Evaluation of tomato (*Solanum lycopersicum* L.) hybrids for quality traits , yield and fruit under polyhouse conditions

Mohan Singh[1]*, K.D. Ameta[2], R.A. Kaushik[3] and K.S. Rajawat[4]

[1-4]Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur-313001, Rajasthan, India

***Corresponding author:** *E-mail address:* mohansingh0051@gmail.com

ABSTRACT

An experiment was conducted at Hi-Tech Unit, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur during the year 2017-18 to evaluate the yield and quality traits of tomato hybrids under polyhouse condition. The experiment was laid out in completely randomized design with nine hybrids replicated four times. The analysis of variance revealed significant variation among the hybrids for all the characters. The experiment results revealed that hybrid Dev was performed extremely well under polyhouse condition with respect to yield parameters viz. yield per plant (5.50 kg) and yield per square meter (24.42 kg). The observation recorded for biochemical analysis showed that maximum titratable acidity (0.509%), ascorbic acid (17.76 mg/100g) and lycopene content (5.80 mg/100g) were recorded in hybrid Arka Samrat. Based on the above experiment Dev and Arka Samrat are promising hybrids under polyhouse cultivation.

Key words : Tomato, polyhouse, yield, quality, hybrids

1. Introduction:-

Tomato (*Solanum lycopersicum* L.) is one of the most important members of Solanaceae family and widely grown across the globe. Tomato was first introduced in Europe in the middle of the sixteenth century and in India it is introduced during seventeenth century probably by Portuguese (Kalloo, 1991). A study suggested that tomato contains an antioxidant lycopene, which markedly reduces the risk of prostate cancer (Kucuk, 2001). Tomato is a good appetizer having pleasing taste (Ram, 1991). Consumption of tomato and its products like soup, puree, paste and ketchup can significantly reduces the risk of developing of colon, rectal and stomach cancer. Based on its nutritive value and presence of lycopene and flavonoids it is mostly considered as 'protective food' (Sepat *et al*. 2013). Tomato fruit

Corresponding authors e-mail:- mohansingh0051@gmail.com

contains high moisture and dry matter (DM) of 5-7.5% (Davies and Hobson, 1981). The composition of dry matter in tomato consists of sugars, mainly glucose and fructose, organic acids (citric and malic acid); minerals, (N, P and K), vitamins and anti-oxidant pigments such as lycopene. Besides its importance for consumption, fruit acidity and total soluble solid content are vital factors in the processing industry. The acidity is related to pH and low pH of the pulp prevents the growth of microorganisms that are harmful (Carvalho, 1980), which decreases the period of needed for sterilization during processing (Stevens, 1972). However, the total soluble solids (TSS) content is important especially when the objective is dehydration, concentrated pulp preparation, or both (Stevens, 1972).

Protected cultivation is a unique and specialized form of agriculture in which the microclimate surrounding the plant is controlled partially or fully, as per the requirement of the plant species grown during their growth period (Mishra *et al*. 2010). Polyhouse cultivation of tomato offers distinct advantages like that earliness, higher productivity and quality fruit particularly pesticide residue free produce, besides higher returns to growers. Under protected environment the natural environment is modified to the suitable conditions for optimum plant growth which ultimately helps in the production of quality tomato suitable for export and domestic consumption (Singh and Sirohi, 2006). Occurrence of frost couple of the day with low temperature during the month of December and January causes mortality of tomato plant when grown in open field condition, but under protected environment, the yield loss can be minimized. Protected cultivation includes the techniques by which crop can be protected from factors which causes loss in yield both in terms of quantity and quality, by which per unit area production can be increased with premium quality produce. Unlike traditional agriculture, this technology opened all the doors of success for rural, semi urban and even urban youth with ample scope of employment and improves socio economic standards (Ameta *et al.* 2019). Therefore, the following experiment was planned with the objective of evaluating tomato hybrids in respect of yield and quality under protected conditions.

2. Materials and Method

2.1 Nursery raising: This investigation conducted during from August, 2017 to March, 2018 at Hi-Tech Horticulture Unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. The size of the polyhouse was 28 m × 32 m (896 sq. m) covered with aluminate sheet and ultra violet stabilized low density polyethylene sheet have 200 micron thickness. Udaipur is situated at 24º 34' N latitude and 73º

42' E longitude at an elevation of 582.17 meter above mean sea level. The region falls under agro climatic zone IV a (Sub-Humid Southern plain and Aravalli Hills) of Rajasthan.

Nine tomato hybrids namely Mahy 302, TO -1057, KSP-1154, Arka Smrat, Emerald, Shahenshah, Dev, Sarthi-044 and Rajesh were included in experiment. The experiment was laid out in a Completely Randomized Design with four replications in naturally ventilated polyhouse. The seeds of tomato were sown in plastic pro-trays having cells of 1.5 inch in size containing growth medium namely coco peat, vermiculite and perlite mixture in the ratio of 3:1:1, respectively. The beds were prepared having 30 cm above from ground level and 1 meter width along with length of polyhouse. A row to row and plant to plant spacing of 45 x 30 cm respectively, was adopted during investigation. All the agricultural operations were followed as per recommended package and practices of tomato. Observations regarding fruit weight (g), fruit diameter (cm), fruit volume (cc), specific gravity (g/cm^3), fruiting span, yield per plant (g) and yield per square meter were recorded.

2.2 Physicochemical analysis

The TSS content of juice was directly measured by the “Digital Refractometer” (Brix: 0.0 to 53.0 %) at 20^{0}C temperature. Acidity content of fruit juice was determined by diluting the known volume of extracted juice with distilled water and titrating the same against standard N/10 sodium hydroxide solution, using phenolphthalein as an indicator (AOAC, 2016). Ascorbic acid content of fruit determined by 2,6-dichlorophenol – indophenols dye method following the procedure of (AOAC 2016).

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titrate (ml)} \times \text{Dye Factor} \times \text{Volume made up (ml)}}{\text{Aliquot (ml) taken for estimation} \times \text{Volume of juice (ml)}} \times 100$$

Total carotenoids, expressed as “lycopene” content in tomato fruit was determined by extracting the 5 g pulp repeatedly with acetone and absorbance was measured at 503 nm with the help of spectrophotometer (Seth and Khandelwal, 2008).

$$\text{Lycopene (mg /100 g)} = \frac{31.206 \times \text{Absorbance}}{\text{Weight of sample (g) taken for estimation}}$$

2.3 Statistical analysis

Five plants were randomly selected per accession per replication for recording observations and the mean worked out. Analysis of variance was done based on CRD as suggested by Panse and Sukhatme (1985) for each of the characters separately.

3. Results and Discussion

Fruit weight (g)

Fruit weight is also another important character contributing to yield per plant directly. There was a highly significant difference among 9 hybrids with respect to fruit weight (Table 1). The range of fruit weight in current study was 82.50 to 93.00 g. Hybrid Sarthi-044 produced heaviest fruits with average weight of 93.00 g, hybrids Dev and Rajesh were *at par* with Sarthi-044 having mean weight of 92.25 g and 91.37 g, respectively. The lowest value (82.50 g) was found in hybrid TO-1057. The fruit weight which is a function of fruit size (fruit length and diameter) may be subject of consumer's or market choice but fruit number is independent of the purpose of end use. Therefore, preference should be given to the hybrids with higher number of fruits per plant rather than those having big and bulking fruits. Dhyani *et al* (2017) also reported maximum fruit weight (106.74) in the hybrid of Marglobe X Pusa Sadabahar.

Fruit Diameter (cm)

There was a significant variation in fruit diameter across the hybrids. The data pertains to fruit diameter ranged from 4.35 to 5.81 cm (Table 1). The highest mean value for fruit diameter was recorded in Rajesh (5.82 cm) followed by Dev (4.98 cm) and Arka Samrat (4.92 cm). The least value (4.35 cm) was observed for KSP-1154. The variation in fruit diameter in different tomato hybrids might be due to the genetic makeup of cultivars and governed by the cell size and intercellular space of the flesh. Maximum fruit diameter (5.00 cm) reported by Sharma and Singh (2015) in hybrid Apoorva was in close to present finding.

Fruit Volume (cc)

The data related to fruit volume ranged from 86.38 to 97.89 cc. The mean fruit volume was given in Table 2 showed that the maximum fruit volume (97.89 cc) was recorded in Sarthi-04 and followed by TO-1057 (94.84 cc) and Rajesh (91.19 cc). The lowest value (86.39 cc) was found in Shahenshah.

Fruiting Span

Duration of fruiting is closely related to availability of fruits in market, results showed that fruiting span ranged from 110.00 to 129.75. The mean fruiting span of plant was given in Table 1 showed that maximum fruiting span (129.75) was recorded in Sarthi-044 which was highly significant and followed by Shahenshah (118.00) and Dev (116.25). The least fruiting (110.00) was observed in Rajesh. Longer harvesting period was desirable for getting higher yields.

Yield per plant (kg)

The difference among the hybrids on marketable fruit yield was highly significant. It is evident from data presented in Table 1 that among all tomato hybrids the maximum fruit yield per plant was observed in hybrid Dev (5.50 kg), which was significantly superior over all the other hybrids studied followed by Shahenshah (5.15 kg) and Arka Samrat (4.32 kg). The hybrid TO-1057 gave the lowest marketable fruit yield (2.62 kg). Variation in yield per plant was might be due to genetic makeup of the plant, more number of flowers and more fruit set percent because of vigorous and healthy plants. Such kind of genetic differences for marketable fruit yield and other plant characters in different tomato hybrids had also been reported by Jindal *et al*. (2015).

Yield per square meter (kg)

The mean yield per square meter of fruit was given in Table 1 showed that the highest mean value for yield per square meter (24.42 kg) was recorded in Dev which was highly significant and followed by Shahenshah (22.87 kg) and Arka Samrat (19.21 kg). The least value (11.62 kg) was found in TO-1057.

Table 1: Performance of tomato hybrids for yield characters under polyhouse condition

Hybrids	Fruit weight (g)	Fruit diameter (cm)	Fruit volume (cc)	Fruiting span	Yield per plant (kg)	Yield per square meter (kg)
Mahy-302	83.75	4.46	86.58	113.75	4.04	17.93
TO-1057	82.50	4.39	94.84	110.25	2.81	12.50
KSP-1154	86.50	4.35	92.03	112.00	2.62	11.62
Arka Samrat	90.50	4.92	88.74	110.25	4.32	19.21
Emerald	86.75	4.61	86.10	112.75	4.16	18.49
Shahenshah	88.55	4.26	86.39	118.00	5.15	22.87
Dev	92.25	4.98	88.92	116.25	5.50	24.42
Sarthi-044	93.00	4.47	97.89	129.75	4.23	18.81
Rajesh	91.38	5.82	91.19	110.00	4.27	18.98
SEm±	1.398	0.113	1.550	0.597	130.88	0.582
CD (P = 0.05)	4.077	0.329	4.523	1.742	381.82	1.697

Specific Gravity (g/cm^3)

Specific gravity of fruits in tomato indicates the quantity of food reserved in the cells and thus, specifies the nutritive value of fruits. There was significant difference in the specific gravity of fruits of different hybrids (Table 2). Results revealed that specific gravity had a range of 0.870 to 1.038 g/cm^3. The fruits of hybrid Dev were most compact with maximum specific gravity of 1.038 g/cm^3 followed by

Shahenshah and Arka Samrat with value of 1.025 g/cm^3 and 1.020 g/cm^3, respectively. Finding of Shibli *et al*. (1995) were *at par* with present results, who reported that specific gravity ranged from 0.95 g/cm^3 to 1.095 g/cm^3 in tomato hybrids.

Total Soluble Solids (°Brix)

The data pertains to total soluble solids ranged from 3.47 to 5.19 ºBrix (Table 2). The highest mean value for total soluble solids (5.19 ºBrix) was recorded in Sarthi-044 and followed by Dev (4.92 ºBrix) and Arka Samrat (4.51 ºBrix). The lowest value (3.47 °Brix) was found in Shahenshah. The total soluble solids content is one of the most important quality parameters in processing tomato. Varieties/hybrids having higher TSS content are better suited for the preparation of processed products like tomato powder, canned products, ketchup, sauce and chutney. High TSS is desirable to yield higher recovery of processed products. Purkayastha and Mahanta (2011) also reported almost similar range of total soluble solids content (3.60 to 5.40 ºBrix) in tomato.

Titratable Acidity (%)

The data pertains to titratable acidity ranged from 0.304 to 0.509 per cent (Table 2). The maximum titratable acidity was recorded in Arka Samrat (0.509 %) followed by Emerald (0.402%) and Mahy-302 (0.396%). The lowest value (0.304 %) was found in Rajesh. The variation in titratable acidity was seen by Sharma and Singh (2015) who reported maximum titratable acidity in tomato hybrid Rupali (0.623 %) grown under plastic house condition, whereas Jindal *et al*. (2015) reported highest titratable acidity (0.56 %) in tomato hybrid HS-18.

Ascorbic Acid (mg/100g)

The mean ascorbic acid of fruit was given in Table 2 showed that the highest mean value for ascorbic acid (17.77 mg/100g) was recorded in Arka Samrat which was highly significant and followed by Dev (15.38 mg/100g) and Rajesh (13.28 mg/100g). The lowest value (10.99 mg/100g) was found in TO-1057. Because tomato is mainly consumed in the processed form, using cultivars with high vitamin C content is desirable that determines the nutritious status of tomato varieties/hybrids. These findings related to ascorbic acid are in accordance with the result Sharma and Singh (2015) who reported that

tomato hybrid Heem Sohna had the highest ascorbic acid content (15.63 mg/100g), whereas maximum ascorbic acid content (20.65 mg/100g) was reported by Jindal *et al*. (2015) in tomato hybrid HS-18.

Lycopene Content (mg/100g)

The lycopene content of fruit was given in Table 2 showed that the highest mean value for lycopene content (5.80 mg/100g) was recorded in Arka Samrat which was highly significant and followed by Dev (4.21 mg/100g) and Sarthi-044 (3.90 mg/100g). The lowest value (3.14 mg/100g) was found in Mahy-302. Lycopene is one of major character controlling the fruit colour which affects the quality of tomato. Jindal *et al*. (2015) reported maximum lycopene content (5.49 mg/100g) in tomato hybrid G-600, whereas Lekshmi and Celine (2015) reported maximum lycopene content of 11.94 mg/100g in INDAM 9802.

Table 2: Performance of tomato hybrids for quality characters under polyhouse conditions

Hybrids	Specific gravity (g/cm^3)	Total soluble solids (°Brix)	Titrable acidity (%)	Ascorbic acid (mg/100g)	Lycopene content (mg/100g)
Mahy-302	0.968	4.00	0.396	12.55	3.15
TO-1057	0.870	4.17	0.364	10.99	3.40
KSP-1154	0.940	3.72	0.309	12.28	3.74
Arka Samrat	1.020	4.51	0.509	17.77	5.80
Emerald	1.008	4.41	0.402	11.00	3.62
Shahenshah	1.025	3.48	0.351	11.05	3.79
Dev	1.038	4.92	0.365	15.38	4.21
Sarthi-044	0.950	5.19	0.310	12.44	3.90
Rajesh	1.003	3.68	0.304	13.28	3.59

SEm±	0.006	0.084	0.004	0.240	0.207
CD (P = 0.05)	0.016	0.244	0.012	0.700	0.604

Conclusion:-

On the basis of results obtained it may be concluded that among the various treatments, cultivar Dev was found superior in yield and yield attributing parameters such as fruit weight, fruit diameter, fruit volume, fruiting span, total yield per plant and yield per square meter. Among the quality parameters, hybrid Arka Samrat showed superiority as contains maximum titrable acidity, ascorbic acid and lycopene content under protected condition in southern Rajasthan.

Acknowledgement

The authors are thankful to the Dr. K.D. Ameta and Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur for providing the research field, necessary facilities and continuous help for this research. The authors also acknowledged ICAR for providing ICAR NTS.

LITERATURE CITED

A.O.A.C. 2016. Official Method of Analysis. Association of Official Agricultural Chemists. Benjamin Franklin Station, Washington, D. C. pp: 16-37.

Ameta,K.D., Kaushik, R.A., Dubey, R.B. and Rajawat, K.S. 2019. Protected Cultivation-An Entrepreneurship for Modern Agriculture. *Biotech Today*, 9(1): 35-40.

Carvalho, V.D., 1980. Chemical and industrial characterstics of tomato. *Agricultural Report, Belo Horizonte*, 6: 63-68.

Davies, J.N., Hobson, G.E., 1981. The constituents of tomato fruit-the influence of environment, nutrition, and genotype. *Critical Review Food Science Nutition,* 15: 205-280.

Dhyani, S., Misra, A.C., Panday, V. and Sajwan, P. 2017. Evaluation of tomato (Solanum lycopersicon L.) hybrids for fruit yield characters in hill region of Uttarakhand, India. International Journal of Current Microbiology and Applied Sciences, 6(9): 1622-1633.

Jindal, S.K., Dhaliwal, M.S. and Chawla, N. 2015. Comparative performance of different tomato hybrids under naturally ventilated polyhouse. *International Journal of Horticulture Science*, **5**(14): 1-12.

Kalloo, G., 1991. Introduction. In: Kalloo G. (ed.) Genetic improvement of tomato, monographs on theoretical and applied genetics. Springer-Verlag, Berlin, pp.1-9.

Kucuk, O. 2001. Phase II randomized clinical trial of lycopene supple-mentation before radical prostatectomy. *Cancer Epidemiology*, *Biomarkers and Prevention*, **10**(4): 861-868.

Lekshmi, S. L and Celine, V. A. 2015. Evaluation of tomato hybrids for fruit, yield and quality traits under polyhouse conditions. *International Journal of Applied and Pure Science and Agriculture*, **01**(7): 58-64.

Mishra, G.P., Singh, N., Kumar, H. and Singh, S.B. 2010. Protected Cultivation for Food and Nutritional Security at Ladakh. *Defence Science Journal*, 60: 219-225.

Panse, V. G. and Sukhatme, P. V. 1985. Statistical Method for Agricultural Workers, (3Ed.), ICAR, New Delhi, pp. 145-146.

Purkayastha, M.D. and Mahanta, C.L. 2011. Physicochemical properties of five different tomato cultivars of Meghalaya and their suitability in food processing. *African Journal of Food Science*, **5**(4): 657-667.

Ram, H.H. 1991. Text book. Vegetable Breeding Principles and Practices. Kalyani Publishers, pp: 171-187.

Sepat, N.K., Sepat, S.R., Sepat, S. and 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. *International Journal of Environmental Sciences*, **3**(4): 1233-1241.

Seth, P. and Khandelwal, S.K. 2008. Biochemical Analysis. Himanshu Publication, New Delhi, pp: 186-187.

Sharma, V.K. and Singh, T. 2015 Performance evaluation of tomato (*Solanum lycopersicum* L.) hybrids for increased productivity under polyhouse conditions in temperate areas. *Journal of Agriculture and Crops*, **1**(6): 68-74.

Shibli, R.A., Ereifej, K.I., Ajlouni, M.A. and Hussain, A. 1995. Evaluation of thirteen open pollinated cultivars and three hybrids of tomato (*Lycopersicon esculentum* Mill.) for physical properties and chemical composition of fruits. *Pakistan Journal of Agriculture Science*, **32**(3): 1-3.

Singh, B. and Sirohi, N.P.S. 2006. Protected cultivation of vegetables in India: problems and future prospects. Proc IS on greenhouses, environmental control and In house mechanization for crop production in the tropics and sub-tropics. *Acta Horticulture*, **710**(38): 339-342.

Stevens, M.A., 1972. Citrate and malate concentrations in tomato fruits: genetic control and maturational effects. *Journal of American Society of Horticultural Science,* 97: 655-658.