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Evaluation of tomato (*Solanum lycopersicum*) genotypes for plant growth, fruit yield and quality

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ABSTRACT

The study was carried out with different tomato (*Solanum lycopersicum* L.) genotypes during 2018 and 2019 at Division of Basic Sciences and Humanities (SKUAST-K), Shalimar, Srinagar (J&K) to assess the plant and fruit growth with quality characters and mineral composition. Healthy and uniform seedlings of twelve tomato genotypes were transplanted in pots with four replications. Among different genotypes, 2016/TODVAR-9 (G_8) recorded the highest leaf area (713.6 cm^2) and fruit yield (1.77 kg/plant) that also showed maximum values TSS (4.35%), titrable acidity (1.32%), vitamin C (36.18 mg/100g), lycopene (6.84 mg/100g) and carotenoid (8.28 mg/100g) contents coupled with maximum P (0.83%), K (2.35%), Mg (0.52%) and Ca (0.23%) contents. Regression analysis of the data showed a strong correlation between leaf area and fruit yield ($r = 0.86^{**}$), leaf area and fruit sugar content ($r = 0.60^{*}$), PLW and fruit Ca content ($r = -0.97^{**}$), fruit Ca content and storage life ($r = 0.97^{**}$) and fruit PLW and storage life ($r = -0.98^{**}$).

Keywords: Fruit yield, Leaf area, Mineral content, Tomato, Vitamin C

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetables used in several traditional dishes because of its compatibility with other food ingredients and high nutritional and antioxidant value. It belongs to the family Solanacae. Tomato fruits are so unique in nature, which can be used as fresh vegetable as well as processed products such as juice, ketchup, sauce, canned fruits, puree, paste, etc. About 171 million tonnes of tomatoes are harvested annually from plantings of 5 mha. Almost 60% of world production comes from Asia, 11.1% from Africa, 13.3% from Europe, 11.3% from Africa, 8.7% from North America, and 6.6% from Central America and South America. The world's top five greatest producers of tomato in 2014 were China, India, the United States, Turkey and Egypt (FAOSTAT 2017).

Genetic diversity strengthens the prospects of plant to exist and survive under variable climatic conditions. It also provides opportunity for plant breeders to develop new and improved cultivars with desirable characteristics, which include both farmer-preferred traits (high yield potential, large seed, etc.) and breeders preferred traits (pest and disease resistance and photosensitivity, etc.). A large number of tomato genotypes with huge variability in plant phenotype, physiology and yield characters are available in the country. Fruit yield and quality characters mostly depends on plant growth and physiological characters. Performances of different genotypes are also influenced by the environment where they are being grown. Therefore, selection of best genotypes for obtaining higher yield with improved fruit quality is of central importance. The present experiment was conducted to select the superior genotypes in terms of fruit yield and quality and to recognize the relationship, if any, exists among different characters.

MATERIALS AND METHODS

The present experiment was conducted in pots during 2018 and 2019 at Division of Basic Sciences and Humanities, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar, India. Soil used in the pots was low in available nitrogen (228.50 kg/ha) and medium in phosphorus (19.25 kg/ha) and potassium (203.20 kg/ha) with normal *p*H (6.98) and organic carbon (0.86%). The recommended doses of fertilizers were supplied as 0.96, 0.80 and 0.48 g of N, P and K, respectively in all pots. In addition, 250 g of vermicompost was also added in each pot. Healthy and uniform seedlings of 12 genotype of tomato namely 2016/Todvar-1 (G_1), 2016/Todvar-2 (G_2), 2016/Todvar-3 (G_3),

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2016/Todvar-4 (G_4), 2016/Todvar-5 (G_5), 2016/Todvar-7 (G_6), 2016/Todvar-8 (G_7), 2016/Todvar-9 (G_8), 2016/Todvar-10 (G_9), 2016/Todvar-11 (G_{10}),2016/Todvar-12 (G_{11}),2017/Todvar-3 (G_{12}) were transplanted in pots containing 8.0 kg of soil with four replications and arranged under complete randomized design (CRD). Observations were made on leaf area, fruit weight, number of fruit, fruit yield, peel thickness, total sugars, titrable acidity, vitamin C, fruit carotenoid and mineral composition. Physiologically ripened fruits were harvested from time to time and their number and weight were estimated. The peel thickness was measured with the help of digital Vernier caliper by peeling out the ripened tomato fruits. The amount of total sugars was determined calorimetrically using phenol sulphuric acid method.

Titratable acidity was measured by titrating 10 ml of tomato juice against 0.1 N NaOH using phenolphthalein as an indicator. The end point appeared light pink in colour. Vitamin C content was determined using 2, 6-Dichlorophenol indophenols method. Determination of total carotenoids and lycopene contents in the fruit was made by the method of Ranganna (1986). Fruit nitrogen and phosphorus were determined by the method of Jackson (1973) while potassium content was determined with the help of Flame photometer. Fruit calcium and magnesium were measured with the help of atomic absorption spectrophotometer (AAS-4141 Pentium). Data obtained from two years experiment were pooled and subjected to the statistical analysis following the procedures as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Physiological and yield attributes: Leaf area is an important attribute of crop plants which contributes to fruit yield as major sink. The present investigation (Table 1) revealed that leaf area varied from 486.58–713.60 cm^2/plant in 2016/Todvar-2 (G_2) and 2016/Todvar-9 (G_8) genotypes, respectively, with mean leaf area of 566.95 cm^2/plant across all genotypes. Variations in leaf area among different tomato genotypes can be attributed to their genetic characters. Hasan *et al.* (2011) also reported a significant difference among different tomato genotypes with respect to their leaf area.

Tomato genotypes varied significantly in average fruit weight and 2016/Todvar-10 (G_9) exhibited the maximum fruit weight of 63.00 g against the minimum fruit weight of 23.06 g in 2016/Todvar-3 along with 2016/Todvar-2 (G_2) genotype. The mean value of individual fruit weight across the genotypes has been analyzed as 43.62 g and six genotypes including G_9 (2016/Todvar-5, 2016/Todvar-9, 2017/Todvar-3, 2016/Todvar-12, 2016/Todvar-7 and 2016/Todvar-10) were able to give the individual fruit weight above the average. In conformity to the present finding, Mehta and Asati (2008) also reported that tomato fruit weight ranged from 42.50–95.83 g with an average fruit weight of 65.59 g.

Study further revealed that 2016/Todvar-9 (G_8) produced highest number of fruits (39.26/plant). However, the number of fruits obtained with 2016/Todvar-8 (G_7) and 2016/Todvar-3 were also at par with G_8 against the minimum number of fruits (25.02/plant) recorded in 2016/Todvar-2 (G_2) genotypes which was also at par with 2016/Todvar-12 (G_{11}), 2016/Todvar-10 (G_9) and 2016/Todvar-7 (G_6) genotypes. However, the mean fruit number of all genotypes was computed as 30.74 g and five genotypes, viz. 2016/Todvar-5 (G_5), 2016/Todvar-11 (G_{10}), 2016/Todvar-3 (G_3), 2016/Todvar-8 (G_7) and 2016/Todvar-9 (G_8) gave the fruit weight above average while others produced a fruit weight below average. Finding of the present study showed resemblance with Manna and Paul (2012) who reported that number of fruits per plant in tomato ranged from 15.32–37.00 with all over mean of 23.30.

Genotype with higher sink potential is expected to result in higher fruit yield if source (leaf area) in not limited (Smith *et al.* 2018). Scrutiny of the data regarding fruit yield designated a great difference among

Table 1 Fruit yield and yield attributes in different genotypes of tomato

Genotype	Leaf area	Fruit weight (g)	Fruit count (no./plant)	Sink capacity	Fruit yield (kg/pot)
G_1 : 2016/Todvar-1	493.17	38.69	27.68	10.71	1.07
G_2 : 2016/Todvar-2	486.58	33.66	25.02	8.42	0.84
G_3 : 2016/Todvar-3	574.51	23.06	38.43	8.86	0.88
G_4 : 2016/Todvar-4	506.42	34.19	28.91	9.89	0.98
G_5 : 2016/Todvar-5	520.82	44.23	31.49	13.93	1.39
G_6 : 2016/Todvar-7	654.24	60.45	26.46	16.00	1.59
G_7 : 2016/Todvar-8	593.38	36.71	38.44	14.11	1.41
G_8 : 2016/Todvar-9	713.60	45.16	39.26	17.73	1.77
G_9 : 2016/Todvar-10	618.02	63.00	25.88	16.31	1.63
G_{10} : 2016/Todvar-11	505.02	37.43	32.20	12.05	1.20
G_{11} : 2016/Todvar-12	524.51	54.47	25.63	13.97	1.39
G_{12} : 2017/Todvar-3	613.10	52.41	29.39	15.40	1.54
CD ($P<0.05$)	7.49	1.03	1.98	1.28	0.43

genotypes which ranged from 0.84 kg/plant in 2016/TODVAR-2 (G_{12}) to 1.77 kg/plant in 2016/TODVAR-9 (G_8) with mean fruit yield of all genotypes as 1.31 kg/plant. Our finding is comparable to the reports noticed by Tiwari and Upadhyay (2011) who informed that fruit yield of tomato ranged from 0.76–0.89 kg/plant with an average value of 0.826 kg/plant. Regression analysis of the present data showed a strong and positive relationship of fruit yield with leaf area ($r = 0.86^{**}$). A strong correlation between leaf area and fruit yield has also been reported by Jo and Shin (2020) in tomato.

Physico-chemical attributes: Peel thickness is an important physical character of fruits which influences physiological weight loss (PLW) and is considered as a determinant of sunburn development (a physiological disorder) on fruit surface. Genotypes having greater fruit peel thickness can resist better against PLW as well as development of sunburn disorder on fruit. Present study revealed that peel thickness varied markedly among genotypes with minimum of 0.49 mm in 2016/TODVAR-9 (G_8) against the maximum value of 0.71 mm recorded in 2017/TODVAR-3 (G_{12}). Accordingly, the average fruit peel thickness across the genotypes was obtained 0.59 mm. It can be seen from the data that five genotypes including 2016/Todvar-11 (G_{11}), 2016/Todvar-2 (G_2), 2016/Todvar-10 (G_9), 2016/Todvar-7 (G_6) and 2016/Todvar-12 (G_{12}) were having peel thickness above the average against the six genotypes fallen below the average. Comparable results have also been reported by Manna and Paul (2012).

Total sugar content of fruit examined in different tomato genotypes (Table 2) explained a remarkable difference among the genotypes. It ranged from 2.94% in 2016/TODVAR-3 (G_3) to 4.35% in 2016/TODVAR-9 (G_8) genotype with 3.61% of sugar content as the central value. Genotypes 2016/Todvar-1 (G_1), 2017/Todvar-3 (G_{12}), 2016/Todvar-10 (G_9) and 2016/Todvar-7 (G_6) showed the fruit sugar content as higher than the average. Genotypic variation in fruit sugar content in the present study verified by the earlier studied in tomato (Lakra *et al*. 2018). Further, fruit sugar content was found to be significantly correlated ($r = 0.60^{*}$) with leaf area per plant.

Like other parameters fruit titrable acidity varied markedly among different genotypes and 2016/TODVAR-9 (G_8) showed maximum titrable acidity (1.32%) along with 2016/Todvar-5 (G_5), 2016/Todvar-7 (G_6), 2017/Todvar-3 (G_{12}) and 2016/Todvar-8 (G_7). However, the least amount of titrable acidity (0.77%) was recorded with G_4-2016/TODVAR-4 which is virtually at par with 2016/Todvar-11 (G_{10}), 2016/Todvar-11 (G_{11}) and 2016/Todvar-3 (G_3) with titrable acidity value of 0.80%, 0.83% and 0.84% respectively. The mean titrable acidity was fixed as 1.05%. Our results confirmed the finding of Chandra *et al.* (2020) who reported that fruit acidity varied significantly among different genotypes of tomato which ranged from 0.27–0.76%.

Data pertaining to fruit vitamin C content again highlighted the superiority of 2016/TODVAR-9 (G_8) with maximum vitamin C content (36.18 mg/100 g) against the minimum content of 17.90 mg/100 g recorded in 2016/TODVAR-4 (G_4) along with 2016/Todvar-11 (G_{10}), 2016/Todvar-12 (G_{11}), 2016/TODVAR-3 (G_3), 2016/Todvar-10 (G_9), 2016/Todvar-2 (G_2) and 2016/Todvar-1 (G_1). The mean value of fruit vitamin C content was calculated as 22.64 mg/100g. As such, in addition to G_8 there were three more genotypes namely 2016/Todvar-5 (G_5), 2017/Todvar-3 (G_{12}) and 2016/Todvar-8 (G_7) which resulted in greater vitamin C content than the average value (22.64 mg/100g). These findings are in agreement with Revanasiddappa (2008).

Tested genotypes also differed significantly with respect to total carotenoid content and 2016/TODVAR-9 (G_8) maintained highest amount of carotenoid (8.28 mg/g) along with 2016/TODVAR-10 (G_9). However, by giving 4.16 mg of carotenoid per gram of fruit fresh weight, 2016/TODVAR-5 (G_5) along with 2016/TODVAR-3 (G_3), 2017/

Table 2 Fruit quality attributes as influenced by different genotypes of tomato

Genotype	Total sugars (%)	Titratable acidity (%)	Vitamin C (mg/100 g)	Carotenoids content (mg/g FW)	Lycopene content (mg/100 g)
G_1 : 2016/Todvar-1	3.81	1.14	20.61	5.27	3.89
G_2 : 2016/Todvar-2	3.05	1.00	19.46	5.04	3.81
G_3 : 2016/Todvar-3	2.94	0.84	18.76	5.02	3.34
G_4 : 2016/Todvar-4	3.38	0.77	17.90	6.36	5.14
G_5 : 2016/Todvar-5	3.50	1.20	24.78	4.16	2.98
G_6 : 2016/Todvar-7	4.30	1.20	22.42	6.20	5.03
G_7 : 2016/Todvar-8	3.10	1.27	30.07	6.15	5.06
G_8 : 2016/Todvar-9	4.35	1.32	36.18	8.28	6.84
G_9 : 2016/Todvar-10	3.98	0.98	18.87	7.74	6.18
G_{10} : 2016/Todvar-11	3.54	0.80	18.39	6.99	5.32
G_{11} : 2016/Todvar-12	3.52	0.83	18.43	5.54	4.21
G_{12} : 2017/Todvar-3	3.83	1.25	25.83	5.04	3.86
CD (P<0.05)	0.26	0.16	1.63	0.91	0.72

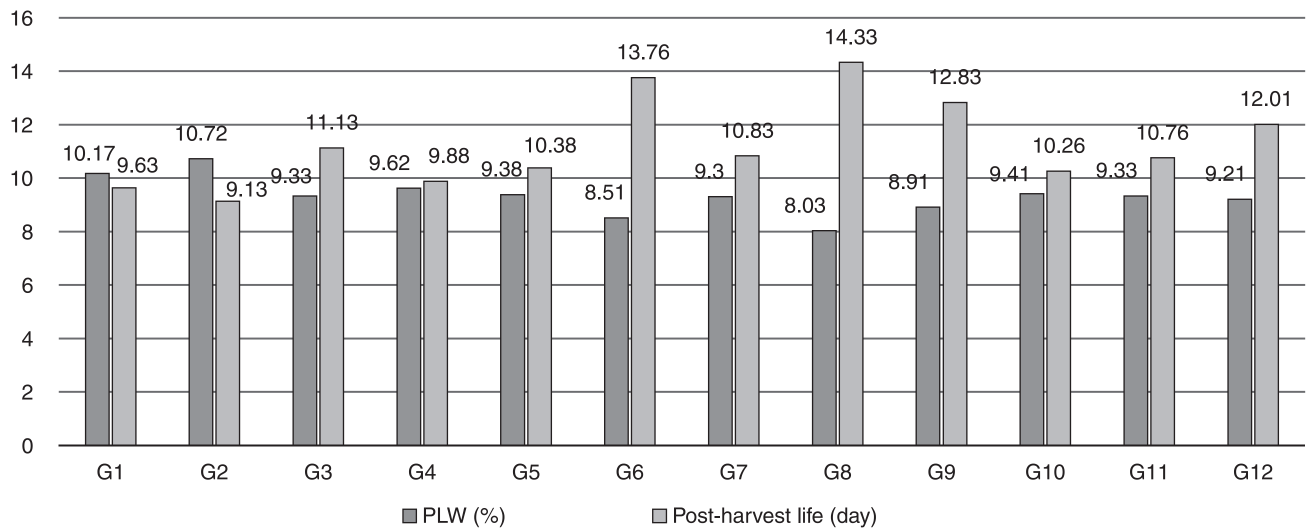

Fig 1 Fruit storage attributes as influenced by different genotypes of tomato.

TODVAR-3 (G_{12}) and 2016/TODVAR-2 (G_2) were proved as the least container of carotenoid. Comparable results have also been reported by earlier researchers (Martí *et al.* 2016, Leiva-Brondo *et al.* 2016) in tomato. Lycopene is an important component of carotenoid comes under carotene group of carotenoid and accordingly it also varied significantly in line with total carotenoid. The maximum lycopene content (6.84 mg/g FW) was recorded with 2016/TODVAR-9 (G_8) which was also at par with 2016/TODVAR-10 (G_9) followed by -2016/TODVAR-11 (G_{10}). Similarly, the minimum lycopene content (2.98 mg/g) was observed with 2016/TODVAR-5 (G_5) and it was found statistically equal to some other genotypes including 2016/TODVAR-3 (G_3). A variation in fruit lycopene content was also reported by other researchers (Gosavi *et al.* 2010).

Mineral composition: Fruit mineral composition is considered as a guide to fruit nutritional quality and present study reports that mineral composition varied significantly in different tomato genotypes. Research findings (Supplementary Table 1) indicated that genotype 2016/Todvar-9 (G_8) showed the highest fruit phosphorus (0.83%), potassium (2.35%), magnesium (0.52%) and calcium (0.23%) contents. However, the lowest phosphorus, potassium, magnesium and calcium contents were recorded as 0.55%, 1.85%, 0.20% and 0.14%, respectively, with 2016/Todvar-3 (G_3), 2016/Todvar-12 (G_{11}), 2016/Todvar-10 (G_9) and 2016/Todvar-1 (G_1) genotypes. The average phosphorus, potassium, magnesium and calcium contents across all the genotypes were analyzed as 0.66%, 2.02%, 0.30% and 0.18%. In addition to the highest mineral contents in G_8, there were at least four other genotypes which showed higher mineral contents than the genotypic average. Variations in fruit mineral composition were also reported by earlier workers (Marles 2016).

Post-harvest attributes: Physiological loss in weight (PLW) that is loss of fruit weight chiefly due to transpiration and also a little due to respiration of food reserves is an important post-harvest attribute which reduce the marketable weight and visual quality of the commodity. Present study (Fig 1) reports that PLW of freshly harvested tomato fruits of twelve tomato genotypes (kept at 20°C) varied between 8.03% in 2016/Todvar-9 (G_8) to 10.72% in 2016/Todvar-2 (G_2). However, the mean PLW value was calculated as 9.33% and five genotypes including 2016/Todvar-7 (G_6), 2016/Todvar-8 (G_7), 2016/Todvar-9 (G_8), 2016/Todvar-10 (G_9) and 2017/Todvar-3 (G_{12}). Variation in PLW due to genotypic differences in tomato has also been reported by earlier researches (Onyia *et al.* 2019). Further, PLW was found to be negatively correlated with fruit calcium content ($r = -0.97^{**}$) as calcium is an important component of cell wall and provide the rigidity to the cell wall which results in reduced water loss of fruit.

Genotype 2016/Todvar-9 (G_8) resulted in the maximum storage life of 14.33 days as compared to minimum storage life of 9.13 days in 2016/Todvar-2 (G_2) genotype. However, the average storage life of all the genotypes has been calculated as 11.24 days. Genotypes like 2016/Todvar-7 (G_6), 2016/Todvar-10 (G_9) and 2017/Todvar-3 (G_{12}) exhibited the greater storage life as compared to average storage life of genotype. Further analysis of the data explained that shelf life of tomato fruits was positively correlated with fruit calcium content ($r = 0.97^{**}$) while negative correlation of shelf life was obtained PLW ($r=-0.98^{**}$). Significant variation in shelf life of tomato fruit was also found in past studies (Khandaker *et al.* 2009).

Thus, finally it can be concluded that different genotypes varied significantly with respect to their plant growth, fruit yield and quality attributes. The highest leaf area as well as fruit yield coupled with higher values quality attributes and mineral compositions was recorded with 2016/TODVAR-9 (G_8). In addition, G_6 (2016/Todvar-7) and G_9 (2016/Todvar-10) proved as high yielding genotypes with higher average fruit weight. However, G_2 (2016/Todvar-2), G_3 (2016/Todvar-3) and G_4 (2016/Todvar-4) genotypes were established as low yielding types with smaller fruit weight and inferior quality of fruits. There were strong relationships between leaf area and fruit yield, PLW and fruit Ca content and fruit Ca content and storage life. As such, Genotypes like 2016/TODVAR-9 (G_8), 2016/Todvar-7, (G_6)) and (2016/Todvar-10 (G_9) may be used for development of improved verities with higher yield and fruit quality of tomato.

REFERENCES

Chandra H M, Shanmugaraj B M, Srinivasan B and Ramalingam S. 2020. Influence of genotypic variations on antioxidant properties in different fractions of Tomato. *Journal of Food Science*. https://www.researchgate.net/publication/232736173.

FAOSTAT. 2017. Production – Crops – Area harvested/ Production quantity – Tomatoes –2014, *FAO Statistics online database*, Food and Agriculture Organization, Rome.

Gomez K A and Gomez A A. 1984. *Statistical Procedures for Agricultural Research*, Edn 2nd, pp. 680. John Wiley and Sons, New York.

Gosavi P U, Kamble A B and Pandure B S. 2010. Effect of organic manures and biofertilizers on quality of tomato fruits. *Asian Journal of Horticulture* **5**(2): 376–78.

Hasan S A, Hayat S, Wani A S and Ahmad A. 2011. Establishment of sensitive and resistant variety of tomato on the basis of photosynthesis and antioxidative enzymes in the presence of cobalt applied as shotgun approach. *Brazilian Journal of Plant Physiology* **23** (3): 175–85.

Jo W J and Shin J H. 2020. Effect of leaf area management on tomato plant growth in greenhouses. *Horticulture, Environment and Biotechnology* **61**: 981–88.

Jackson M L. 1973. *Soil chemical analysis*. New Delhi: Prentice-Hall.

Khandaker M M, Sharif Hossain A B M, Sani, W., Saifuddin M. and Alenazi, M. 2009.Effect of harvesting and storage conditions on the postharvest quality of tomato (*Lycopersicon esculentum* Mill). *Australian Journal of Crop Science* **3**(2):113–21.

Leiva-Brondo M, Valcarcel M, Marti R, Rosello S and Cebolla-Cornejo, J. 2016. New opportunities for developing tomato varieties with enhanced carotenoid content. *Scientia Agricola* **73**(6): 512–19.

Lakra A, Trivedi J and Mishra S. 2018. Studies on biochemical composition of various tomato (*Solanum lycopersicum* L.) genotypes. *International Journal of Current Microbiology and Applied Science* **7**(12): 977–87.

Manna M and Paul A. 2012. Studies on genetic variability and characters association of fruit quality parameters in tomato. *HortFlora Research Spectrum* **1**(2): 110–16.

Marles R J. 2016. Mineral nutrient composition of vegetables, fruits and grains. *Journal of Food Composition Analysis* **56**: 193–203.

Martí R, Rosello S and Cebolla-Cornejo J. 2016. Tomato as a source of carotenoids and polyphenols targeted to cancer prevention. *Cancers* **8**. doi:10.3390/cancers8060058

Mehta N and Asati B S. 2008. Genetic relationship of growth and development traits with fruit yield in tomato (*Lycopersicon esculentum* Mill). *Karnataka Journal of Agricultural Science* **21**(1): 92–96.

Oniya V N, Chukwudi U P, Ogwudu V C, Atugwu A I, Eze S C, Ene C O and Umeh S. 2019. Evaluation of tomato genotype growth, yield, and shelf life enhancement in Nigeria. *Journal of Agricultural Science and Technology* **21**:143–52.

Ranganna S. 1986. *Handbook of Analysis and Quality Control for Fruits and Vegetable Products,* pp. 192–97. Tata McGraw Hill Pub. Co. Ltd., New Delhi, India.

Revanasiddappa K V. 2008. Breeding investigations involving biparental mating and selection approaches in tomato (*Solanum lycopersicum* Mill.). MSc (Agri.) Thesis, submitted to University of Agricultural Sciences, Dharwad (India).

Smith M R, Rao I M and Merchant A. 2018. Source-sink relationship in crop plants and their influence on yield development and nutritional quality. *Frontiers in Plant Science* **9**: 1889.

Tiwari J K and Upadhyay D. 2011. Correlation and path-coefficient studies in tomato (*Lycopersicon esculentum* Mill.). *Research Journal of Agriculture Science* **2**(1): 63–68.