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Standardization of cherry tomato (*Solanum lycopersicum* var. *cersiforme*) cultivars and training systems under hydroponics

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Abstract
The present experiment was carried out during September 2020 to March 2021 in polyhouse, Nursery (Block 1), ICAR - Central Institute of Subtropical Horticulture (CISH), Lucknow, Uttar Pradesh. The experiment was conducted in Randomized Block Design (RBD), with 18 treatments, replicated thrice with nutrient film technique hydroponic system. The present investigation was carried out to find out the best cultivar (Red Gold, Borgeese, Cherry Tomato Yellow, Nagmoti, Hybrid F1, Red Little Marble) and training system (Single stem training, Double stem training and Natural (no training) growth) under hydroponics. The double stem training system was best for more traits except, days to first flowering, days to 50% flowering, number of flowers per cluster, number of clusters per plant, number of fruits per plant which were best under natural growth. From the present experimental findings, it is found that treatments, Red Little Marvel and Cherry Tomato Yellow with double stem training system was superior in both growth, yield and quality traits.

Keywords: Cherry tomato, nutrient film techniques, training system, hydroponics

Introduction

Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) is a type of table tomato with small fruits belonging to the family solanaceae. It is praised for its sweet taste and high nutritional values (Kobryn and Hallmann, 2005). Cherry tomato contains antioxidant and phytochemical compounds including lycopene, β-carotene, flavonoids (Rosales *et al.*, 2011) and other essential nutrients polysaccharides, oligosaccharides, and fiber (Ilic and Misso, 2012). Due to the high antioxidant properties of lycopene due to these antioxidant properties of lycopene, it can reduce the risk of cancer (Sato *et al*., 2002).

Due to increasing health consciousness, changing food habits, and purchasing power of Indian society demand for cherry tomato has increased in India in metropolitan cities and affluent society areas. It is imported in India on investment of a good amount foreign exchange from China and Thailand throughout our ports like Nhava Sheva sea, Tughlakabad, and Bombay air cargo as dried, dehydrated. In India, cherry tomato is grown under protected cultivation in the geoponic system. The grower faces the problem of nematodes, the microbial build-up for soil-borne diseases (Biebel J. P., 1960), salt accumulation in the root zone, drainage problems resulting in the reduction yield and quality of produce.

Hydroponics may be a motive to solve these problems and make nation Aatmnirbher (self-sufficient) in cherry tomato production. Hydroponics is a method of cultivation practiced in the absence of soil. Here water is allowed to flow through the root zone of the crops. The root of the crops is immersed in the nutrient water. The water contains each and every nutrient according to the need of crops. The essential nutrients are NPK and every crop has its own nutrient needs. If the nutrient levels are not according to the plant's need, it will lead to the malfunction of the crop. Hydroponics may play an important role in order to produce maximum food with efficient input use, and low climatic and insect pest risks. Hydroponic farming has the efficiency to increase the many-fold production by using the roof and defective land with multiple cropping under the adverse climatic situations with minimum external inputs and energy. This technology is highly productive, amenable to automation, conserves water and land under water scarcity, degraded soil, and severe market competition. Though there are a series of deliberations taken place on urban hydroponics under protected cultivation as well as under natural conditions, the testimony of hydroponic techniques still needs to prove under Indian conditions.

Though cherry tomato is a popular hydroponic crop in European nations in India no work has been done for the development of the package of practices for hydroponic cherry tomato production which changed from location to location particularly varieties, plant architect management system, nutrients solution combinations.
Hydroponics falls within the category of soilless cultivation systems. In these systems, the medium contributes to the growth of the crops at a variable rate, and the medium can be made up of substances of various origins and properties (i.e. organic, inorganic, and inert). Hydroponics, in general, provides for high-quality crops while conserving water and fertilizer.
Nutrient Film Technique (NFT) is a hydroponics technique that produces high-quality agricultural products in less time than other systems. The NFT is based on the continuous passage of a nutrient solution through plant roots. By continually feeding mineral elements and water, this operation allows for a shorter culture period and a reduction in hydric stress. A prototype for cherry tomato culture based on the NFT is offered, based on the advantages of hydroponics over standard soil culture.
Monitoring metrics for nutritional solutions include hydrogen concentration (pH), electrical conductivity (EC), and temperature. The ultimate goal is to incorporate the proposed technology into a low-cost, simple, and easy-to-use greenhouse based on soilless cultivation.
Cherry tomato varieties showed distinct responses towards the hydroponic protected cultivation and training systems. Because each and every variety will have its own characters and abilities.
There are no ideal varieties and training systems in cherry tomato hydroponic cultivation in the subtropical region of India. There is a need to identify an ideal variety and suitable training system for higher yield better quality hydroponic cherry tomato cultivation.
It is however necessary to evaluate the real potential of soilless production techniques for the cherry tomato, in relation to yield and to crop management, adapting techniques of hydroponic production to subtropical conditions.
The role of hydroponics is important in the cultivation of cherry tomato. As the data recorded, the production in hydroponic cherry tomato was comparatively higher than the plants in geoponic cultivation in open atmospheric conditions. And the crop is cultivable even in the offseason in the case of hydroponics.

Materials and Methods

The present investigation entitled "Standardization of cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) cultivars and training systems under hydroponics" conducted during the period of September, 2020 to March, 2021 at ICAR-CISH Nursery (Block-1), Central Institute of Subtropical Horticulture, Rehman Khera, Lucknow (Uttar Pradesh). The hydroponic system using NFT (Nutrient Film Technique) was established under the fan pad cooled poly house to study the effect of training systems on yield parameters and quality parameters.
The 18 treatments comprised of six cultivars (Red Gold, Borgeese, Cherry Tomato Yellow, Nagmoti, Hybrid F1 and Red Little Marble) with three types of training system (single stem, double stem and natural (no training) growth) are laid out in a randomized block design which is replicated thrice (Table.1)

Table 1: List of treatments used in present investigation

Treatment	Details
T_1	Red gold trained with single stem
T_2	Red gold trained with double stem
T_3	Red gold with natural growth
T_4	Borgeese trained with single stem
T_5	Borgeese trained with double stem
T_6	Borgeese with natural growth
T_7	Cherry Tomato Yellow trained with single stem
T_8	Cherry Tomato Yellow trained with double stem
T_9	Cherry Tomato Yellow with natural growth
T_{10}	Nagmoti trained with single stem
T_{11}	Nagmoti trained with double stem
T_{12}	Nagmoti with natural growth
T_{13}	Hybrid F1 trained with single stem
T_{14}	Hybrid F1 trained with double stem
T_{15}	Hybrid F1 with natural growth
T_{16}	Red Little Marble trained with single stem
T_{17}	Red Little Marble trained with double stem
T_{18}	Red Little Marble with natural growth

Lucknow is situated on the northern Gangetic plains of India which is the capital city of Uttar Pradesh. The geographical location of Lucknow is between 26.50˚ North and 80.50˚ East. Lucknow is located at an elevation of 123 meters above mean sea level. The total area covered by Lucknow is around 3204 square kilometres. Lucknow has a warm humid subtropical climate with cool, dry winters from December to February and dry, hot summers from April to June. The rainy season is from mid-June to mid-September, when Lucknow gets an average rainfall of 1010 mm mostly from the south-west monsoon winds. In winter the maximum temperature is around 25˚ Celsius and the minimum is in the 6˚ to 8˚ Celsius range. Fog is quite common from late December to late January. Summers are very hot with temperatures rising to the 40˚ to 45˚ Celsius range.
The cherry tomato crop was raised on the installed hydroponics system. The trellising system was established to support the plants. Seedlings were transplanted on Nutrient Film Technique pipe at a spacing of 30 x 20cm with 10 plants in one row. The plant were tied to trellising system with the help of threads. The crop pruning was carried out as per the established procedures. The standard package of practices were followed for raising the crop as per recommendations of the ICAR-CISH. In the Nutrient film technique the system was run throughout the day without any break of nutrient solution was maintained. Data were recorded on plant height, days to first flowering, days to 50% flowering, number of flowers per cluster, number of flowers per plant, number of fruits per cluster, number of bunches per plant, number of fruits per plant, days to first fruit harvest, average fruit weight, bunch weight, fruit weight per plant, fruit weight per structure, fruit length, fruit diameter, total soluble solids, acidity, total sugars and reducing sugars.
The data collected in respect of various parameters on growth, yield and quality attributes were analysed statistically as described by Gomez and Gomez (1984). The critical difference (CD) values were calculated at 5% (p=0.05) probability level where F test was found significant.

Results and Discussion

Growth Parameters

Significant differences were observed among different cultivars for plant height (Table.2). Among the three types of training system, the maximum plant height is recorded in Red

Little Marble with double stem training system (148.95 cm) and the minimum plant height in Nagmoti with natural (no training) growth (65.17 cm). The favourable micro climate inside the polyhouse may have enabled plant growth and development by increasing the rate of plant response to diffused sunlight inside the polyhouse through photosynthesis and respiration, resulting in longer inter nodal length and an increase in plant height growth variables. Similar results were obtained by Farid *et al.* (2021) in cherry tomato, Najeema *et al.* (2019) in cherry tomato, Ghanshyam *et al.* (2018) [6] in capsicum, Salsara *et al.* (2018) in capsicum, Anand *et al.* (2018) [1] in tomato, Sanjeev *et al.* (2018) [20] in capsicum, Renuka *et al.* (2015) [18] and Shukla *et al.* (2011) in capsicum.

Significant differences were observed among different cultivars for days to first flowering (Table.2). Among the three types of training system, the lower number of days to first flowering is recorded in Nagmoti with natural (no training) growth (31.59 days) and the higher number of days in Borgeese with double stem training (46.60 days). Early flowering indicates early fruit formation, which aids in the production of early and high yields. Nagmoti and Red Gold may have an earlier flower initiation due to their increased capacity to provide assimilates to the reproductive site during the sensitive phase before flower initiation, as well as a suitable microclimate inside the polyhouse. Similar results were obtained from the findings of Salsara *et al.* (2018) in capsicum, Parson *et al.* (2018) [17] in tomato, Sanjeev *et al.* (2018) [20] in capsicum, Harmenjeet *et al.* (2017) [7] in tomato and Kiran *et al.* (2014) [10] in cherry tomato.

Significant differences were observed among different cultivars for days for 50% flowering (Table.2). Among the three types of training system, the lower number of days to first flowering is recorded in Nagmoti with natural (no training) growth (37.92 days) and the higher number of days in Borgeese with double stem training (52.94 days). Under polyhouse conditions with ideal light and temperature, these traits are governed by genetic make-up and are least affected by variations in microclimate. The results obtained were in accordance to Ghanshyam *et al.* (2018) [6] in capsicum, Parson *et al.* (2018) [17] in tomato and Kiran *et al.* (2014) [10] in tomato.

Significant differences were observed among different cultivars for number of flowers per cluster (Table.2). Among the three types of training system, the maximum number of flowers per cluster is recorded in Cherry Tomato Yellow with natural (no training) growth (8.40) and the minimum number of flowers per cluster in Borgeese (4.12) with double training system. This variance in flower production per cluster among cherry tomato cultivars could be related to the cultivars inherent genetic potential to generate flowers under regulated environmental conditions. Similar results were obtained by Najeema *et al.* (2018) [14] in cherry tomato and Kiran *et al.* (2014) [10] in cherry tomato.

Significant differences were observed among different cultivars for number of flowers per plant (Table.2). Among the three types of training system, the maximum number of flowers per plant is recorded in Hybrid F1 (30.92) with double stem training and the minimum number of flowers per plant in Borgeese (11.73) with single stem training system. Similar results were obtained from the findings of Renuka *et al.* (2015) [18] in cherry tomato and Nelson *et al.* (2012) [15] in cherry tomato.

Significant differences were observed among different cultivars for number of fruits per cluster (Table.2). Among the three types of training system, the maximum number of fruits per cluster is recorded in Hybrid F1 (8.06) with natural (no training) growth and the minimum number of fruits per cluster in Borgeese (3.93) with single training system. The genetic potentiality of genotypes responding to the favourable micro climate under polyhouse could explain the substantial variance in number of fruits per cluster seen in this study and similar results obtained by Najeema *et al.* (2018) [14] in cherry tomato, Parson *et al.* (2018) [17] in tomato, Renuka *et al.* (2015) [18] in cherry tomato, Kiran *et al.* (2014) [10] in cherry tomato and Nelson *et al.* (2012) [15] in cherry tomato.

Significant differences were observed among different cultivars for number of clusters per plant (Table.2). Among the three types of training system, the maximum number of clusters per plant is recorded in Red Little Marble (4.67) with single stem training and the minimum number of clusters per plant in Cherry Tomato Yellow (2.34) with natural (no training) growth.

Significant differences were observed among different cultivars for number of fruits per plant (Table.2). Among the three types of training system, the maximum number of fruits per plant is recorded in Hybrid F1 (22.73) with natural (no training) growth and the minimum number of fruits per plant in Borgeese (10.60) with double stem training system. The increased fruit set might be due to higher rate of anther dehiscence, higher pollen viability. Similar results obtained by Ghanshyam *et al.* (2018) [6] in capsicum, Salsara *et al.* (2018) in capsicum, Parson *et al.* (2018) [17] in tomato, Sanjeev *et al.* (2018) [20] in capsicum, Shukla *et al.* (2011) in capsicum and Moboko and Du Plooy (2009) [13] in tomato.

Significant differences were observed among different cultivars for days to first fruit harvest (Table.2). Among the three types of training system, the lower number of days to first fruit harvest is recorded in Red Little Marble (73.33 days) under double stem training and the higher number of days in Nagmoti (87.93 days) with single stem training. Earliness can help you get a better price and earn more money. As a result, for commercial growing, early cultivars are usually selected. The early harvest in this experiment could be attributed to the varietal response to the warm growing environment in the polyhouse and early flowering. Late flowering caused the delayed ripening of the fruit. This was conformity with results by Ghanshyam *et al.* (2018) [6] in capsicum, Sanjeev *et al.* (2018) [20] in capsicum, Harmanjeet *et al*. (2017) [7] in tomato and Kiran *et al.* (2014) [10] in cherry tomato.

Significant differences were observed among different cultivars for average fruit weight (Table.3). Among the three types of training system, the maximum average fruit weight is recorded in Red Little Marble (25.55 gm) with single stem training system and the minimum average fruit weight in Nagmoti (9.09 gm) with natural (no training) growth. Average fruit weight contributed directly towards fruit yield per plant. These results are in conformity with those obtained by Leontina *et al.* (2021) in tomato, Najeema *et al.* (2018) [14] in cherry tomato, Parson *et al.* (2018) [17] in tomato, Palolo *et al.* (2017) in mini-tomato, Renuka *et al.* (2015) [18] in cherry tomato, Kiran *et al.* (2015) in cherry tomato, Hesham *et al.* (2013) [8] in cherry tomato and Nelson *et al.* (2012) [15] in cherry tomato. Significant differences were observed among different cultivars for bunch weight (Table.3). Among the three types of training system, the maximum bunch weight is recorded in Red Little Marvel (105.51 gm) with double stem training system and the minimum bunch weight in Nagmoti

(31.33 gm) with natural (no training) growth. These results are in conformity to the findings of Salsara *et al.* (2018) in capsicum.

Significant differences were observed among different cultivars for fruit yield per plant (Table.3). Among the three types of training system, the maximum fruit yield per plant is recorded in Red Little Marble (3.06 kg) with double stem training system and the minimum fruit yield per plant in Nagmoti (0.94 kg) with natural (no training) growth. The largest fruit yield is mostly attributable to the highest number of fruiting clusters per plant and, conversely, the highest fruit weight. This higher yield per plant is due to earlier flowering, a higher number of flower clusters per plant, a higher fruit set percentage, a large number of leaves, higher fruit weight, and taller plants, all of which improve photosynthetic activity and, as a result, yield per plant.

Table 2: Growth parameters of different cultivars and training systems of cherry tomato under hydroponics

Cultivars	Plant Height (cm)	Days to first flowering	Days to 50% flowering	Number of flowers per cluster	Number of flowers per plant	Number of fruits per cluster	Number of bunches per plant	Number of fruits per plant	Days to first fruit harvest
Red gold									
Single stem training	109.70	36.83	43.16	6.32	18.24	5.83	3.68	16.50	82.08
Double stem training	111.75	37.90	44.24	6.04	23.33	5.56	3.79	14.89	81.05
Natural	99.26	35.76	42.09	7.69	15.25	7.54	2.90	22.21	80.27
Borgeese									
Single stem training	111.30	45.49	51.83	3.84	11.73	3.70	2.79	11.03	80.55
Double stem training	104.10	46.60	52.94	4.12	14.04	3.93	3.90	10.60	82.37
Natural	94.03	44.38	50.72	5.52	10.08	5.31	3.01	14.64	79.60
Cherry tomato yellow									
Single stem training	81.40	39.88	46.22	5.42	15.98	4.87	4.12	13.53	82.36
Double stem training	82.54	40.99	47.33	7.08	26.97	6.53	3.20	18.53	83.65
Natural	81.83	38.77	45.11	8.40	15.96	7.85	2.34	22.52	82.86
Nagmoti									
Single stem training	68.30	32.66	39.00	5.20	14.46	5.01	2.93	13.68	87.93
Double stem training	69.21	33.77	40.11	5.95	23.17	5.76	2.38	16.42	85.50
Natural	65.16	31.59	37.92	6.15	11.41	5.97	2.49	16.63	84.74
Hybrid F1									
Single stem training	91.40	40.10	46.22	6.81	19.70	6.62	3.59	19.29	82.41
Double stem training	92.54	41.21	47.55	8.03	30.62	7.51	3.70	21.51	81.35
Natural	81.83	38.99	45.33	7.95	15.17	8.06	3.14	22.73	81.01
Red little marble									
Single stem training	131.57	37.22	43.55	5.69	16.58	4.51	4.67	13.17	73.64
Double stem training	148.95	38.29	44.63	5.00	18.56	4.78	4.44	13.45	73.33
Natural	111.43	36.47	42.81	6.26	11.81	6.07	3.89	17.40	74.55

Table 3: Yield and quality parameters of different cultivars and training systems of cherry tomato under hydroponics

Cultivars	Average fruit weight (gm)	Bunch weight (gm)	Fruit weight per plant (kg)	Fruit weight per structure (kg/m^2)	Fruit length (cm)	Fruit diameter (mm)	Total Soluble Solids (˚Brix)	Acidity (%)	Total Sugars (%)	Reducing Sugars (%)
Red gold										
Single stem training	22.14	77.54	2.32	6.96	3.35	25.03	7.40	0.77	3.99	2.14
Double stem training	17.57	72.88	2.18	6.56	3.43	26.25	8.60	0.68	3.14	1.51
Natural	18.43	68.22	2.04	6.12	4.39	25.01	7.86	0.77	3.05	1.37
Borgeese										
Single stem training	21.84	74.27	2.22	6.67	4.39	32.69	7.23	0.50	2.57	0.97
Double stem training	23.90	82.01	2.45	7.36	4.29	32.84	7.43	0.59	2.53	1.01
Natural	22.57	71.70	2.15	6.44	4.04	31.01	6.40	0.47	2.48	1.02
Cherry tomato yellow										
Single stem training	11.31	57.03	1.70	5.11	2.48	23.55	8.46	0.65	6.03	3.45
Double stem training	12.46	57.93	1.73	5.20	2.14	25.15	10.00	0.73	6.80	3.30
Natural	11.00	56.28	1.68	5.05	1.75	24.88	9.16	0.66	4.08	3.04
Nagmoti										
Single stem training	9.43	32.43	0.97	2.90	2.19	21.20	8.83	0.62	3.15	1.69
Double stem training	10.38	32.52	0.97	2.92	2.19	21.74	8.76	0.62	3.79	1.03
Natural	9.09	31.33	0.94	2.81	2.04	21.82	8.16	0.63	4.11	1.91
Hybrid F1										
Single stem training	12.13	68.04	2.04	6.11	2.58	25.17	5.90	0.54	3.20	1.48
Double stem training	13.55	70.18	2.10	6.29	2.52	25.48	7.20	0.56	3.58	1.52
Natural	11.70	62.37	1.87	5.60	2.75	23.21	5.80	0.52	2.99	1.42
Red little marble										
Single stem training	24.24	92.48	2.77	8.31	4.79	33.61	6.66	0.65	3.79	2.33
Double stem training	25.55	105.51	3.06	9.18	5.29	34.19	7.66	0.60	4.48	1.98
Natural	21.43	91.92	2.75	8.25	4.71	33.71	6.43	0.65	4.34	2.08

Table 4: Analysis of variance of different training systems of cherry tomato under hydroponics

Sl. No.	Parameters	Training System	Mean	C.V.	S.Em (±)	C.D. (5%)
1	Plant Height (cm)	Single stem	98.94	6.79	3.32	10.24*
		Double stem	101.51	7.25	3.64	11.23*
		Natural	88.92	5.23	2.30	7.09*
2	Days to first flowering	Single stem	38.70	6.70	1.28	3.95*
		Double stem	39.79	6.52	1.28	3.96*
		Natural	37.66	7.11	1.32	4.08*
3	Days to 50% flowering	Single stem	45.03	5.93	1.32	4.07*
		Double stem	46.13	5.97	1.32	4.07*
		Natural	44.10	6.25	1.36	4.19*
4	No. of flowers per cluster	Single stem	5.55	17.97	0.49	1.52*
		Double stem	6.04	17.35	0.52	1.60*
		Natural	7.10	19.20	0.67	2.05*
5	No. of flowers per plant	Single stem	16.11	17.98	1.43	4.42*
		Double stem	22.78	20.01	2.26	6.95*
		Natural	13.28	19.60	1.29	3.97*
6	No. of fruits per cluster	Single stem	5.09	18.91	0.48	1.47*
		Double stem	5.68	14.14	0.46	1.46*
		Natural	6.8	12.28	0.48	1.52*
7	No. of bunches per plant	Single stem	3.63	17.60	0.32	0.97*
		Double stem	3.57	17.51	0.31	0.95*
		Natural	2.96	15.24	0.22	0.69*
8	No. of fruits per plant	Single stem	14.53	19.91	1.43	4.41*
		Double stem	15.90	18.69	1.47	4.53*
		Natural	19.35	18.80	1.80	5.55*
9	Days to first fruit harvest	Single stem	81.49	1.76	0.71	2.18*
		Double stem	81.21	1.72	0.69	2.13*
		Natural	80.50	1.35	0.54	1.66*
10.	Average fruit weight (gm)	Single stem	17.23	49.80	4.08	12.86*
		Double stem	16.85	42.77	3.25	10.24*
		Natural	15.70	40.72	2.97	9.36*
11	Bunch weight (gm)	Single stem	66.96	21.64	8.37	26.37*
		Double stem	70.17	19.88	6.90	21.27*
		Natural	63.64	20.79	7.64	24.08*
12	Fruit weight per plant (kg)	Single stem	2.00	21.66	0.25	0.79*
		Double stem	2.08	15.21	0.18	0.58*
		Natural	1.90	20.84	0.23	0.72*
13	Fruit wt. /structure (kg/m^2)	Single stem	6.01	21.66	0.75	2.37*
		Double stem	6.25	15.13	0.55	1.72*
		Natural	5.71	20.84	0.69	2.17*
14	Fruit length (cm)	Single stem	3.30	11.43	0.18	0.57*
		Double stem	3.31	22.76	0.36	1.13*
		Natural	3.28	20.02	0.29	0.93*
15	Fruit diameter (mm)	Single stem	26.87	9.13	1.20	3.77*
		Double stem	27.61	7.31	0.98	3.09*
		Natural	26.61	8.50	1.10	3.47*
16	TSS (˚Brix)	Single stem	7.41	18.86	0.67	2.12*
		Double stem	8.27	13.80	0.55	1.72*
		Natural	7.30	12.19	0.42	1.33*
17	Acidity (%)	Single stem	0.62	22.74	0.07	0.21*
		Double stem	0.63	23.93	0.07	0.23*
		Natural	0.62	19.47	0.06	0.17*
18	Total Sugars (%)	Single stem	3.79	20.93	0.46	1.44*
		Double stem	4.05	14.28	0.33	1.05*
		Natural	3.51	28.11	0.49	1.54*
19	Reducing Sugars (%)	Single stem	2.01	28.80	0.33	1.05*
		Double stem	1.72	29.34	0.29	0.92*
		Natural	1.81	27.86	0.29	0.92*

*Significant at p=0.05

These results are in agreement with the those obtained by Slanter *et al.* (2020) [21] in cherry tomato, Najeema *et al.* (2019) in cherry tomato, Ghanshyam *et al.* (2018) [6] in capsicum, Anand *et al.* (2018) [1] in tomato, Sanjeev *et al.* (2018) [20] in capsicum, Venkadeswaran *et al.* (2018) [23] in cherry tomato, Ohta (2017) [16] in cherry tomato, Palolo *et al.* in (2017) in mini-tomato, Ashit and Mathad (2017) [2] in cherry tomato and Kiran *et al.* (2014) [10] in cherry tomato.

Significant differences were observed among different cultivars for fruit yield per structure (Table.3). Among the three types of training system, the maximum fruit yield per plant is recorded in Red Little Marble (9.18 kg/m^2) with double stem training system and the minimum fruit yield per structure in Nagmoti (2.81 kg/m^2) with natural (no training) growth. This increase in yield per structure could be due to a higher number of fruit clusters per plant, number of fruits per cluster, higher fruit set percentage, and individual fruit weight compared to other genotypes, as well as the development of more efficient chloroplast in leaves triggered by diffused sunlight under polyhouse conditions. The results are similar to the findings of Harmanjeet *et al.* (2017) [7] in tomato and Ashif and Mathad (2017) [2] in cherry tomato.

Significant differences were observed among different cultivars for fruit length (Table.3). Among the three types of training system, the maximum fruit length is recorded in Red Little Marble (5.29 cm) with double stem training system and the minimum fruit length in Cherry Tomato Yellow (1.75 cm) with natural (no training) growth. Highest fruit length of the cultivars is mainly due to their genetic character and the response of these genotypes to acclimatize to the polyhouse conditions. These results are in line with the findings of Leontina *et al.* (2021) in tomato and Kiran *et al.* (2014) [10] in cherry tomato.

Significant differences were observed among different cultivars for fruit diameter (Table.3). Among the three types of training system, the maximum fruit diameter is recorded in Red Little Marble (34.19 mm) with double stem training system and the minimum fruit diameter in Nagmoti (21.00 mm) with natural (no training) growth. Highest fruit diameter of the cultivars is mainly due to their genetic character and the response of these genotypes to acclimatize to the polyhouse conditions. These results are in line with the findings of Leontina *et al.* (2021) in tomato and Palolo *et al.* (2017) in cherry tomato.

Significant differences were observed among different cultivars for total soluble solids (TSS) (Table.3). Among the three types of training system, the maximum TSS is recorded in Cherry Tomato Yellow (10.00˚Brix) with double stem training system and the minimum TSS in Hybrid F1 (5.80˚Brix) with natural (no training) growth. A higher total soluble solids content was observed in plants grown with double stem training, suggesting that the smaller size of the fruits in the treatments trained with two stems contributed to the increase in soluble solids, due to their concentration in fruits. These results were similar to the findings of Leontina *et al.* (2021) in tomato, Farid *et al.* (2021) in cherry tomato, Chandni *et al.* (2020) [4] in cherry tomato, Najeema *et al.* (2018) [14] in cherry tomato, Palolo *et al.* (2017) in mini-tomato, Kiran *et al.* (2014) [10] in cherry tomato, Bhattarai *et al.* (2013) [3] in cherry tomato, Hesham *et al.* (2013) [8] in cherry tomato, Nelson *et al.* (2012) [15] in cherry tomato and Maboko *et al.* (2017) [2] in cherry tomato.

Significant differences were observed among different cultivars for acidity (Table.3). Among the three types of training system, the maximum acidity is recorded in Red Gold (0.77%) with single stem training system and the minimum acidity in Hybrid F1 (0.52%) with natural (no training) growth. Similar results were obtained from the findings of Christos *et al.* (2021) [5] in tomato, Chandni *et al.* (2020) [4] in cherry tomato and Hesham *et al.* (2018) [8] in cherry tomato.

Significant differences were observed among different cultivars for total sugars (Table. 3). Among the three types of training system, the maximum total sugars is recorded in Cherry Tomato Yellow (6.80%) with single stem training system and the minimum total sugars in Borgeese (2.48%) with natural (no training) growth. The greater sugar concentration could be owing to increased photosynthetic activity under protected conditions, resulting in the storage of more sugars. Increased photosynthetic activity in the polyhouse would boost sucrose synthesis, affecting glucose and fructose accumulation in the fruits and resulting in higher TSS. The results are similar to the findings of Chandni *et al.* (2020) [4] in cherry tomato and Venkadeswaran *et al.* (2018) [23] in cherry tomato.

Significant differences were observed among different cultivars for reducing sugars (Table.3). Among the three types of training system, the reducing total sugars is recorded in Cherry Tomato Yellow (3.45%) with single stem training system and the minimum reducing sugars in Borgeese (0.97%) with single stem training system. Similar results obtained from findings of Chandni *et al.* (2020) [4] in cherry tomato.

Conclusion

In this study, Red Little Marble was found superior among the cultivars and recorded the maximum plant height (148.95 cm), days to first fruit harvest (73.33 days), average fruit weight (25.55 gm), bunch weight (105.51 gm), fruit yield per plot (3.06 kg), fruit yield per structure (9.13 kg/m^2), fruit length (5.29 cm) and fruit diameter (34.19 mm). On the other hand, the cultivar, Cherry Tomato Yellow recorded maximum number of flowers per cluster (8.40), number of flowers per plant (26.95), number of fruits per cluster (7.85) and number of fruits per plant (22.52) while Nagmoti had the maximum days to first flowering (31.59 days), days to 50% flowering (37.92 days), TSS (10.00˚Brix), acidity (0.75%), total sugars (6.80%) and reducing sugars (3.45%). In terms of training system, the cultivars trained with double stem training exhibited the superior traits such as plant height, number of flowers per plant, days to first fruit harvest, average fruit weight, bunch weight, fruit yield per plant, fruit yield per structure, fruit length, fruit diameter, TSS, acidity, total sugars and reducing sugars. From the study it is concluded that the cultivars Red Little Marble and Cherry Tomato Yellow with double stem training system was found superior for growth, yield and quality traits under hydroponics.

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