Environment and Ecology 40 (3B) : 1570—1577 July—September 2022
ISSN 0970-0420

Quantification of the Effect of Organic Manure and Biofertilizer on Quality Traits of Cherry Tomato (*Solanum lycopersicum* var *cerasiformae*) Genotypes

Ankita Sharma, D. P. Sharma, Reena Nair, Pragya Singh

Received 20 April 2022, Accepted 31 May 2022, Published on 11 August 2022

ABSTRACT

The present research work was carried out at the Horticulture complex, Department of Horticulture, J.N.K.V.V, Jabalpur, (M.P.) during the *rabi* season in 2018–19 under open field conditions to identify desirable quality traits of cherry tomato genotypes. The genotypes grown in the experiment were laid on completely randomised asymmetrically designed (factorial) blocks with five levels of genotypes, three levels of vermicompost doses and biofertilizers, which were evaluated and studied on the basis of the mean performance of cherry tomato genotypes for quality characters. Maximum vitamin C content (25.36mg100 g^{-1}) was recorded in 2018/TOC VAR-1. Genotype 5 2018/TOC VAR-5 possessed the highest magnitude (3.97%) of total sugar content and reducing sugar content (2.95%), whereas 2018/TOC VAR-2 possessed the highest pH (4.13). Higher value of ascorbic acid content (24.82 mg100 g^{-1}), acidity (0.34%), pH value (4.12), total sugar (3.90%) and reducing sugar (2.90%) was recorded under vermicompost 5t ha^{-1} and *Azotobacter* 4 kg ha^{-1}, which showed significant superiority. T_9 2018/TOC VAR-4 receiving Vermicompost 5 t ha^{-1} and Azotobacter possessed significant more acidity percentage (0.44%), higher pH of 4.19. Thus was concluded that T_9 was the best treatment among all.

Keywords Cherry tomato genotypes, Quality, *Azotobacter*, Vermicompost, Yield.

Ankita Sharma*
Research Scholar, Department of Horticulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur, 482004, Madhya Pradesh, India

Dr. D.P. Sharma
Professor and Director Extension Services, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur, Madhya Pradesh, India

Dr. Reena Nair
Assistant Professor, Department of Horticulture, COA, Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur, Madhya Pradesh, India

Dr. Pragya Singh
Guest Teacher, Department of Horticulture, R.V.S.K.V.V, Gwalior (MP), India

Email : ankitasharma199511.as@gmail.com
*Corresponding author

INTRODUCTION

Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*), belonging to the family Solanaceae, is derived from cultivated tomato lines through domestication. The fruits are utilized in different ornamental dishes, fresh markets and are highly valued for their excellent taste and attractive color due to high lycopene content. (Ramya *et al.* 2016) Cherry tomato fruits are readily accepted by customers as they're pleasing in appearance and delicious to taste. In their study, Rune and Michelle (2011) stated that fresh cherry tomatoes have high chalconaringenin and rutin as compared to Lycopene. It is mostly considered to be a "protective food" due to its nutritive value, antioxidant molecules such as carotenoids, lycopene, ascorbic acid, vitamin E and phenol compounds such as flavonoids (Sepat *et al.* 2013). Tomato fruits higher in both acids and sugars have good flavor which reduces the cost of processing, whereas bland tomatoes have low acidity and tart tomatoes have low sugar content considered as insipid tomatoes (Yahia and Brecht 2012). The complexity in the color of tomato fruit is a consequence of the presence of a diverse carotenoid pigments and the appearance is conditioned by diverse types of pigments and concentrations. (Radzevičius *et al.* 2014) In addition, market value of the cherry tomato is, on average, two to three times higher than other varieties (Araujo 2013). Soluble solids and Titrable acidity are considered to be vital components for the flavor of tomato and should match the consumer's preference (Bravo *et al*. 2012). The flavor of tomato is determined by the amount of sugars mostly glucose and fructose which constitutes 65% of the soluble solids and the acid present (Ibrahim *et al.* 2017). The taste and aroma of tomato is insighted by the different chemical constituents which are relevant for sweetness, sourness and overall intensity of tomato fruit. (Rai *et al.* 2011)

Distinct quality attributes of cherry tomato laid an emphasis on fresh and processed produce as high content of antioxidant and phytochemical compounds are a requisite for better marketing and processing. Cherry tomato fruits have an excellent consumer acceptance due to its distinguished characteristics such as high sweetness (Preczenhak *et al.* 2014) and some diverse organoleptic attributes superior to the traditional tomato fruits (Pinheiro 2016). Despite the quality of the fresh produce of tomatoes, the acceptability is always questionable due to the excessive use of chemical fertilizers and pesticides. Vermicompost obtained after decomposition of organic material is rich in potassium Hanc and Vasak (2015), Renuka *et al.* (2014) and Çolpan *et al.* (2013) reported that potassium enhanced the yield and fruit quality of tomato. Quality parameters such as ascorbic acid and soluble sugar content in cherry tomato fruits indicated that quality can be improved by the addition of vermicompost. Some reports presented by Jindo *et al.* (2016) have signified that the growth, yield and quality of vegetables such as tomato, okra can be benefitted from an increase in soil organic carbon content due to application of vermicompost. Cherry tomatoes are tolerant towards diseases as they have a higher nutritional content of vitamin C (>57 mg/100 gfw), antioxidants, photochemical components and lycopene content, which exceed 10mg/100g fresh weight(Islam *et al.* 2012 and Kavitha *et al.* 2014)

The current study was undertaken to throw light on the impact of different doses of vermicompost and biofertilizer with a view to apprehend the quality attributes of cherry tomato genotypes. The quality of the fruit was assessed through the content of the compounds such as Total soluble solids, acidity, pH, ascorbic acid and total sugars.

MATERIALS AND METHODS

The field experiment was conducted at Horticulture complex, Department of Horticulture, J.N.K.V.V., Jabalpur (MP) during the *rabi* season in 2018-19 under open field condition and the quality analysis was conducted in laboratory of department of horticulture, J.N.K.V.V., Jabalpur which is situated in 23.9°N latitude and 79.58°E longitudes with an altitude of 411.8 m above the mean sea level, to identify desirable quality traits of cherry tomato genotypes.

RESULTS AND DISCUSSION

The quality attributes of cherry tomato such as Total Soluble Solids, Titrable acidity, pH, ascorbic acid, total sugars, reducing sugar and non-reducing sugars are influenced by temperature, light intensity and biofertilizers. Firmness in fruits of cherry tomato indicates the keeping quality after the harvest as it stays for a longer time due to reduced ripening.

Total soluble solids (°Brix)

Total soluble solids (TSS) content is an important trait to determine the processing of the cherry tomatoes. Determination of TSS in percent was done by hand refrectometer having a range of 0 to 32°Brix,

Table 1. Mean performance of quality characters in cherry tomato.

Treatments	TSS (°Brix)	pH	Ascorbic acid (mg 100 g^{-1})	Acidity	Total Sugar %	Reducing Sugar%	Non-reducing sugar %
Genotypes							
$G_1$2018/TOC VAR-1	6.62	4.07	25.38	0.24	3.95	2.94	1.01
$G_2$2018/TOC VAR-2	5.81	4.13	23.58	0.21	3.86	2.63	1.23
$G_4$2018/TOC VAR-4	6.87	4.01	23.61	0.43	3.69	2.61	1.07
$G_5$2018/TOC VAR-5	4.73	4.11	22.73	0.38	3.97	2.95	1.02
$G_6$2018/TOC VAR-6	4.01	4.05	25.03	0.40	3.70	2.72	0.99
SEm±	0.061	0.007	0.17	0.005	0.07	0.06	0.04
CD 5% level	0.17	0.02	0.50	0.015	0.19	0.17	0.12
Vermicompost doses							
B_1 Control	5.50	4.04	22.97	0.32	3.71	2.57	1.14
B_2 Vermicompost 2.5 t ha^{-1}	5.72	4.07	24.04	0.33	3.87	2.83	1.04
B_3 Vermicompost 5 t ha^{-1}	5.61	4.12	25.17	0.34	3.90	2.90	1.00
SEm±	0.047	0.005	0.13	0.004	0.05	0.04	0.03
CD (p=0.05)	0.137	0.015	0.39	0.012	0.14	0.12	0.08
Interactions							
T_1 G_1B_1	6.24	4.02	24.41	0.22	3.68	2.75	0.93
T_2 G_1B_2	6.88	4.07	25.26	0.24	4.27	3.13	1.14
T_3 G_1B_3	6.75	4.13	26.47	0.25	3.87	2.91	0.96
T_4 G_2B_1	5.63	4.09	22.28	0.21	3.95	2.33	1.62
T_5 G_2B_2	5.87	4.10	23.90	0.22	3.72	2.71	1.01
T_6 G_2B_3	5.95	4.19	24.55	0.20	3.93	2.84	1.08
T_7 G_4B_1	6.87	3.98	22.60	0.43	3.65	2.74	0.91
T_8 G_4B_2	6.92	4.01	23.10	0.42	3.42	2.36	1.06
T_9 G_4B_3	6.83	4.04	25.13	0.44	4.00	2.75	1.25
T_{10} G_5B_1	4.87	4.08	21.67	0.37	3.75	2.53	1.23
T_{11} G_5B_2	4.97	4.11	22.90	0.38	4.09	3.17	0.93
T_{12} G_5B_3	4.34	4.14	23.63	0.39	4.05	3.16	0.89
T_{13} G_6B_1	3.88	4.02	23.92	0.37	3.56	2.50	1.06
T_{14} G_6B_2	3.95	4.05	25.07	0.39	3.87	2.80	1.08
T_{15} G_6B_3	4.19	4.09	26.10	0.43	3.67	2.85	0.81
SEm±	0.105	0.012	0.30	0.009	0.11	0.10	0.07
CD (p=0.05)	0.31	0.030	N/A	0.025	0.34	0.30	0.20

by placing one or two drops of clear tomato juice on the prism. The flavor of the product depends on TSS. The genotypes of cherry tomato differed significantly for the values of TSS in °Brix.

A perusal of data with respect to total soluble solids (TSS) of tomato fruits is presented in Table 1. The data pertaining to TSS showed highly significant differences among the cherry tomato genotypes. TSS of cherry tomatoes varied significantly between 4.01–6.87°Brix. The data exhibited that G4 2018/TOC VAR-4 had higher (6.87°Brix) TSS content and was preceded by G1 2018/TOC VAR-1 having 6.63 °Brix. G6 2018/TOC VAR-6 had the minimum (4.01 °Brix) TSS content. Higher TSS content and low acidity are important factors for processed tomato products. The enhanced deposition of the solids and the conversion of organic acids into sugars lead to a higher content of TSS. Similar results have been obtained by Juarez-Lopez *et al.* (2009), Silva *et al.* (2011), Islam *et al.* (2012) and Renuka *et al.* (2014) in cherry tomato. Total soluble solid as influenced by different vermicompost levels also showed significant variation. It is evident from Table that the maximum TSS (5.72 °Brix) was obtained with treatment B_2 receiving vermicompost 2.5t ha^{-1} and Azotobacter 4 kg ha^{-1}. Minimum TSS was noted in treatment B1 (5.5 °Brix) having 100% RDF alone. These findings

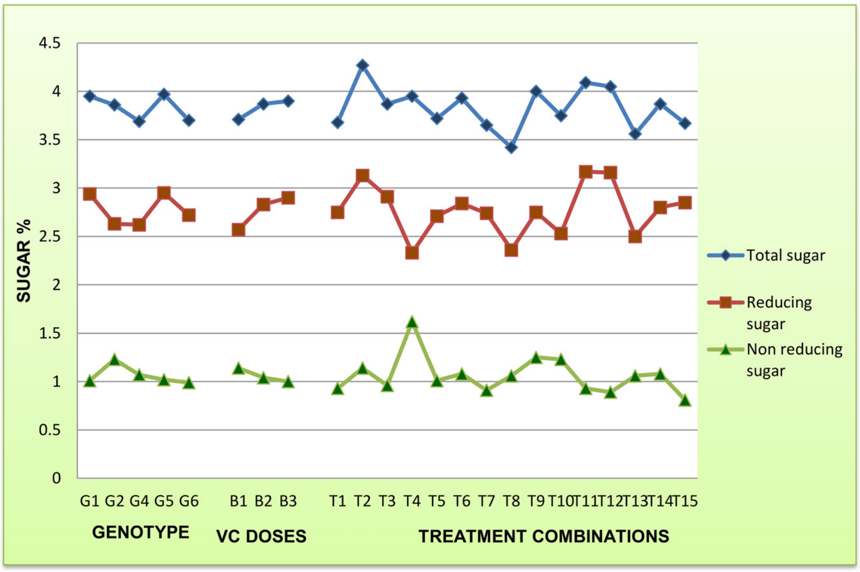

Fig. 1. Graphical representation of sugars in cherry tomato under different treatments.

are in consonance with those of Sharma *et al.* (2010), who noted a higher value of TSS under the application *Azotobacter.* Significant results were obtained with treatment combinations. It was found that genotype 2018/TOC VAR-4 with treatment having combination of vermicompost 2.5 t ha^{-1} and *Azotobacter* 4 kg ha^{-1} (T_8) recorded maximum value of TSS (6.92). However, minimum total soluble solids were obtained in treatment combination T_{13} (3.88 °Brix). The mean values of °Brix degree differed as per the variety, method of cultivation and crop harvest period for the same group of tomatoes. One percent increase in the TSS content of cherry tomato fruit leads to twenty percent increment in the recovery of the processed products (Fig. 1).

Ascorbic acid (mg 100 g^{-1})

The estimation of ascorbic acid was done by using the assay method so proposed by Ranganna in 1986 using fresh cherry tomato samples. The results are presented in Table 1.

Amongst genotypes of cherry tomato, the maximum vitamin C content (25.38 mg 100g^{-1}) was recorded in G_1 2018/TOC VAR-1. The lowest magnitude for this character was observed in G_5 2018/TOC VAR-5 having 22.7 mg 100 g^{-1} of ascorbic acid content. The results so obtained were in concurrence with the findings of Juarez-Lopez *et al*. (2009), Crisanto-Juarez *et al.* (2010) and Ceballos-Aguirre and vallejo cabrera (2012). Higher amount of ascorbic acid content may be due to more number of locules. A significant variation in the ascorbic acid content may be due to a large divergence among the different cultivars of cherry tomato and their genetic makeup and ability to perform under open field conditions. In factor II, the higher value of ascorbic acid content (25.17 mg 100 g^{-1}) was recorded in treatment B_3 (vermicompost 5 t ha^{-1} and *Azotobacter* 4 kg ha^{-1}) followed by B_2 (24.04 mg100 g^{-1}). The minimum value (22.97 mg 100 g^{-1}) was noticed in B_1 Control (RDF). Abduli *et al*. (2013) noted an increase in Vitamin C and total sugar content in tomatoes using vermicompost. The finding further showed that Ascorbic acid of fruit was not influenced significantly by interactions. Ascorbic acid content values ranged from 21.67–26.47 mg 100 g^{-1} of fresh fruit. Moreover, the maximum Ascorbic acid content (26.47 mg 100 g^{-1}) was obtained in treatment combination T_3 2018/TOC VAR-1 receiving vermicompost 5t ha^{-1} and the minimum (21.67 mg 100g^{-1}) was recorded in T_{10} 2018/TOC VAR-5

Control (RDF). The results were in conformity with the experiment conducted by Razzak *et al*. (2013) in cherry tomato.

Acidity (%)

The data for various treatments with respect to acidity percentage given in Table 1 indicates that the treatments have a highly significant impact on the characters. The titratable acidity indicated as percent citric acid attained by titrating 10 ml of tomato juice to pH 8.2 with 0.1N NaOH. Lower acidity is a deciding factor for the processing of tomatoes as it reduces the time that is required for processing.

The genotypes with respect to acidity % indicated the significant impact. $G_4$2018/TOC VAR-4 exhibited (0.43%) maximum total acidity percentage, and G_2 2018/TOC VAR-2 indicated the minimum value (0.21%) of total acidity %.The cultivars of cherry tomato with lower titrable acidity may be due to rapid utilization of organic acids in respiration during maturity. This is in consonance with the findings of Sumathi *et al.* (2013) in tomato and Razzak *et al.* (2013) in cherry tomato. Acidity % was significantly influenced by vermicompost doses B_3 vermicompost 5t ha^{-1} and *Azotobacter* 4 kg ha^{-1} recorded the highest magnitude for acidity percentage (0.34%) and the least (0.32%) was observed with Control (RDF). In case of interaction, T_9 2018/TOC VAR-4 receiving vermicompost 5tha-1 and *Azotobacter* 4 kg ha^{-1} possessed significant more acidity (0.44%) over the rest except T_7 (0.43%), T_8 (0.42%) and T_{15} (0.43%) which were at par. Treatment combination T_4 2018/TOC VAR-2 Control (RDF) possessed the minimum acidity (0.21%).The lower values obtained for acidity may be due to the red fruits taken for analysis (Rana *et al.* 2014). A similar trend was observed by Juarez-Lopez *et al.* (2009), Ceballos Aguirre and Vallejo-Cabrera (2012) and Gharezi *et al.* (2012) in cherry tomato.

pH

A perusal of the data presented in Table 1 revealed that pH of cherry tomato fruit was influenced by different levels of vermicompost, which was found to be significant. The pH of each juice sample was measured by using pH meter with a glass electrode. The pH range for tomato fruit lie is between 4.0 and 4.5. The lower the pH of cherry tomato fruit, the higher is the tartness which is used as a quality determining factor by consumers.

Among factor I, genotype 2018/TOC VAR-2 possessed the highest (4.13), and it was preceded by G_5 2018/TOC VAR-5 (4.11) which was at par with G2. However, G_4 was found to be associated with the lowest (4.01). The observation on pH revealed that as influenced by different levels of vermicompost was found to be significant. The maximum (4.12) and minimum (4.04) pH was observed in treatment B_3 (vermicompost 5 t ha^{-1} and *Azotobacter* 4 kg ha^{-1}) and B_1 (100% RDF) respectively. Similar results have been obtained by Crisanto-Juárez *et al*. (2010), Araghian *et al*. (2015) and Truong *et al.* (2018) as fruit pH increased with an increase in the biofertilizer concentration. pH due to interaction was found to be significant. The higher pH (4.19) was recorded in treatment combination T_6 (2018/TOC VAR-2 receiving vermicompost 5 t ha^{-1} and Azotobacter) followed by T_{12} 2018/TOC VAR-4 vermicompost 5 t ha^{-1} and *Azotobacter* 4 kg ha^{-1} having pH 4.14. T_7 (2018/TOC VAR-4 Control) recorded the lowest value (3.98) for this quality character.

Total sugar (%)

The data pertaining to total sugar content of tomato fruit as influenced by genotypes and levels of vermicompost is presented in Table 1. The sugar concentration of tomato fruits is affected by plant nutrient source such as vermicompost and biofertilizers, water supply and intensity of light. Sugar content determines the flavor attributes in cherry tomato. It could be observed that the sugar percentage was significantly influenced by genotype, vermicompost levels, and their combinations.

The observation of sugar content disclosed that among factor I, genotype 5 2018/TOC VAR-5 possessed the highest magnitude of (3.97%) sugar content; it, however, did not differ significantly from G_1 2018/TOC VAR-1. However, G_4 2018/TOC VAR-4 was found to be associated with the lowest (3.69%) total sugar per cent. The data so obtained are similar to the values published by Nguyen Hong Minh et al.

(2013) and Ibrahim *et al.* (2017). Among factor II, higher total sugar content (3.90%) was observed in B_3 (vermicompost 5 t ha^{-1} and *Azotobacter* 4 kg ha^{-1}) and showed significant superiority. Least sugar content was recorded in B1 (3.71%) with 100% RDF. The interaction effects were found to be significant. The highest total sugar content (4.27%) was obtained in T22018/TOC VAR-2 vermicompost 5tha-1 and Azotobacter 4 kg ha^{-1}. Treatment combination T_8 (G_4B_2) recorded lowest total sugar content (3.42%). Jindo *et al.* (2016) reported that tomato fruit quality can be improved due to increase in soil organic carbon by the addition of vermicompost.

Reducing sugar (%)

The data pertaining to reducing sugar % among the different genotypes of cherry tomato given in Table 1 indicates that the treatments give the significant impact on the characters. Reducing sugar was determined by general volumetric method standardized by A.O.A.C. (1960). The study of the data indicated that higher value for reducing sugar was observed in G_5 2018/TOC VAR-5 (2.95%) followed by G1 2018/TOC VAR-1 having 2.94% which was at par. Least reducing sugar (2.61%) was reported in genotype 2018/TOC VAR-4. The present investigation is in cognizance with the findings of Ibrahim *et al.* (2017) on physiological and biochemical characteristics of different tomato grown in Rajshahi region of Bangladesh. The reducing sugar % of cherry tomato was significantly influenced by the doses of vermicompost and *Azotobacter*. B_3 Vermicompost (5t ha^{-1}) and *Azotobacter* 4 kg ha^{-1} recorded the maximum (2.90%) and was found to be at par with B_2 (2.83%). B_1 (100% RDF) recorded the lowest value (2.57%) for this quality character. With regard to the interaction, combination G_5B_2 recorded the maximum reducing sugar percent (3.17%) which is at par with treatment combination G_1B_2 (T_2) (3.13%) and 3.16% in G_5B_3 (T_{12}). However, the minimum (2.33%) was recorded under the treatment combinations T_4 2018/TOC VAR-2 Control.

Non-reducing sugar (%)

The data pertaining to non-reducing sugar in Table 1 due to genotypes depicted that the highest (1.23%) was obtained in G_2 2018/TOC VAR-2 followed by G_4 (1.07). Lowest 1.01% was observed in treatment G_1 2018/TOC VAR-1. Due to decreased degradation of acids during ripening and senescence, a highly significant and varied result was obtained for non-reducing sugars. Similar results have been demonstrated by Caliman *et al*. (2010) and Razzak *et al.* (2013) in tomatoes. With regards to vermicompost levels, the minimum non-reducing sugar (1%) was recorded under B3 vermicompost (5 t ha^{-1}) and *Azotobacter* (4 kg ha^{-1}) while it was maximum (1.14%) under B_1 (100% RDF). In case of interaction, the highest 1.62% was recorded in G_2B_1 2018/TOC VAR-2 Control. The lowest 0.81% was noted in treatment combination T_{15} comprising of 2018/TOC VAR-6 grown with vermicompost (5 t ha^{-1}) and *Azotobacter* (4 kg ha^{-1}). The findings are substantiated with those reported by Hossain *et al.* (2010) and Ibrahim *et al.* (2017).

CONCLUSION

It is evident from the study that a higher dose of vermicompost and biofertilizer had a beneficial effect on fruit quality by enhancing the nutritional and economic value of cherry tomato for consumers and farmers respectively. A higher value of ascorbic acid content (25.17mg 100 g^{-1}), acidity percentage (0.34%), pH value (4.12), total sugar (3.90%) and reducing sugar (2.90%) was obtained with vermicompost 5tha-1 and *Azotobacter* 4 kg ha^{-1}. G_4 2018/TOC VAR-4 had higher (6.87 ^{o}Brix) total soluble solids content and total acidity percentage (0.43%). These data so substantiated on various quality attributes of cherry tomato fruit ensures to provide eminent information for the consumers, producers and industrial processor for plantation and processing industry to produce better quality product and potential cultivar.

ACKNOWLEDGEMENT

The authors are highly grateful to the Department of Horticulture, J.N.K.V.V., Jabalpur, Madhya Pradesh, for providing technical and financial assistance during the research work.

REFERENCES

Abduli MA, Amiri L, Madadian E, Gitipour S, Sedighian S (2013) Efficiency of vermicompost on quantitative and qualitative growth of tomato plants. *Internat J Environm Res* 7 (2) : 467—472.

Araghian S, Bagherzadeh A, Sadrabadi R (2015) Effect of brown algae and vermicompost application on some cherry tomato traits in hydroponic system. *Agroecol J* 10 (4) : 77—83.

Araujo L (2013) Cherry tomato grown in different concentrations of nutrient solution in hydroponic capillary. *Unimontes Científica* 15 (1) : 18—27.

Bravo S, Garcia-Alonso J, Martin-Pozuelo G, Gomez V, Santaella M, Navarro-Gonzalez I (2012) The influence of postharvest UV-C hormesis no lycopen, β-carotene and phenolic content antioxidant activity of breaker tomato. *Food Res Internat* 49 : 296—302.

Caliman FRB, Henriques da Silva DJ, Stringheta PC, Rezende Fontes PC, Rodrigues Moreira G, Chartuni Mantovani E (2010) Quality of tomatoes grown under a protected environment and field conditions. *Idesia* (*Arica*) 28 (2) : 75—82.

Ceballos-Aguirre N, Vallejo-Cabrera FA (2012) Evaluating the fruit production and quality of cherry tomato (*Solanum lycopersicum* var. *cerasiforme*). *Revista Facultad Nacional de Agronomía Medellín* 65 (2) : 6593—6604.

Crisanto-Juarez AU, Vera-Guzman AM, Chavez-Servia JL, Carrillo-Rodríguez JC (2010) Fruit quality of wild tomatoes (*Lycopersicon esculentum* var. *cerasiforme* Dunal) from Oaxaca, Mexico. *Revista fitotecnia Mexicana* 33 (4) : 7—13.

Çolpan E, Zengin M, Zbahçe A (2013) The effects of potassium on the yield and fruit quality components of stick tomato. *Horticult Environ Biotechnol* 54 : 20—28.

Gharezi M, Joshi N, Indiresh KM (2012) Physico-chemical and sensory characteristics of different cultivars of cherry tomato. *The Mysore J Agricult Sci* 46 (3) : 610—613.

Hanc A, Vasak F (2015) Processing separated digestate by vermicomposting technology using earthworms of the genus Eisenia. *Internat J Environ Sci Technol* 12 : 1183—1190.

Hossain ME, Alam MJ, Hakim MA, Amanullah ASM, Ahsanullah ASM (2010) An assessment of physico-chemical properties of some tomato genotypes and varieties grown at Rangpur. *Bangladesh Res Pub J* 4 (3) : 135—243.

Ibrahim M, Helali M, Alam AKMS, Talukder D, Akhter S (2017) Physiological and biochemical characteristics of different tomato grown in Rajshahi region of Bangladesh. *Bangladesh J Sci Indust Res* 52— 195.

Islam MS, Mohanta HC, Ismail MR, Rafii MY, Malek MA (2012) Genetic variability and trait relationship in cherry tomato (*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray). *Bangladesh J Bot* 41 (2) : 163—167.

Jindo K, Chocano C, De Aguilar JM, Gonzalez D, Hernandez T, Garcia C (2016) Impact of compost application during 5 years on crop production, soil microbial activity, carbon fraction, and humification process. *Commun in Soil Sci Pl Analysis* 47 : 1907—1919.

Juarez-Lopez P, Castro-Brindis R, Colinas-Leon T, mirez-Vallejo P, Sandoval-Villa M, Reed DW (2009) Evaluation of quality in fruits of seven native tomato (*Lycopersicon esculentum* var. *cerasiforme*) genotypes. *Revista Chapingo Serie Horticultura* 15 (2) : 5—9.

Kavitha P, Shivashankara KS, Rao VK, Sadashiva AT, Ravishankar KV, Sathish GJ (2014) Genotypic variability for antioxidant and quality parameters among tomato cultivars, hybrids, cherry tomatoes and wild species. *J Sci Food Agric* 94 : 993—999.

Minh NH, Long TT, Minh NT (2013) The result of evaluating process some new hybrid tomato combinations at the northern coastal areas of Vietnam in autumn and spring-summer season. *J Sci Develop* 11 (5) : 621—628.

Nguyen HM, Tran TL, Nguyen TM (2013) The result of evaluating process some new hybrid tomato combinations at the northern coastal areas of Vietnam in autumn and spring-summer season. *J Sci Develop* 11 (5) 621—628.

Preczenhak AP, Juliano TVR, Chagas RR, Silva PR, Schwarz K, Morales RGF (2014) Agronomic characterization of mini tomato genotypes. *Horticult Brasileira* 32 : 348—356.

Pinheiro RR (2016) Light supplementation on tomato cultivated in different management systems in greenhouse, pp 97.

Radzevičius A, Viskelis P, Viškelis J, Karklelienė R, Juskeviciene D (2014) Tomato fruit color changes during ripening on vine. *Int J Biological Vet Agric Food En* 8 : 114—116.

Rai GK, Kumar R, Singh J, Rai PK, Rai SK (2011) Peroxidase, polyphenol oxidase activity, protein profile and phenolic content in tomato cultivars tolerant susceptible to *Fusarium oxiporum* F. sp. *Lycopersici*. *Pakistan J Bot* 43 (6) : 2987—2990.

Ramya R, Ananthan M, Krishnamoorth V (2016) Evaluation of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] genotypes for yield and quality traits. *Asian J Horticult* 11 (2) : 329—334.

Rana N, Kumar M, Walia A, Sharma S (2014) Tomato fruit quality under protected environment and open field conditions. *Int J Bio-resource Stress Manag* 5 (3) : 422—426.

Ranganna S (1986) Hand Book of Analysis and Quality Control of Fruit and Vegetable Products. *Tata McGraw-Hill Educ* 838—865.

Razzak HA, Ibrahim A, Wahb-Allah M, Alsadon A (2013) Response of cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) to pruning systems and irrigation rates under greenhouse conditions. *Asian J Crop Sci* 5 (3) : 275—285.

Renuka DM, Sadashiva AT, Kavita BT, Vijendrakumar RC, Hanumanthiah MR (2014) Evaluation of cherry tomato lines (*Solanum lycopersicum* var. *cerasiforme*) for growth, yield and quality traits. *Pl Arch* 14 (1) : 151—154.

Rune S, Michel V (2011) Properties of chalconaringenin and and rutin isolated from cherry tomatoes. *J Agricult Food Chem* 59 (7) : 3180—3185.

Sepat NK, Sepat SR, Sepat S, Kumar A (2013) Energy use efficiency and cost analysis of tomato under greenhouse and open field production system at Nubra valley of Jammu and Kashmir. *Int J Environm Sci* 3 : 1233—1241.

Sharma RP, Tiwari RR, Sureja RN, Gajbhiye AK (2010) Effect of inorganic and bio-fertilizers on fruit quality of tomato. *Ind J Horticult* 67 : 301—304.

Silva AC, Cost CA, Sampio RA, Martins ER (2011) Evaluation of heat tolerance cherry tomato lines under organic production system. *Revista Caatinga* 24 (3) : 33—40.

Sumathi T, Suchindra R, Narayanan RS, Nainar P (2013a) Studies on evaluation of tomato (*Solanum lycopersicum* Mill) genotypes under polyhouse condition for yield attributing characters. *Pl Arch* 13 (2) : 975—978.

Truong H, Wang CH, Kien TT (2018) Effect of vermicompost in media on growth, yield and fruit quality of cherry tomato (*Lycopersicon esculentun* Mill.) under net house conditions. *Compost Sci Utilization* 26 (1) : 52—58.