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A comparative study on tomato (*Solanum lycopersicum*) quality under different soil and nutrient management

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ABSTRACT

The present experiment was conducted during 2019–20 and 2020–21 at Navsari Agricultural University, Navsari, Gujarat to determine the quality of tomato (*Solanum lycopersicum* L.) cultivars in terms of their biochemical compositions grown under different soil types. Different genotypes of tomatoes (DVRT-2, GT-2, GT-6, and GT-7) were grown in normal, saline, and organic soils for two consecutive years. Different biochemical and antioxidative enzymes were analyzed from the mature fruits at the harvesting stage. The saline grown DVRT-2 cultivar revealed highest total carbohydrate content (5.97%), total antioxidant activity by DPPH (57.13 µg/ml), vitamin C (17 mg/100 gm), lycopene (16.58 mg/100 gm), antioxidant enzymes like ascorbate peroxidase (170.93 U/mg protein), catalase (9.11 U/mg protein), peroxidase (66.91 U/mg protein), superoxide dismutase (86.74 U/mg protein). Saline-grown GT-6 and DVRT-2 both had the highest phenyl alanine ammonia lyase activity (8.09 m molcinnamic ac. /g/mg). Conventional soil-grown DVRT-2, had the highest ash content (19.31%) and fat content (0.087%), total protein (0.86%). Therefore, among the cultivars, DVRT-2 was found to be a saline-resistant genotype. PCA analysis revealed a total of eight different principal components while 70% of the variance was explained by the first three PCs. In terms of nutritional content, organic soil was determined to be superior to normal soil, followed by saline cultivation. Mild stress is the cause of the qualitative enhancement in the fruits grown in organic soil.

Keywords: Antioxidant, CA, Conventional, Organic soils, Saline

Tomatoes (*Solanum lycopersicum* L.) are perennial herbaceous plants that are mostly grown in temperate and tropical areas, either in open fields or under greenhouses. Due to their high phytonutrient content, tomatoes are consumed widely all over the world and have been demonstrated recently to have positive health benefits (Venkadeswaran *et al.* 2018). The nutritional value of a crop might change based on several environmental and cultural factors. According to Zhang *et al.* (2017), salinity stress has a stronger effect on raising the fruit sugar and total acid content of tomatoes, which improves their quality. Though extreme saline condition can reduce the fruit yield but mild salinity may have a positive effect on the agricultural produce (Singh *et al.* 2011). In contrast, the fruits raised in normal soil, the organically cultivated tomatoes showed higher levels of vitamin C, carotenoids (like lycopene) and key minerals (including P, K, Mg, and Ca) that are vital to human health. Different genotypes of tomato can also respond in a various way against stress or cultivation conditions. As different genetic composition of the same species has a great impact on produce quality. Significant differences have been found among various cherry tomato varieties under normal and polyhouse condition (Chandni *et al.* 2020). A number of genotypes of tomato showed significant differences with respect to yield and nutrition cultivated under the Chhattisgarh plain conditions (Lakra *et al.* 2020). The tomato flavour is dependent mostly on the cultivar and the growing conditions, depending on which, a high amount of sugar is accumulated in the fruit. Also, tomato fruit is reasonably rich in other favourable compounds such as ferulic, caffeic acids and have minor amounts of vitamin E.

In light of the aforementioned circumstances, an experiment was planned to determine the quality of few tomato cultivars in terms of yield and biochemical compositions when grown in normal, organic, and saline soil. The objective of the present experiment was to investigate how a variety of biochemical characteristics are affected by various types of soil management.

MATERIALS AND METHODS

Experimental details: The present experiment was conducted during 2019–20 and 2020–21 at Navsari

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Agricultural University, Navsari (20.807545ºN; 73.022260º E and 7.6 m height from sea level), Gujarat. The experiment was conducted by the transplanting of seedlings of different tomato genotypes which were collected in the winter season from Horticulture Research farm, Navsari Agricultural University, Navsari, Gujarat. Earthen pots were taken for the experiment (36 pots) and every 12 pots were filled with 20 kg of normal soil (garden soil), certified organic soil, and saline soil (4.39 dS/m) (Table 1). The certified organic soil was procured from organic farm Navsari Agricultural University, Navsari, Gujarat which is certified by Gujarat Organic Product Certification Agency (Certification No. ORG/SC/1111/002486) and affiliated by APEDA. After the pot was filled with the particular soils per pot were transplanted with single (at 4 true leaf stage) seedlings. The pots filled with normal garden soil were used as a control against both organic soils as well as saline soil. In organic soil, bio compost (castor cake) was applied based on a nitrogen equivalent basis (recommended dose of nitrogen 100 kg/ha) and no chemical fertilizer was applied. In contrast, in the case of saline and garden soils recommended dose of fertilizer (RDF) was applied @100:50:50 kg/ha. In organic soil, all the bio-compost was applied at a time as a basal dose while in the case of saline soil and conventional soil split application of nitrogen was done. Half of the nitrogen was applied as basal dose and the remaining nitrogen was added in two splits at 40 and 60 days after transplanting (DAT) at the time of flowering and fruit setting, respectively. Irrigation (purely RO water of *p*H was 7.3 and EC is 0.0347 dS/m) was applied twice in the week according to the requirement of the crop. Harvesting was done by consecutive picking of tomato fruits at their physiological maturity and subjected to laboratory analysis. For every parameter in a laboratory experiment, observations were taken in three repetitions.

Biochemical analysis: Total carbohydrate was analyzed by using a spectrophotometer with the help of the anthrone method as described by Hedge *et al.* (1962). Crude fibre estimation was carried out by washing the dried sample by acid and alkali. After that, the sample was weighed, incinerated, cooled and reweighed again. The crude fibre was calculated by the loss of weight. The protein content was determined by the procedure of Lowry *et al.* (1951). Ash analysis was done by the weight difference after the ignition of the dried fruit sample in muffle furnace at 600ºC. Total fat content was determined by using the soxhlet apparatus. Dry matter content was estimated by drying the samples in hot air oven at 65°C until the weight remained constant and the difference between raw and dry weight of the sample material was recorded followed by calculation of the dry matter percentage. Beta (ß) carotene (Pro-Vitamin A) analysis was done according to the method described by Mahadevan and Sridhar (1986). Chlorophyll content was determined by using a spectrophotometer through the method by Arnon (1949). Lycopene content was determined by using a spectrophotometer according to the method given by Sadasivam and Theymoli (1987). Ascorbic acid (vitamin C) was determined by extraction of ascorbate content with 4% oxalic acid followed by titration with the dichlorophenol indophenols (DCPIP) dye. The total phenol content was determined by Folin-Ciocalteau reagent through the meth described by Malick and Singh (1980). The total antioxidant activity was determined using the 1, 1 diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging assay Blois (1958).

Enzyme activity assay: The crude extract was prepared by homogenizing the frozen plant sample in a buffer medium. Tomato samples which were stored at -20° were used for the enzyme extraction. The samples were washed with distilled water twice. Super dismutase (SOD) assay was carried out by the homogenization of frozen sample in 40 ml of 100 mM Na_2HPO_4/KH_2PO_4 (*p*H 7.0) and homogenate centrifuged at 4000 g for 15 min at 40°C. The supernatant then passed through a PD-10 column which was then equilibrated with 50 mM $Na_2CO_3/NaHCO_3$ (*p*H 10.2) to remove low molecular weight substances that interfere with the enzyme assay. For the Catalase (CAT) assay, all the procedures were the same as the Super dismutase (SOD) enzyme except that of the desalting step and the centrifugation was carried out at 105000 g. For the Peroxidase (POD) assay, the sample was dried and soaked in 100 ml of 0.1 M phosphate buffer of *p*H 6.0 overnight and thoroughly homogenized by blending for 15–20 min. The contents were centrifuged at 10,000 g for 15 min to remove cell debris. The supernatant was removed carefully from the sediments and filtered through

Table 1 Physico-chemical properties of conventional, saline and organic soil at initial and harvesting stage

Soil type	Available nitrogen content (g/kg)	Available phosphorus content (g/kg)	Potassium content k (g/kg)	EC (dS/m)	*p*H	ESP content (me/100 gm)	Cation exchange capacity content (me/100 gm)	Organic carbon content (%)
Initial stage								
Conventional soil	22.50	11.24	12.40	0.54	7.66	3.62	38.65	0.50
Saline soil	18.24	7.44	8.90	4.39	8.24	6.15	31.29	0.45
Organic soil	24.52	9.67	11.15	0.68	7.98	2.62	56.22	0.80
Harvesting stage								
Conventional soil	27.78	10.78	11.88	0.45	7.52	3.48	35.38	0.47
Saline soil	19.72	8.60	9.50	3.90	8.04	6.00	29.93	0.42
Organic soil	27.73	11.28	11.235	0.59	7.85	2.48	56.12	0.82

the Whatman No. 1 filter paper to get more clarity of the crude enzyme extract and was stored at 4°C until used. For the Ascorbate peroxidase (APX) assay, the sample (5 g) was homogenized in 20 ml of ice-cold extractant. The extraction medium contained 50 mM Na_2HPO_4/KH_2PO_4 (*p*H 7.0), 1mM EDTA, 5% Polyvinylpyrrolidone (PVP-40) and 1mM ascorbic acid. The homogenate was filtered through four layers of gauze and centrifuged at 105,000 g for 10 min at 40°C.

Catalase (CAT) activity was determined by using a spectrophotometer at room temperature by monitoring the decrease in the absorbance at 240 nm resulting from the decomposition of H_2O_2 according to the method of Aebi *et al.* (1983). Superoxide dismutase (SOD) activity was determined by measuring the inhibition in the photoreduction of nitro blue tetrazolium (NBT) by SOD enzyme according (Kumar *et al.* 2012). The peroxidase (POD) activity was determined according to the method given by Onsa *et al.* (2004). Ascorbate peroxidase (APX) activity was estimated by the method of Nakano and Asada (1981). Phenylalanine ammonia lyase (PAL) activity was determined by Brueske *et al.* (1980).

Statistical analysis: The experimental design followed in this study is a completely randomized design (CRD) (factorial concept). Data analysis of statistical data had been done with a 5% level of significance. Duncun's multiple range test was performed to compare the means. Principal component analysis has been done for data reduction. All the analyses were performed using R 4.2.2 statistical software.

RESULTS AND DISCUSSION

Results revealed that DVRT-2 among all other genotypes produced the highest amount of carbohydrate content (5.97%) an increase of 9.29% in saline soil followed by 2.73% in organic soil over conventional soil. The higher carbohydrate content in organic tomatoes depicts that, they endure oxidative stress, which causes more sugar to accumulate in the fruits (Hallmann and Rembialkowska 2007). Ash content was highest in DVRT-2 among all other genotypes while the highest amount of ash content was produced under conventional soil (19.31%). A decrease of 5.54% and 10.90% over organic and saline soils in regards to ash content was found. Tomato fruits from organically grown plants had less ash than those from conventionally produced plants may be due to the disrupted mechanism of mineral uptake, translocation, and accumulation under salinity stress. Total fat content decreased by 8.92% and 12.92% in organic soil and saline soil respectively compared to conventional soil-grown fruits. An increase of 2.33% and 0.85% in dry matter in the fruits cultivated under conventional soil and organic soil was found compared to saline soil. The decrease in dry matter content may be

Table 2 Carbohydrate, ash, fat, crude fiber, dry matter, total protein, chlorophyll and ascorbic acid content of different genotypes of tomato under different soil management types

Treatment	Carbohydrate (%)	Ash (%)	Fat (%)	Crude fibre (%)	Dry matter (%)	Total protein (%)	Chlorophyll at fruiting stage (mg/g)	Ascorbic acid (mg/100 g)
GT-2 × Conventional soil	$4.67^{c} \pm 0.156$	$16.62^{def} \pm .0866$	$0.082^{ab} \pm 0.0034$	$1.077^{c} \pm 0.078$	$4.64^{c} \pm 0.415$	$0.73^{c} \pm 0.056$	$1.15^{c} \pm 0.078$	$13.42^{fg} \pm 1.216$
GT-2 × Saline soil	$4.94^{bc} \pm 0.223$	$15.18^{g} \pm 0.4578$	$0.072^{bc} \pm 0.0056$	$1.067^{c} \pm 0.045$	$4.56^{c} \pm 0.256$	$0.58^{d} \pm 0.043$	$1.11^{c} \pm 0.094$	$16.70^{a} \pm 1.341$
GT-2 × Organic soil	$4.67^{c} \pm 0.267$	$16.01^{efg} \pm 1.233$	$0.075^{bc} \pm 0.0061$	$1.187^{ab} \pm 0.132$	$4.57^{c} \pm 0.371$	$0.71^{c} \pm 0.065$	$1.21^{bc} \pm 0.034$	$15.01^{de} \pm 1.441$
GT-6 × Conventional soil	$4.71^{c} \pm 0.389$	$17.93^{bc} \pm 1.412$	$0.088^{a} \pm 0.0051$	$1.087^{bc} \pm 0.094$	$4.66^{c} \pm 0.612$	$0.77^{bc} \pm 0.059$	$1.19^{c} \pm 0.116$	$13.05^{g} \pm 1.296$
GT-6 × Saline soil	$5.03^{bc} \pm 0.412$	$15.5^{fg} \pm 0.941$	$0.072^{bc} \pm 0.0098$	$1.082^{c} \pm 0.072$	$4.59^{c} \pm 0.278$	$0.60^{d} \pm 0.049$	$1.17^{c} \pm 0.072$	$16.16^{b} \pm 1.289$
GT-6 × Organic soil	$4.75^{c} \pm 0.289$	$16.36^{defg} \pm 1.289$	$0.075^{ab} \pm 0.0045$	$1.21^{a} \pm 0.0365$	$4.63^{c} \pm 0.289$	$0.72^{c} \pm 0.073$	$1.25^{bc} \pm 0.056$	$14.63^{e} \pm 1.523$
GT-7 × Conventional soil	$3.74^{d} \pm 0.145$	$18.09^{bc} \pm 1.442$	$0.068^{bc} \pm 0.0057$	$1.107^{abc} \pm 0.041$	$4.86^{abc} \pm 0.472$	$0.75^{bc} \pm 0.081$	$1.28^{abc} \pm 0.192$	$13.62^{f} \pm 1.289$
GT-7 × Saline soil	$4.06^{d} \pm 0.266$	$16.28^{defg} \pm 1.113$	$0.064^{c} \pm 0.0067$	$1.077^{c} \pm 0.092$	$4.73^{bc} \pm 0.314$	$0.70^{c} \pm 0.045$	$1.21^{bc} \pm 0.134$	$15.11^{d} \pm 1.287$
GT-7 × Organic soil	$4.05^{d} \pm 0.139$	$17.26^{bcd} \pm 1.239$	$0.065^{bc} \pm 0.0031$	$1.12^{abc} \pm 0.072$	$4.79^{bc} \pm 0.184$	$0.72^{c} \pm 0.069$	$1.35^{abc} \pm 0.078$	$14.93^{de} \pm 1.672$
DVRT-2 × Conventional soil	$5.18^{b} \pm 0.377$	$19.31^{a} \pm 1.552$	$0.087^{a} \pm 0.0062$	$1.203^{a} \pm 0.097$	$5.14^{a} \pm 0.318$	$0.86^{a} \pm 0.046$	$1.46^{ab} \pm 0.082$	$14.78^{de} \pm 1.328$
DVRT-2 × Saline soil	$5.97^{a} \pm 0.173$	$17.15^{cde} \pm 1.349$	$0.075^{ab} \pm 0.0057$	$1.11^{abc} \pm 0.0816$	$4.98^{ab} \pm 0.277$	$0.70^{c} \pm 0.092$	$1.29^{abc} \pm 0.071$	$17.00^{a} \pm 1.672$
DVRT-2 × Organic soil	$5.33^{b} \pm 0.418$	$18.33^{ab} \pm 1.156$	$0.081^{ab} \pm 0.0079$	$1.213^{a} \pm 0.126$	$5.03^{ab} \pm 0.468$	$0.82^{ab} \pm 0.078$	$1.51^{a} \pm 0.093$	$15.65^{c} \pm 1.673$

explained as the lower accumulation of biomass due to the deterioration of photosynthetic pigments under salinity (Tantawy *et al.* 2009). Organically grown tomatoes contain a higher amount of dry matter as compared to conventional tomatoes (Herencia *et al.* 2011). Chlorophyll content in the fruiting stage, decreased up to 4.58% and 10.21% in conventional and saline soil, respectively over organic soil cultivation. The disruption of chlorophyll synthesis as a result of sodium ion buildup under salinity occurred during the fruiting stage (Al-Dakheel *et al.* 2015). According to Ye *et al.* (2020), organic fertilizers increases the rate of photosynthesis thus increasing the total chlorophyll synthesis as compared to control tomatoes. Chlorophyll A decreased in chrysanthemum treated with high concentration of salt (Vanlalruati *et al.* 2019). The increased level of total protein content was found in the tomatoes, cultivated in conventional soil as well as organic soil up to 20.12% and 14.71%, respectively compared to saline soil (Table 2). According to Ali *et al.* (2021), saline-grown tomatoes have lower protein contents than traditionally grown tomatoes, because under the salinity stress, protein synthesis was inhibited.

The genotype DVRT-2 contained the highest lycopene content (16.58%) under saline conditions. Lycopene content increased up to 11.75% and 7.00% in saline soil and organic soil, respectively. The elevation of lycopene under salinity stress is because of the stimulation of *psy 1* gene under stress, which is crucial for lycopene biosynthesis (Giannakoula and Ilias 2013). Beta carotene content was found in the highest amount in the genotype DVRT-2 (377.2251 mg/g) under conventional soil conditions. Mohamed and Ismail (2012) found lower beta carotene content in tomatoes under saline. According to Borghesi *et al.* (2011), saline stress inhibits the biosynthetic pathway of carotenoids by down-regulating the gene that is encoding the enzyme beta-cyclase. The ascorbic acid (Vitamin C) content increased by 18.41% and 9.75% in saline soil and organic soil respectively compared to the fruits grown in conventional soil while, DVRT-2 among all other genotypes produced the highest amount of total phenol content (106.61 mg/100 g) in organic soil grown tomato which is at par with saline soil. However, the amount of total phenol increased up to 7.64% and 6.19% in the fruits of organic soil and saline soil, respectively. It was clear that DVRT-2 among all other genotypes had the highest ascorbate peroxidase enzyme activity (170.9351 U/mg protein) under saline conditions and a significant difference among all three types of soil on ascorbate peroxidase enzyme activity in mature tomato crop was recorded. The findings of Oliveira *et al.* (2013) suggested that tomatoes grown in organic soil contained higher amounts of ascorbic acid. Mondal *et al.* (2009) reported that ripening in guava under oxidative stress conditions increased significantly the amount of ascorbic acid. Vegetables, particularly berries and fruits,that are cultivated organically have somewhat higher levels of vitamin C, sugars, carotenoids, antioxidant activity, and phenolic and flavonoid components (Çakmakçı and Cakmakcı 2023). Ascorbate peroxidase enzyme activity had been increased from 2.83% up to 10.95% in organic

Table 3 Lycopene, beta carotene, phenol, ascorbate peroxidase, catalase, PAL, peroxidase, SOD and antioxidant activity of different genotypes of tomato under different soil management types

Treatment	Lycopene (mg/100 g)	Beta carotene (mg/100 g)	Phenol (mg/100 g)	Ascorbate peroxidase (U/mg protein)	Catalase (U /mg protein)	PAL (m mol cinnamic ac./g/ min)	Peroxidase (U/mg protein)	SOD (U/mg protein)	Antioxidant (µg/ml)
GT-2 × Conventional soil	13.25^{f}± 1.256	365.98^{e}±12.561	93.23^{cd}±4.671	137.15^{i}±4.771	7.01^{c}±0.451	3.91^{b}±0.054	27.97^{e}±1.342	47.09^{g}±3.297	40.51^{g}±1.305
GT-2 × Saline soil	14.65^{de}±1.341	348.83^{i}±29.331	101.05^{abc}±6.781	150.59^{i}±8.295	7.24^{c}±0.823	8.07^{a}±0.062	66.76^{a}±7.094	84.04^{b}±5.123	48.90^{cd}±3.006
GT-2 × Organic soil	14.29^{e}±1.386	356.58^{h}±25.619	103.76^{ab}±11.144	139.85^{i}±11.672	4.30^{d}±0.289	8.03^{a}±0.952	34.47^{c}±1.552	66.81^{e}±5.112	46.96^{cde}±2.178
GT-6 × Conventional soil	13.24^{f}±1.117	368.43^{d}±17.624	92.74^{d}±7.902	137.18^{j}±14.964	7.59^{bc}±0.389	3.95^{b}±0.215	28.61^{e}±1.208	48.01^{fg}±1.834	42.65^{fg}±3.073
GT-6 × Saline soil	15.36^{bcd}±1.439	356.22^{h}±15.569	99.54^{abcd}±4.661	153.93^{e}±11.329	7.47^{bc}±0.581	8.09^{a}±0.134	66.66^{a}±3.401	84.71^{ab}±5.449	50.50^{bc}±4.129
GT-6 × Organic soil	14.68^{de}±1.278	359.47^{g}±34.891	101.44^{ab}±8.239	141.82^{h}±10.593	4.61^{d}±0.037	8.06^{a}±0.532	35.52^{c}±1.782	69.86^{d}±0.856	47.87^{cd}±2.945
GT-7 × Conventional soil	14.36^{e}±1.266	366.48^{e}±30.114	96.33^{bcd}±5.129	141.16^{hi}±7.831	7.53^{bc}±0.766	3.92^{b}±0.056	24.46^{f}±2.078	48.72^{fg}±3.218	40.25^{g}±5.229
GT-7 × Saline soil	16.06^{ab}±1.515	361.75^{f}±28.391	98.89^{abcd}±10.832	163.93^{c}±5.228	7.85^{bc}±0.267	8.00^{a}±0.712	66.68^{a}±5.129	85.79^{ab}±3.238	45.17^{def}±0.071
GT-7 × Organic soil	15.32^{cd}±1.756	362.22^{f}±16.220	99.77^{abcd}±6.782	144.44^{g}±15.491	4.75^{d}±0.396	7.93^{a}±0.452	36.76^{bc}±2.783	75.18^{c}±8.912	43.84^{efg}±1.569
DVRT-2×Conventional soil	15.17^{cd}±0.967	377.22^{a}±9.356	100.07^{abcd}±12.553	160.79^{d}±12.381	8.26^{ab}±0.076	3.9^{b}±0.116	31.83^{d}±4.551	49.80^{f}±0.089	50.3^{bc}±4.056
DVRT-2 × Saline soil	16.58^{a}±2.067	371.05^{c}±31.273	106.54^{a}±10.438	170.93^{a}±15.293	9.11^{a}±0.087	8.09^{a}±0.934	66.91^{a}±4.098	86.74^{a}±6.129	57.13^{a}±3.891
DVRT-2 × Organic soil	15.65^{bc}±1.245	372.87^{b}±35.671	106.61^{a}±3.875	166.48^{b}±12.451	7.32^{bc}±0.056	8.03^{a}±0.005	38.19^{b}±1.782	77.10^{c}±4.209	53.42^{b}±2.934

PAL, Phenylalanine ammonia lyase; SOD, Superoxide dismutase.

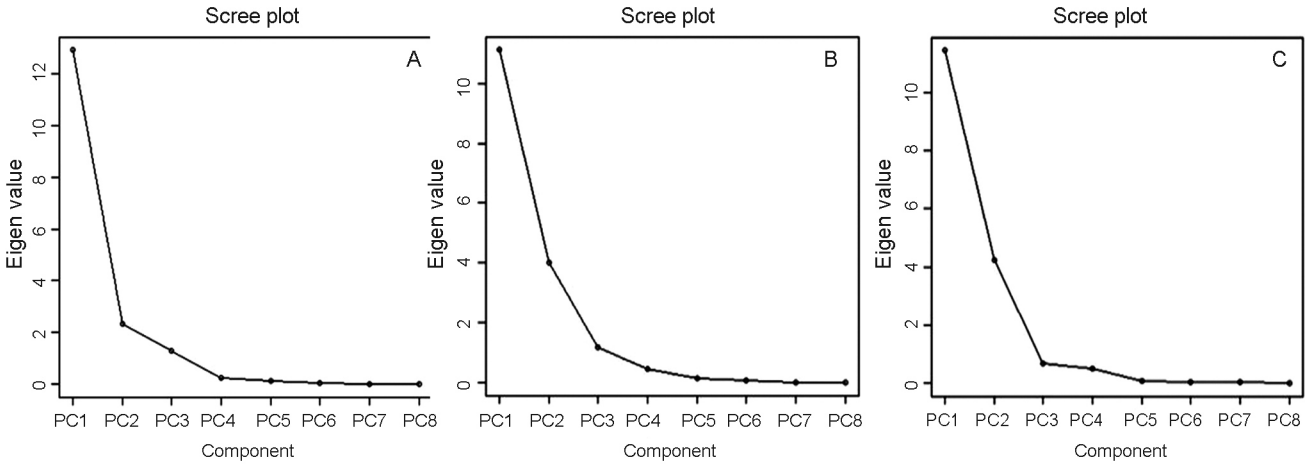

Fig. 1 (A) Screeplot of biochemical parameters under conventional cultivation; (B) Saline cultivation; (C) Organic cultivation.

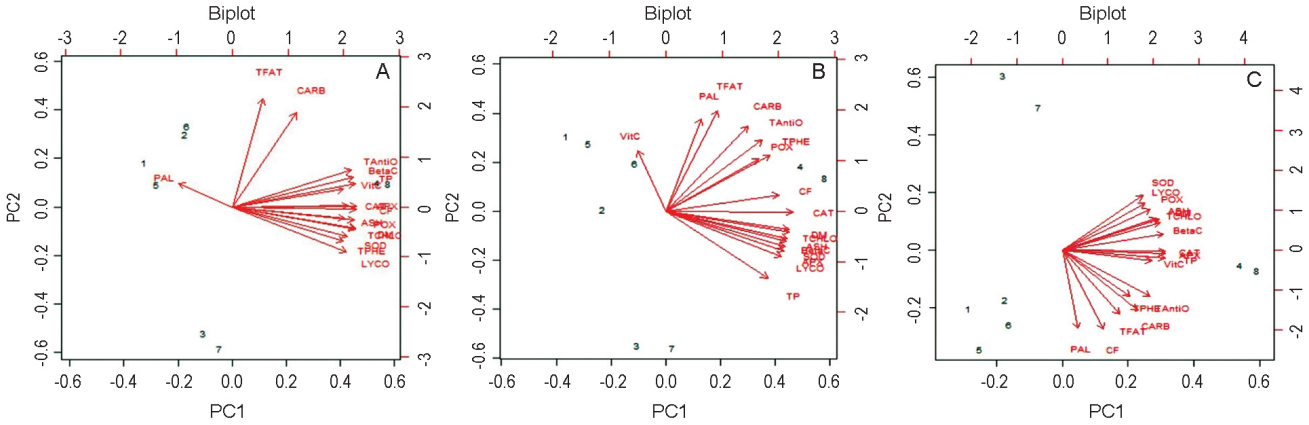

Fig. 2 (A) PCA Biplot of biochemical parameters under conventional cultivation; (B) Saline cultivation; (C) Organic cultivation. PAL, Phenylalanine ammonia lyase; SOD, Superoxide dismutase; POX, Peroxidase lycopene; Beta C, Beta carotene.

and saline soil, respectively. Catalase activity had been decreased by 4.21% in conventional soil and 33.75% in organic soil, compared to saline soil. It was clear that GT-6 and DVRT-2 both had the highest phenylalanine ammonia-lyase enzyme activity (8.09 mmol cinnamic ac./g/min) under saline soil cultivated fruits. The PAL activity was found to be increased both under organic as well as saline soil in our experiment. The salinity stress induces oxidative stress, which activates many enzymes like PPO (Polyphenol oxidase) and increases total phenol content as reported by Al-Hassan *et al.* (2015). The genotype namely DVRT-2 among all other genotypes showed the highest peroxidase enzyme activity in saline conditions (66.91 U/mg protein). Perez-Labrada *et al.* (2019) observed that under saline tomatoes had higher phenylalanine enzyme activity as compared to tomatoes grown under normal soil. The peroxidase activity decreased by 57.73% and 45.72% in POD in conventional as well as organic soil, respectively. Superoxide dismutase activity increases of 76.26% and 49.23% in saline as well as organic soil over conventional soil had occurred while the highest SOD activity was found in DVRT-2 (86.74 U/mg protein) fruits grown under saline soil (Table 3). According to Sofo *et al.* (2015), during the ripening stage of fruit, the level of reactive oxygen species (ROS) rises and as a result of which, mitochondrial protein is damaged. To combat the harmful effects of (ROS), antioxidative enzymes like ascorbate peroxidase activity is also increased.

Principal component analysis of the present experimental data revealed a total of eight principal components (PC). Three Principal components among eight (PC1, PC2 and PC3) had an eigen value of more than one. It has been seen that more than 70% variance was explained by the first 3 PCs. The scree plot also agrees with the same result as the curve attained an elbow shape or flattened at PC3 (Fig. 1A, 1B, and 1C) for all three types of soil. The PCA biplot diagram (Fig. 2A, 2B, and 2C) represented a focused total of 17 arrows to depict each variable. Biplot between PC1 and PC2 for conventional soil cultivation, raised the parameters like total carbohydrate total fat, total antioxidant, beta carotene, total protein, and vitamin C as positive loading whereas APX, POX, SOD, total phenol, and lycopene exhibited negative loading (Fig. 2A). Those variables which showed, a positive significant correlation had a major role in improving the fruit quality under conventional soil management type. The Biplot produced for the response of different biochemical parameters under saline cultivation has been depicted in Fig. 2B. Under saline stress, parameters like POX, total phenol, PAL, total fat, carbohydrate, and total antioxidant

showed positive loading between PC1 and PC2 biplot, which had a major role in improving the fruit quality under saline soil management. Organic soil cultivation depicted positive loading of the parameters like SOD, lycopene, POX, ash, total chlorophyll, and beta carotene shows positive loading (Fig. 2C), leading to a high chance for quality improvement under organic cultivation. A general thumb rule is to retain the principle components that account for at least 70% of total variability (Craig and Rachel 2017).

In the nutshell, our study depicted that DVRT-2 genotype had highest nutritional value for both years in term of biochemical parameters like carbohydrates, ash, dry matter, crude fibre, total protein, total antioxidants, total phenol, vitamins like vitamin-C, beta carotene, pigments like lycopene in mature fruits at harvesting stage. Enzymes like ascorbate peroxidase, peroxidase, catalase, superoxide dismutase were also found highest in DVRT-2 genotypes. Phenylalanine ammonia lyase activity and fruit girth were found highest in GT-6 genotypes. In terms of nutritional content, organic cultivation was determined to be superior to conventional farming, followed by saline cultivation. Under organic cultivation, no chemical fertilizer had been applied. Hence, none of the nutrients is applied in its readily available which creates mild nutritional stress. It can be conferred that, mild nutritional stress is the cause of the qualitative enhancement that organic farming has introduced while on the other hand, the extreme stress caused by salinity has deteriorated the quality of fruits.

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