 17, 37, 23] in cherry tomato. Lower acidity is the most deciding factor for processing of tomatoes as it reduces heating time required for processing Prema *et al.* (2011) [36].

Lycopene pigment in cherry tomato fruit decides the optimum stage of ripening and also an important criterion for processing. Hence, breeding for high lycopene would also help in developing tomato varieties or hybrids which would improve the general health status of consumers. Lycopene pigment in tomato fruit decides the optimum stage of ripening and also an important criterion for consumed as salad and processing. Recently it has been identified as a nutritional factor because of its antioxidant property. The highest lycopene (8.22 mg 100 g^{-1}) was recorded in the genotype IIHR 2753 followed by Pant Cherry Tomato 1 (8.18 mg 100 g^{-1}) and IIHR 2754 (8.17 mg 100 g^{-1}) while, the lowest content was recorded in the genotype VR 35 (5.02 mg 100 g^{-1}). Kaur and Cheema (2005) [22] reported supportive evidences for present findings. This is in consonance with the experiments conducted by Suchindra *et al.* (2012) [48] in tomato and Stommel *et al.* (2005), Juarez-Lopez *et al.* (2009), Adalid *et al.* (2010), Crisanto-Juarez *et al.* (2010), Ceballos-Aguirre and Vallejo-Cabrera (2012), Ceballos-Aguirre *et al.* (2012), Gharezi *et al.* (2012), Choi *et al.* (2014), Kavitha *et al.* (2014), Rai *et al.* (2014), Renuka *et al.* (2014) and Ramya *et al.* (2016) [47, 21, 3, 13, 10, 9, 17, 12, 23, 37, 43, 38] in cherry tomato. Total Carotenoids content in cherry tomato is nutritionally an important parameter. Utilization of cherry tomato as source of carotene can be exploited very well on industrial level as nutraceutical. From the present investigation, the highest total carotenoids content of 18.13 mg 100 g^{-1} was observed in the genotype IIHR 2754 followed by IIHR 2753 (12.88 mg 100 g^{-1}) and Pant Cherry Tomato 1 (11.34 mg 100 g^{-1}) whereas, the lowest value of 6.48 mg 100 g^{-1} was noted in the genotype VGT 95. The present results were in accordance with the reports of Nadeem *et al.* (2013) and Rathod (2014) [32, 41] in tomato and Stommel *et al.* (2005), Adalid *et al.* (2008), Adalid *et al.* (2010), Adalid *et al.* (2012), Ceballos-Aguirre *et al.* (2012), Kavitha *et al.* (2014) and Rai *et al.* (2014) [47, 2, 3, 4, 9, 23, 37] in cherry tomato.

The highest total phenol content in leaf (0.54 mg 100 g^{-1}) was recorded in the genotype LE 87 and IIHR 2754 followed by LE 13 (0.53 mg 100 g^{-1}) and VR 35 (0.53 mg 100 g^{-1}) and it was low in IIHR 2876 (0.37 mg 100 g^{-1}). Gomathi (2008) in tomato and Olivier (2011) [18, 34] in cherry tomato also confirmed similar results. The highest total antioxidant (1.94 µ mol. AA g^{-1}) was recorded in the genotype IIHR 2754 followed by Pant Cherry Tomato 1 followed by IIHR 2753 (1.38 µ mol. AA g^{-1}) and Pant Cherry Tomato 1 (1.22 µ mol. AA g^{-1}) while, the lowest content was recorded in the genotype LE 598 (0.72 µ mol. AA g^{-1}). This is conformity with the findings of Lenucci *et al.* (2006) [25] in cherry tomato.

Based on *per se* performance of genotypes, it is concluded that the cherry tomato genotypes LE 13, LE 87, LE 1223, VGT 89, IIHR 2753, IIHR 2754, Pant Cherry Tomato 1 and Pusa Cherry Tomato 1 are good performing for various yield and quality characters taken under study. It was considered that these materials could be used as a source of germplasm in breeding programmes of cherry tomato in order to increase the internal quality of fruits. In this perspective, they could be exploited further in different breeding programmes.

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