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Evaluation of Cherry Tomato Genotypes for Qualitative Traits under Open Field and Protected Condition

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Authors' contributions

This work was carried out in collaboration among all authors. Author Chandni performed the statistical analysis and wrote the protocol and first draft of the manuscript. Author DS performed final correction of the drafted manuscript for correspondence. Author SA designed the program and analyzed the study. Author SSM helped in analysis of the biochemical parameters. All authors read and approved the final manuscript.

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ABSTRACT

Vegetable, due to higher neutraceutical component, are termed as protective food against various major and minor diseases. Scientific agro-techniques under optimum growing condition like temperature, relative humidity and light intensity, positively influence the qualitative and quantitative attributes of most of the vegetable crops including cherry tomato. It is one of potential vegetable crop, which is extensively utilized for table purpose and for preparing recipies in five star restaurants. Cherry tomato fetches higher prices in market due to good taste and higher nutrients, thus making qualitative attributes as an important factor to give higher returns to the farmers. Thus, this experiment was conducted to estimate the qualitative attributes in eighteen genotypes of cherry tomato grown under both open field and polyhouse conditions. The result of the study revealed that under open field condition, BRCT-30 was the best genotype with maximum value for lycopene content (6.62 mg 100^{-1} g FW) and β-carotene (2.30 mg 100^{-1} g FW), second maximum value for total

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soluble solids (7.85°Brix), third maximum value for reducing sugar and fourth highest position for ascorbic acid content (43.65 mg/100 g FW). Under polyhouse condition, the best genotype for quality parameters was BRCT-36 with maximum total soluble solids (10.81°Brix), lycopene (7.48 mg 100^{-1} g FW) and β-carotene (2.49 mg 100^{-1}g FW) along with average range of values for ascorbic acid (72.36 mg 100^{-1} g FW) and titrable acidity (0.55 mg 100^{-1} g FW).

Keywords: Neutraceutical; lycopene; attributes; trellis; β-carotene.

1. INTRODUCTION

Cherry tomato (*Solanum lycopersicum* L. var. *cerasiforme*), a botanical species of cultivated tomato, has high demand in national and international market due to its high quality and good taste [1]. They are excellent sources of vitamin A, C and K and also good sources of antioxidants and phyto-chemical compounds, including lycopene, β-carotene, flavonoids, vitamin C and many other essential nutrients [2]. Cherry tomatoes are usually consumed raw as it is endued with various health benefits, including reduced risk of heart diseases and cancer. It is a table purpose crop which has an anti-inflammatory property with wider application in treatment of chronic diseases and as a pain killer due to its rich content of bioflavonoid and carotenoids [3]. Since it has fixed calories, it is widely used to control weight. Apart from genetic makeup, qualitative attributes are highly influenced by the growing environment. With ever increasing human nutritional deficiencies, it has become imperative to screen the varieties of cherry tomato for qualitative attributes along with good yield under different growing conditions. Keeping the above facts in view, the present investigation was conducted to study the effect of growing conditions i.e. open field and protected condition on qualitative attributes of cherry tomato.

2. MATERIALS AND METHODS

The experiment was conducted in polyhouse and open field on trellis at Bihar Agricultural University, Sabour, Bhagalpur, Bihar which lies in Indo-Gangetic plains of eastern India. Eighteen diverse cherry tomato genotypes were evaluated in randomized block design, replicated thrice in the autumn-winter season of 2018-19 in polyhouse covered with transparent UV-stabilized polythene of 200 microns and open field trained on iron trellis (Table 1). Thirty days old plants were transplanted maintaining 50 cm x 50 cm planting distance.

Seven qualitative attributes, i.e., lycopene, β–Carotene, total soluble solids, total sugar, reducing sugar, titrable acidity and ascorbic acid content were measured from composite sample prepared from ten fruits from each replication. Total sugar was estimated by Lane-Eynon method [4], reducing sugar as per [5] by heat

Table 1. Plant genotypes traits used in the study

S.N.	Genotype	Source	Morphological description
1	BRCT-33	BAU, Sabour	Oval, red fruits, indeterminate
2	BRCT- 21	BAU, Sabour	Round, red fruits, indeterminate
3	BRCT- 22	BAU, Sabour	Round, red fruits, indeterminate
4	BRCT- 23	BAU, Sabour	Oval, red fruits, indeterminate
5	BRCT- 24	BAU, Sabour	Round, red fruits, indeterminate
6	BRCT- 25	BAU, Sabour	Oval, red fruits, indeterminate
7	BRCT- 20	BAU, Sabour	Plum shape, red fruits, indeterminate
8	BRCT- 26	BAU, Sabour	Round, red fruits, indeterminate
9	BRCT-34	BAU, Sabour	Round, red fruits, indeterminate
10	BRCT-27	BAU, Sabour	Round, red fruits, indeterminate
11	BRCT-35	BAU, Sabour	Oval, red fruits, indeterminate
12	BRCT-28	BAU, Sabour	Round, red fruits, indeterminate
13	BRCT-36	BAU, Sabour	Oval, red fruits, indeterminate
14	BRCT-29	BAU, Sabour	Pyriform, red fruits, indeterminate
15	BRCT-30	BAU, Sabour	Round, red fruits, indeterminate
16	BRCT-31	BAU, Sabour	Round, red fruits, indeterminate
17	BRCT-37	BAU, Sabour	Round, red fruits, indeterminate
18	BRCT-32	BAU, Sabour	Pyriform, red fruits, determinate

titration method using Fehling's solution, ascorbic acid as per [5] using meta phosphoric acid as reagent carrying out titration against 2, 6-dichlorophenol indophenol dye. Titrable acidity was estimated by procedure illustrated by [5] and expressed as in percentage citric acid equivalent. Lycopene and beta-carotene were estimated by the spectrophotometric procedure established by [6]. TSS was estimated using ERMA hand refractometer (0-32°Brix). Statistical analysis was performed using SPSS version 16.2 software.

3. RESULTS AND DISCUSSION

The ANOVA for qualitative attributes of cherry tomato under both the condition showed that the traits vary significantly among genotypes of cherry tomato and the results are in line with the work done in tomato crop by Rana and coworkers in 2014. High variability for performance of the genotypes for all the seven qualitative attributes was observed in all the eighteen genotypes of cherry tomato under the two growing conditions, *viz*., in open field and under protected structure.

3.1 Qualitative Attributes of Cherry Tomato

For estimation of qualitative attributes, ten fruits were plucked randomly from each replication and results were estimated for lycopene (mg/100 g FW), β–Carotene (mg/100 g FW), total soluble solids (°Brix), total sugar (%), reducing sugar (%), titrable acidity (%) and ascorbic acid content (mg/100 g FW) in Table 1.

The range of TSS in fruits of crop grown at open field was between 4.69 and 8.44 °Brix, the highest values obtained in genotypes BRCT-25, BRCT-30 and BRCT-32 (8.44, 7.85 and 7.33 °Brix, respectively) and least value in BRCT-34 (4.69°Brix). Under protected condition, the range of TSS varied from 8.07 to 10.81 °Brix. The genotype BRCT-36 (10.81°Brix) possessed highest TSS followed by BRCT-28 (10.40 °Brix), BRCT-33 (10.00 °Brix), BRCT-26 (9.94 °Brix) and BRCT-24 (9.84 °Brix), whereas BRCT-27 (8.07 °Brix) recorded minimum TSS. Total soluble solids content was higher in fruits under polyhouse condition by 51.88% than open field condition (Fig. 1). Previously [8] and [9] also reported higher TSS in protected condition in tomato. The TSS of tomatoes including cherry tomatoes chiefly comprises of reducing sugar [10]. Therefore, increase in photosynthetic activity in polyhouse would enhance sucrose synthesis, thereby influencing the glucose and fructose accumulation in fruits, leading to enhanced TSS [9]. Higher level of TSS is also related to higher level of optimum temperature (25-30°C) which can be easily maintained in polyhouse condition. The results are in line with the findings of the research done by [11] and [12] in cherry tomato [8,13,14,15] in tomato.

Lycopene content was 50.59% more under polyhouse than open field (Fig. 1). Lycopene ranged between 0.52 to 6.62 mg/100 g in crop of open field while 1.07 to 7.48 mg/100 g in the crop grown under protected condition. BRCT-30 (6.62 mg/100 g) followed by BRCT-36 (6.07 mg/100 g) possessed maximum lycopene under field condition, whereas BRCT-27 was found with least lycopene content (0.52 mg/100 g). BRCT-36 (7.48 mg/100 g) followed by BRCT-30 (7.46 mg/100 g) possessed maximum value for lycopene content, whereas BRCT-32 was with least lycopene content (1.07 mg/100 g) among all the eighteen genotypes of cherry tomato grown under protected condition (Table 1).

β–Carotene content was 50.47% more under polyhouse than open field (Fig. 1). In open field condition, β–Carotene content ranged between 0.17 to 2.30 mg/100 g, with BRCT-30 (2.30 mg/100 g) possessing the highest β–Carotene followed by BRCT-36 (1.96 mg/100 g), BRCT-24 (1.48 mg/100 g) and BRCT-22 and BRCT 26 (each with 1.45 mg/100 g), whereas BRCT 20 (0.39 mg/100 g) followed by BRCT 32 (0.40 mg/100 g) were with least value (Table 1). β–Carotene content varied between 0.36 to 2.49 mg/100 g in polyhouse crop, in which genotype BRCT-36 and BRCT-30 recorded maximum values (each with 2.49 mg/100 g) followed by BRCT- 22 (2.26 mg/100 g) and BRCT 26 (2.23 mg/100 g), however BRCT 32 was with minimum lycopene content (0.36 mg/100 g). Higher values for lycopene and β–Carotene content under polyhouse (than open field) may be due to effect of optimum environmental conditions like temperature and photo synthetically active radiation (PAR) on fruit quality traits. The optimum temperature range for high lycopene synthesis is 21-24°C, whereas lower or higher temperatures hamper lycopene synthesis [16]. During the peak fruiting season the average diurnal open field temperature remained in the range of 15-18°C in which the synthesis of lycopene was hampered. On the other hand, the same under polyhouse remained in the range of 18.5 – 21.5°C providing a desirable situation for lycopene synthesis. Colour accumulation is largely related to temperature condition and light intensity. Increased temperature and direct sunlight affected the colour formation process and deteriorated the coloured carotenoids in fruits. Similar findings were reported by [17] and [12] in cherry tomato.

The significant differences in values of total sugar and reducing sugar among genotypes were recorded under both the conditions. The values were higher in harvested fruit in polyhouse than field by 19.80% and 30.44%, respectively (Fig. 2). Total sugar ranged from 4.49% to 6.46% in open field and 5.31% to 7.46% under protected conditions. BRCT-26 (6.46%) followed by BRCT-24 (6.30%) possessed highest total sugar in field condition while BRCT-23 was found with least value (4.49%). In polyhouse, BRCT-24 (7.46%) followed by BRCT-28 (6.95%) and BRCT-26 (6.81%) recorded highest total sugar, whereas BRCT-21 gave least value of 5.31%. In open field, reducing sugar was in the range of 2.95-4.96%, whereas under protected conditions the range was 4.27-6.68%. BRCT-37 (4.96%) followed by BRCT-31 (4.91%) and BRCT-30 (4.86%) in open conditions, whereas BRCT-24 (6.68%) followed by BRCT-31 and BRCT-34 (5.57% each) and BRCT-23 (5.56%) recorded the highest values for reducing sugar. For the same parameter BRCT-23 in open field (2.95%) and BRCT-33 in polyhouse (4.27%) was with least values (Table 1). The significant difference in values of total sugar and reducing sugar among genotypes was recorded under both the conditions. The values were higher in harvested fruit from polyhouse than field and the results are in line with the research outcome of the work done by [8,9,18,19] in tomato. On the other hand, finding of [7] are contradictory to this result. The high sugar content may be due to higher photosynthetic activity leading to accumulation of greater quantities of sugars under protected condition [9].

Ascorbic acid content among different genotypes also varied significantly and was in the range of from 20.83 to 50.05 mg/100 g FW in open field (Table 1). BRCT-37 (50.05 mg/100 g) followed by BRCT-26 (47.33 mg/100 g), BRCT-23 (43.94 mg/100 g) and BRCT-30 (43.65 mg/100 g) contained highest ascorbic acid, whereas BRCT-35 (20.83 mg/100 g) and BRCT-32 (21.86 mg/100 g) were with least values. Under protected condition, ascorbic acid ranged from 54.88 to 95.12 mg/100 g FW under which genotype BRCT-37 (95.12 mg/100 g FW), BRCT-21 (94.26 mg/100g FW), BRCT-34 (92.95 mg/100 g FW), BRCT-33 (92.61 mg/100 g FW), BRCT-35 (92.42 mg/100 g FW) and BRCT-32 (92.40 mg/100 g FW) recorded highest value, whereas BRCT-30 (54.88 mg/100 g FW) recorded lowest value followed by BRCT-31 (59.34 mg/100 g FW).

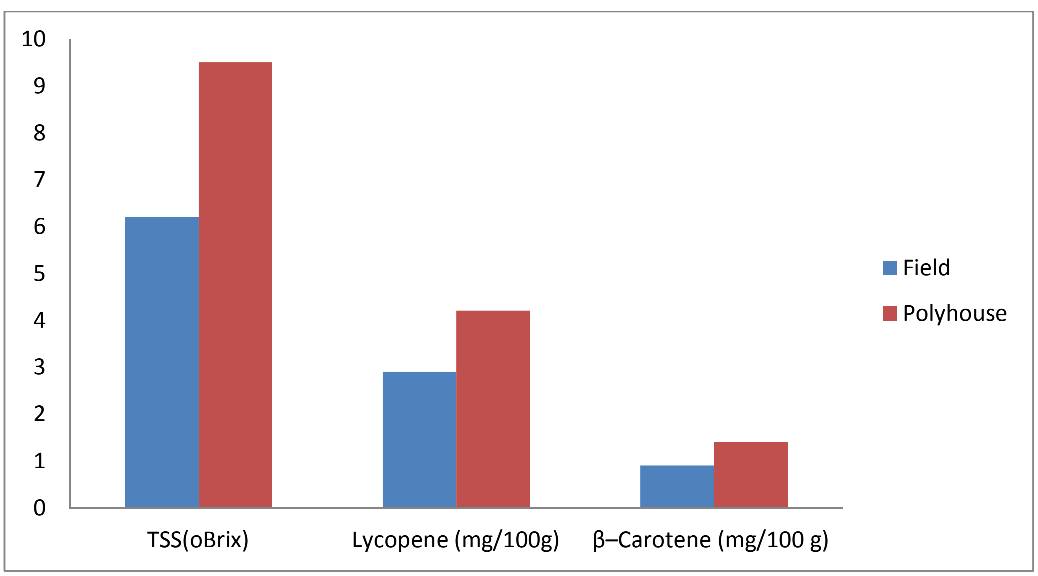

Fig. 1. Average TSS (^{o}Brix), lycopene (mg/100 g) and β–Carotene (mg/100 g) values in cherry tomato under open field and polyhouse condition

Table 2. Qualitative traits of cherry tomato genotypes under open field and polyhouse condition

Genotype	TSS(°Brix)		Lycopene (mg/100 g)		β–Carotene (mg/100 g)		Total sugar (%)		Reducing sugar (%)		Titrable Acidity (%)		Ascorbic acid (mg/100 g)	
	Field	Poly	Field	Poly	Field	Poly	Field	Poly	Field	Poly	Field	Poly	Field	Poly
BRCT-33	6.80^{efg}	10.00^{bc}	2.06^{de}	2.94^{e}	0.67^{d}	0.98^{bc}	4.59^{ab}	5.50^{a}	3.37^{abc}	4.27^{a}	0.39^{cde}	0.64^{f}	28.02^{bc}	92.61^{h}
BRCT- 21	6.10^{bcde}	9.20^{bc}	3.24^{g}	3.51^{f}	1.12^{f}	1.17^{c}	4.52^{ab}	5.31^{a}	3.79^{cde}	4.46^{a}	0.44^{fgh}	0.66^{f}	28.09^{bc}	94.26^{h}
BRCT- 22	6.58^{defg}	9.41^{bc}	4.39^{h}	6.78^{i}	1.45^{g}	2.26^{e}	5.05^{c}	6.18^{b}	3.88^{de}	4.60^{a}	0.33^{a}	0.53^{d}	34.34^{e}	81.01^{ef}
BRCT- 23	5.71^{bc}	9.53^{bc}	2.16^{e}	3.04^{e}	0.71^{d}	1.02^{bc}	4.49^{a}	6.25^{b}	2.95^{a}	5.56^{b}	0.34^{ab}	0.52^{d}	43.94^{h}	66.15^{c}
BRCT- 24	6.45^{cdef}	9.84^{ab}	4.48^{h}	1.34^{b}	1.48^{g}	0.45^{a}	6.38^{i}	7.46^{cd}	4.21^{ef}	6.68^{c}	0.38^{bcd}	0.42^{bc}	37.87^{fg}	81.34^{ef}
BRCT- 25	8.44^{i}	9.64^{ab}	2.89^{f}	2.95^{e}	0.94^{e}	0.98^{bc}	4.79^{b}	6.09^{b}	3.64^{bcd}	5.50^{b}	0.45^{fgh}	0.35^{a}	26.74^{b}	84.92^{fg}
BRCT- 20	5.46^{ab}	9.31^{bc}	1.21^{b}	2.92^{e}	0.39^{b}	0.97^{bc}	5.38^{de}	6.53^{b}	4.69^{g}	5.46^{b}	0.46^{gh}	0.57^{e}	39.17^{g}	91.96^{h}
BRCT- 26	5.45^{ab}	9.94^{bc}	4.37^{h}	6.71^{i}	1.45^{g}	2.23^{e}	6.46^{i}	6.81^{bc}	4.54^{fg}	5.38^{b}	0.40^{cdef}	0.51^{d}	47.33^{i}	73.99^{d}
BRCT-34	4.69^{a}	9.46^{bc}	1.43^{bc}	2.84^{e}	0.48^{bc}	0.92^{b}	4.59^{ab}	6.29^{b}	3.68^{bcd}	5.57^{b}	0.52^{i}	0.51^{d}	35.49^{ef}	92.95^{h}
BRCT-27	5.68^{bc}	8.07^{a}	0.52^{a}	1.69^{c}	0.17^{a}	0.56^{a}	6.10^{h}	6.66^{b}	4.65^{fg}	5.49^{b}	0.51^{i}	0.65^{f}	30.65^{cd}	90.02^{gh}
BRCT-35	5.45^{ab}	9.41^{ab}	1.39^{b}	6.40^{h}	0.45^{bc}	2.13^{e}	5.26^{cd}	6.40^{b}	3.26^{ab}	5.44^{b}	0.48^{hi}	0.45^{c}	20.83^{a}	92.42^{h}
BRCT-28	6.97^{fg}	10.40^{bc}	1.97^{d}	6.57^{hi}	0.66^{d}	2.08^{e}	5.72^{fg}	6.95^{bc}	4.52^{fg}	5.36^{b}	0.37^{abc}	0.52^{d}	30.59^{cd}	76.72^{de}
BRCT-36	6.14^{bcdef}	10.81^{c}	6.07^{i}	7.48^{j}	1.96^{h}	2.49^{f}	4.55^{ab}	5.44^{a}	3.83^{cde}	4.37^{a}	0.52^{i}	0.55^{de}	31.46^{d}	72.36^{d}
BRCT-29	5.84^{bcd}	9.64^{bc}	3.41^{g}	4.78^{g}	1.11^{f}	1.55^{d}	5.16^{cd}	6.41^{b}	3.75^{cd}	5.35^{b}	0.42^{defg}	0.39^{ab}	28.22^{bc}	64.63^{bc}
BRCT-30	7.85^{hi}	9.60^{ab}	6.62^{j}	7.46^{j}	2.30^{i}	2.49^{f}	5.59^{ef}	6.33^{b}	4.86^{g}	5.47^{b}	0.51^{i}	0.53^{d}	43.65^{h}	54.88^{a}
BRCT-31	6.68^{efg}	9.52^{bc}	2.27^{e}	6.40^{h}	0.73^{d}	2.13^{e}	5.53^{ef}	6.54^{b}	4.91^{g}	5.57^{b}	0.43^{efgh}	0.52^{d}	28.18^{bc}	59.34^{ab}
BRCT-37	5.75^{bc}	9.48^{bc}	1.60^{c}	2.42^{d}	0.53^{c}	0.81^{b}	5.97^{gh}	6.18^{b}	4.96^{g}	5.44^{b}	0.44^{fgh}	0.41^{bc}	50.05^{j}	95.12^{h}
BRCT-32	7.33^{gh}	8.93^{bc}	1.25^{b}	1.07^{a}	0.40^{b}	0.36^{a}	4.65^{ab}	6.19^{b}	3.57^{bcd}	5.35^{b}	0.39^{cde}	0.40^{b}	21.86^{a}	92.40^{h}
S.Em (±)	0.18	0.22	0.06	0.07	0.03	0.03	0.09	0.20	0.15	0.17	0.01	0.01	0.89	2.07
CD (p=0.05)	0.53	0.63	0.16	0.21	0.09	0.07	0.25	0.58	0.42	0.50	0.04	0.04	2.55	5.95
CV (%)	5.02	3.99	3.45	3.02	5.65	3.06	2.91	5.50	6.23	5.65	5.81	4.68	4.57	4.43

Note: Means with different alphabets are significantly different

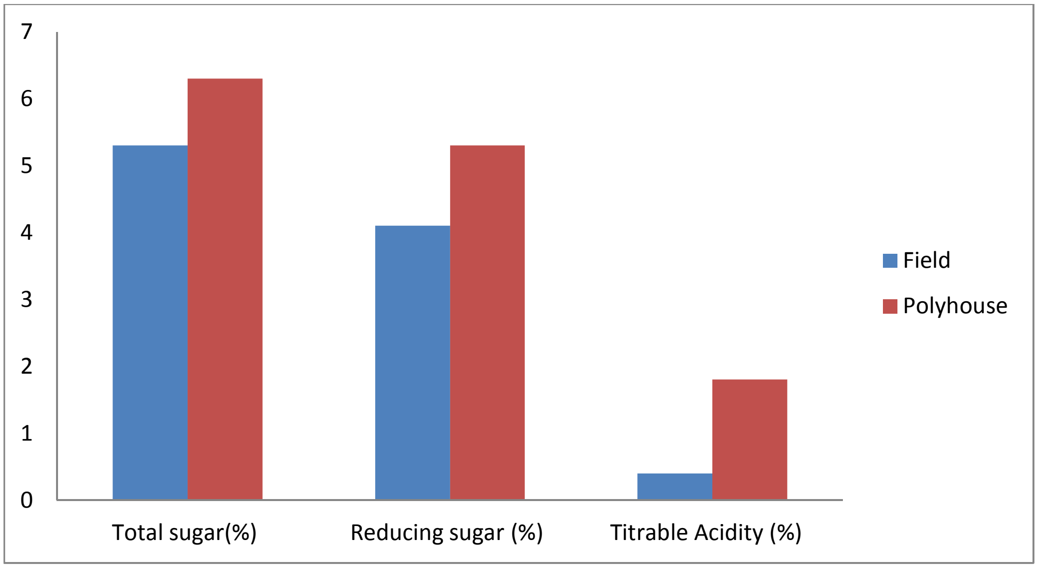

Fig. 2. Average total sugar (%), reducing sugar (%) and titrable acidity (%) content in cherry tomato under open field and polyhouse condition

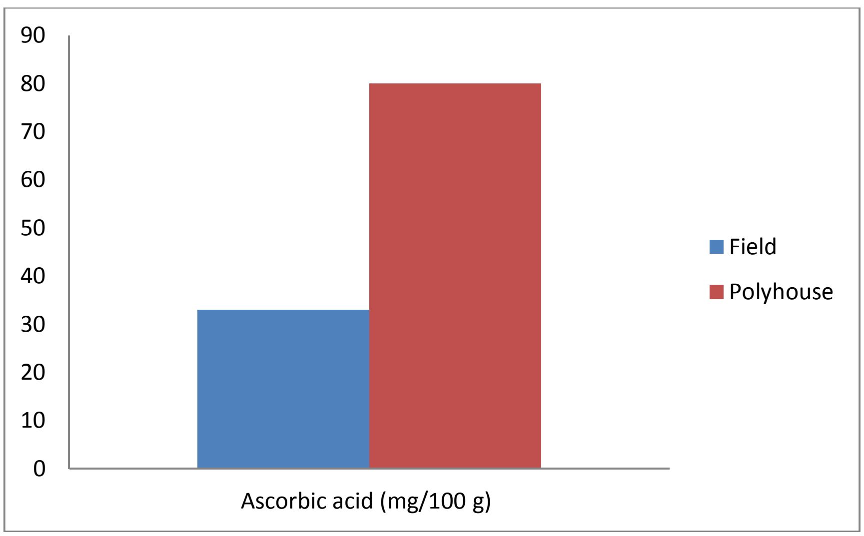

Fig. 3. Average ascorbic acid (mg/100 g) content in cherry tomato under open field and polyhouse

Ascorbic acid content was 140.25% higher in polyhouse fruits than in open field fruits (Fig. 3). The significant variation of ascorbic acid value among various genotypes under different condition may be due to specific genetic makeup of individual genotype and its interaction with micro-environment. In protected cultivation, the micro climate surrounding the plant body is controlled partially or fully as per the requirement of crops grown during their period of growth. The results were in accordance with the findings of the research work done by [20,21,8,13] in tomato and [14] and [18] in cherry tomato under poly house. The synthesis of ascorbic acid occurs from sugar [22]. Therefore, higher photosynthesis resulting in higher sugar accumulation lead to higher levels of ascorbic acid in polyhouse fruits.

4. CONCLUSION

In general, all the seven qualitative attributes of the cherry tomato were higher in polyhouse than the fruits grown in open field condition. However few genotypes performed well under field condition with high value in qualitative attributes. For qualitative attributes at open field conditions, genotype BRCT-30 (TSS:7.85 °Brix, lycopene: 6.62 mg/100 g FW, ß-carotene:2.30 mg/100 g FW, ascorbic acid: 43.65 mg/100 g FW and titrable acidity: 0.51%) and BRCT-36 (TSS:6.14 °Brix, lycopene:6.07 mg/100 g FW, ß-carotene: 1.96 mg/100 g FW, ascorbic acid:31.46 mg/100 g FW and titrable acidity: 0.52%) performed good. Under protected condition, genotype, BRCT-36 (TSS: 10.81 °Brix, lycopene: 7.48 mg/100 g FW, ß-carotene: 2.49 mg/100 g FW, ascorbic acid: 72.36 mg/100g FW and titrable acidity: 0.55%) and BRCT-28 (TSS:10.40 °Brix, lycopene: 6.57 mg/100 g FW, ß-carotene: 2.08 mg/100 g FW, ascorbic acid: 76.72 mg/100 g FW and titrable acidity: 0.52%) gave excellent performance.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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