

**Performance of Tomato (*Solanum lycopersicum* L.)  
Hybrids Under Polyhouse Condition**

**वेवज १/४ कृषि यलदकि/डे ,य-१/२ध । ढज फलेसक i,यह्गमल ea  
चन'कु**

**MOHAN SINGH**

**THESIS**

**Master of Science in Agriculture  
(Horticulture)**



**2018**

**DEPARTMENT OF HORTICULTURE  
RAJASTHAN COLLEGE OF AGRICULTURE  
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY,  
UDAIPUR- 313001 (RAJ.)**

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Thesis

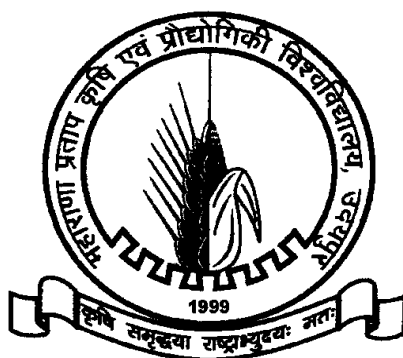
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In partial fulfillment of the requirements for the Degree of

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***(HORTICULTURE)***



**By**

**MOHAN SINGH**

**2018**

**MAHARANA PRATAP UNIVERSITY OF AGRICULTURE &  
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RAJASTHAN COLLEGE OF AGRICULTURE, UDAIPUR**

**CERTIFICATE-I**

**Dated    /    /2018**

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**CERTIFICATE-II**

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This is to certify that the thesis entitled, **“Performance of Tomato (*Solanum lycopersicum* L.) Hybrids Under Polyhouse Condition”** submitted for the degree of **Master of Science in Agriculture** in the subject of Horticulture embodies bonafied research work carried out by **Mr. Mohan Singh** under my guidance and supervision and that no part of the thesis has been submitted for any other degree. The assistance of help received during the course of investigation have been fully acknowledged. The draft of thesis was also approved by advisory committee on    /    /2018.

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**(Dr. K.D. Ameta)**  
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Enclose: One original and three copies of bound thesis forwarded to the Director, Resident Instructions, Maharana Pratap University of Agriculture and Technology, Udaipur through the Dean, Rajasthan College of Agriculture, Udaipur.

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## ACRONYMS

%	-	Per cent
&	-	And
/	-	Per
@	-	At the rate of
<sup>0</sup> B	-	Degree Brix
<sup>0</sup> C	-	Degree Celsius
A.O.A.C.	-	Association of Official Analytical Chemists
C.D.	-	Critical difference
C.R.D.	-	Completely Randomized Design
d.f.	-	Degree of freedom
<i>et al.</i>	-	( <i>et alibi</i> ) and elsewhere
<i>etc.</i>	-	Etcetera
FAO	-	Food and Agriculture Organization
Fig.	-	Figure
g	-	Gram
ha	-	Hectare
<i>i.e.</i>	-	( <i>id est</i> ) that is
Max.	-	Maximum
mg	-	Milligram
Min.	-	Minimum
Mm	-	Mili meter
MSS	-	Mean sum of square
No.	-	Number
NS	-	Non-significant
R.H.	-	Relative humidity
SE <sub>m±</sub>	-	Standard error of mean
TSS	-	Total soluble solids
<i>viz.</i>	-	( <i>videlicet</i> ) namely

## 1. INTRODUCTION

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Tomato (*Solanum lycopersicum* L.) is one of the most important members of Solanaceae family and widely grown across the globe. It originated and domesticated

in the Andean region of the South America and in Mexico from the wild ancestor of *Lycopersicon esculentum sub. species cerasifoeme* (Bai and Lindhout, 2007). A study suggested that tomato contains an antioxidant lycopene, which markedly reduces the risk of prostate cancer (Kucuk, 2001). It is a good appetizer having pleasing taste (Ram, 1991). Consumption of tomato and its products 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). The major tomato growing countries are China, India, USA, Turkey, Egypt and Italy. In the world during 2014-15 the total area under tomato cultivation is 4.81million hectares with a production of 163.02 million MT and productivity was 33.9 MT per hectare in the world. India is the second largest producer (11.5%) of tomato in the world. In India, tomato was grown in area of 8.09 lakh hectares with a production of 196.97 lakh MT and productivity of 24.34 MT per hectare (Anon., 2017).

Tomato is one of the principal vegetable crop, produced under protected condition in India. Edible portion of tomato contain energy 18 kcal, protein 0.95g, fat 0.11g, carbohydrate 4.01g, total sugar 2.49 g, Ca 11.0 mg, Fe 0.68 mg, Mg 9.0 mg, P 28.0 mg, K 218.0 mg, Na 11.0 mg, Zn o.14 mg, thiamin 0.036 mg, riboflavin 0.022 mg, vitamin B 60.079 mg, vitamin E 0.56 mg, fatty acid total saturated 0.015 g and fatty acid total unsaturated 0.044 g per 100 g (USDA, 2013). It is also a source of other compounds with antioxidant activities, including chlorogenic acid, plastoquinones, rutin, tocopherol and xanthophylls (Leonardi *et al.* 2000). Fresh and processed tomatoes are the richest sources of the dietary antioxidant lycopene, which possibly protects cells from oxidants that have been associated with cancer (Rao and Rao, 2007). Tomato is one of the most important solanaceous vegetable crops grown for its delicious fruits. It is a versatile vegetable used for various culinary purposes. They are processed into puree, paste, ketchup, sauce, juice, pickles, soup etc. Tomato juice has become an excellent delicacy as appetizer and beverage. The processed products regulate the market price of tomato and reach to consumers in a variety of forms or as ingredients in a wide array of processed commodities. Although, India has a wide range of diverse agro-climatic conditions, but vegetable cultivation practices have generally been restricted to regional and seasonal needs. In general, protected structures are used to overcome low temperature in temperate regions or high

temperature in the countries having tropical climate. There is a lot of potential for increasing the area manifold under low cost greenhouses in peri-urban areas for production of high value low volume vegetables during off-season to take benefit of the high price of the produce (Phookan and Saikia , 2003) and to setup the vegetable production and improve its quality.

Tomato is a warm season crop and requires relatively long season to produce a profitable crop. It is highly susceptible to frost. Optimum temperature for fruit setting and lycopene development is 15-20 °C and 21-24 °C, respectively. In tomato fruit setting is poor when average temperature exceeds 30°C or falls below 10°C. Tomato grows best in sandy loam to clay loam soils with a pH of 6.0-6.5. On the basis of growth habit, tomato plants are classified in three groups viz. indeterminate, semideterminate or inter-mediate and determinate. The indeterminate varieties of tomato are grown in southern region of india and green house conditions. Polyhouse cultivation of tomato offers distinct advantages of earliness, higher productivity and quality 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 coupled with low temperature during the month of December to January causes mortality of tomato plant when grown in open field condition, but under protected environment, the yield losses can be minimized. India being a vast country with diverse and extreme agro-climatic conditions, the protected vegetable cultivation technology can be utilized for year round and off-season production of high value, low volume vegetables, production of virus free quality seedlings, quality hybrid seed production and as a tool for disease resistance breeding programs (Wani *et al.* 2011). Though, the technology for producing quality tomato fruit have been standardized but there is very little information are available on performance of hybrids under polyhouse condition in southern Rajasthan.

Keeping the above facts in view, the present investigation entitled “Performance of Tomato (*Solanum lycopersicum* L.) Hybrids Under Polyhouse Condition” was under taken during 2017-2018 with the following objective:

1. To asses growth, yield and quality parameters of tomato hybrids under polyhouse condition.

2. To find out economic feasibility of hybrids under polyhouse condition.

## **2. REVIEW OF LITERATURE**

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Tomato is one of the most popular vegetable commercially cultivated under protected cultivation. A number of experiments have been conducted throughout the world to establish a variety of choice in a crop for a particular region, with regard to its growth, performance, fruit quality and yield. The available research works pertaining to growth, yield and quality parameters of tomato hybrids under polyhouse conditions are reviewed in this chapter.

### **2.1 Growth and Yield Parameter**

Bhangu and Singh (1993) conducted an experiment to study the performance of seven tomato cultivars under rainfed condition in polyhouse and observed that maximum number of fruits per plant and yield was shown by Punjab Kesari while fruits weight was maximum in cultivar Punjab Tropic.

Singh *et al.* (1994) carried out a trial on tomato cultivars under rainfed condition and observed maximum mean plant height (75.90 cm) in BT 12 and mean fruits weight (54.87 g), whereas highest yield per hectare (15755.00 kg ha<sup>-1</sup>) was recorded for cultivar Arka Vikas.

Singh and Lal (2003) evaluated 11 determinate tomato hybrids during spring-summer season in open field condition and observed highest plant height (89.2 cm) and number of locules per fruit (4.8) in Katrain-2, whereas fruit per plant (19.2) was found maximum in Katrain-1. Maximum fruit yield per hectare (328.6 q ha<sup>-1</sup>) and fruit weight (104.3) were recorded in cultivar Katrain-3. Hazarika and Phookan (2005) evaluated 27 cultivars of tomato under plastic rain shelter during summer

season. They observed plant height, branches per plant, percent fruit set and yield per plant were highest in tomato cv. Yash. Arora *et al.* (2006) conducted an experiment for the evaluation of eighteen tomato hybrids under greenhouse during the winter season, results showed maximum plant height in Rakshita, inflorescences per plant in NTH-2005, individual fruit weight (102 g) and total fruit yield was recorded in NTH-2008.

Pandey *et al.* (2006) studied four tomato varieties in farmer's field with farmer's participation under plastic house condition for yield potential and other yield characters. They observed that minimum days to flowering (35) and maximum fruit set percent (93.9%), marketable fruit yield per hectare (89.05 t ha<sup>-1</sup>) was obtained from NSITH-162.

Singh *et al.* (2006) carried out an experiment to study performance of different tomato cultivar under greenhouse conditions in northern India. The heaviest fruit weight of 145 and 140 g in FA-574 and maximum number of fruit per truss 5.6 and 5.4 cluster<sup>-1</sup> and highest yield per plant 5.8 and 5.6 kg plant<sup>-1</sup> were recorded cv. R-144 (Daniela), during 2000-2001 and 2001-2002 respectively.

Ahmad *et al.* (2007) studied comparative performance of eleven tomato cultivar in open field condition and observed that Rio Grande gave the earliest fruit maturity (82.40 days). Cultivar Local round showed maximum plant height (110.50 cm). Number of branches per plant (10.77), fruits per plant (98.30), fruit weight per plant (3.03 kg), fresh fruit yield per hectare (68.36 t ha<sup>-1</sup>) and dry fruit yield per hectare (4.49 t ha<sup>-1</sup>) was observed from cultivar Shalkot.

Chapagain *et al.* (2011) carried out an experiment to study the performance of eight tomato varieties under plastic house for two consecutive years from 2009 to 2010. The minimum days to first flowering (37 days), harvesting (77 days) and the maximum plant height (268.7 cm), clusters per plant (36.23) were recorded in variety Srijana, whereas maximum fruit weight (61.94 g) was observed in Manish and fruit diameter (5.78 cm) from cultivar US-04. The highest marketable yield per hectare (86.6 t ha<sup>-1</sup>) was recorded from variety All Rounder.

Kanwar (2011) studied the performance of tomato genotypes in the polyhouse and revealed that all tested tomato genotypes are far superior. The maximum plant height (169.20 cm) and minimum days to first harvesting (88.50) were observed in

cultivar Naveen 2000, whereas yield per plant (1.28 kg), yield per ha (712.22 q ha<sup>-1</sup>) and number of fruits per plant (26.81) were highest in Shivalik under greenhouse conditions. Sima *et al.* (2011) carried out a study on the performance of six tomato hybrids under polyhouse and observed maximum plant height (248.33 cm), Fruit weight (130.7 g) and fruit diameter (66.21mm) were obtained from Monroe F<sub>1</sub>, number of inflorescences were maximum (9.00) in Marissa F<sub>1</sub> and highest yield kg/m<sup>2</sup> (11.74) was recorded from Menhir F<sub>1</sub>. Ali *et al.* (2012) studied performance of nine exotic tomato hybrids and observed maximum stem diameter (1.217 cm), fruit diameter (5.187 cm), yield per plot (1.915 kg) and significantly higher yield (6939 kg) for hybrid T-7010, while the plant height (72.00 cm), fruit length (7.797 cm) was maximum in hybrid T-7012, whereas maximum fruit weight (112 g) was recorded for hybrid T-7030.

Gautam *et al.* (2013) carried out an experiment for the evaluation of four tomato varieties on farmer's field with farmer's participation for yield potential and other yield characters and observed least time to flowering (44.49 days), days to first harvest after transplanting (73.14 days), maximum number of clusters per plant (11.90), number of flowers per cluster (1.99), number of fruits per plant (23.02), highest marketable fruit yield per hectare (290.29 q) were recorded from variety Kashi Vishesh and also found low incidence of Yellow Leaf Curl Virus disease in this variety. Singh *et al.* (2013) evaluated nineteen tomato hybrids under greenhouse conditions and observed maximum plant height (302.0cm) in hybrids Yash, number of inflorescences per plant (14.4) in C-1601, whereas fruits per truss (5.8), minimum days to flowering in 50% plants (79) and highest number of fruits per plant (62) were recorded in hybrid Centurian. Fruit weight (56 g) and total fruit yield per hectare (1287.6 q ha<sup>-1</sup>) were obtained from hybrid Avinash-2.

Cheema *et al.* (2013) investigated twenty six tomato hybrids along with Check Naveen under net house and observed maximum plant height (194.50 cm) and number of fruits per cluster (10.50) in G-600, fruits per plant (58.40), number of clusters per plant (12.50) in TAI 687, average fruit weight (72.50 g) in To-Ind Hyb/5 and maximum fruit yield per plant (2.35 kg) was recorded from To-Ind Hyb/3. Mehraj *et al.* (2014) analyzed the performance of twenty tomato cultivar coded from V1-V20. Results revealed that maximum plant height (116 cm) and number of leaves (147) were found in cultivar Mini Anindyo Red (V8) and Hybrid Tomato US440 (V18),

respectively. The maximum number of branch per plant (5.7), number of fruit per plant (6.7), fruit diameter (61.3 mm), fruit weight (100 g), yield per plant (667.1 g), yield per plot (6.7 kg) and calculated yield per hectare (22.3 MT) were found from cultivar Mini Chika (V10).

Jindal *et al.* (2015) carried out an experiment to study performance of different tomato hybrids for economic traits under polyhouse conditions during 2008-09, 2009-10 and 2010-2011. The hybrid HS-18 recorded maximum number of fruits per cluster (8.50, 8.50 and 8.54), respectively. Maximum fruit weight (96.83 g), plant height (202.83 cm) were recorded in G-600 during all three year, whereas hybrid HS-18 gave highest yield per plant (3.19, 3.30 and 3.11 kg per plant, respectively) during all the three years. Sharma and Singh (2015) evaluated fourteen fresh tomato hybrids under polyhouse in mid hill condition of Uttarakhand, India. The results showed that the tomato hybrid Himraja could perform outstandingly well for various morphological and quality characters *viz.*, plant height (315.00 cm), percent fruit set (84.09), higher number of marketable fruits per plant (58.53) and maximum marketable fruit yield per hectare (1080 q).

Lekshmi and Celine (2015) evaluated twelve tomato hybrids of public and private sectors under polyhouse conditions. The results indicated that tomato hybrid Naveen gave maximum plant height (2.80 m), INDAM 9802 was earliest to flowering (26.27 days), number of fruits per cluster in INDAM 3001 (50.16), fruit set percentage in Arka Rakshak (53.00), fruits per plant in F<sub>1</sub> T 30 (35.66) and yield per plant (1444.44 g) in INDAM 9802. Rai *et al.* (2016) carried out an experiment to study the performance of fifty six genotypes of tomato for yield and quality traits during *Kharif* season. Among the genotypes 97/754 was the earliest to harvesting (72.67 days), EC-538146 had the highest number of fruits per cluster (4.87) and maximum fruits per plant (64.78) were recorded in EC-126903. Highest fruit weight (88.13 g) was obtained from Solan Tomato-1, whereas highest yield per plant (2033.25 g) was observed for KS-254.

Kumar *et al.* (2017) evaluated sixteen tomato germplasm in open field condition for horticultural traits under Lucknow conditions and observed that maximum plant height (77.95 cm), number of flower per plant (162.67), number of cluster per plant (35.33), number of fruit per plant (35.33), number of flower per cluster (10.67) and fruit yield per hectare (58.52 MT) were recorded for Pusa Hybrid-

2 while number of branches per plant (24.58) were maximum in Punjab Chhuhara. Mahender *et al.* (2017) conducted an experiment to study performance of twelve tomato hybrids under northern Telangana conditions and observed maximum significant plant height (122.66 cm) in hybrid Priya, number of branches per plant (42.17) in Arka Shreshta whereas, number of fruit per plant (26.7) and maximum yield per hectare (338.92 q) were obtained from variety Abhinava. Spaldon and Hussain (2017) evaluated performance of tomato genotypes for yield, quality and reaction against biotic stress. Results revealed that maximum number of fruits per plant was recorded in Pusa Ruby (30.82) and marketable fruit yield per plot (5.07 kg) was obtained from hybrid Tokita, similarly Kanneh *et al.* (2017) investigated introduced tomato genotypes for desired horticultural characteristics to identify superior and observed that maximum plant height at 50% flowering (77.70 cm) was recorded in BC1F2 and plant height at 100% flowering (100.90 cm) was found in R6P6. The heaviest fruits (75.30 g) were observed in R3P9 and number of fruit per plant (61.00) and marketable fruit per plant (54) were recorded from P1 097. Saidu *et al.* (2017) evaluated introduced genotypes for adaptation and identification in open field condition and observed maximum plant height at 50 per cent flowering (72.40cm), at 100 per cent flowering (108.40), number of fruit set per plant (87.00), number of fruit per plant (62) were recorded in P1 097, whereas heaviest fruits (82.01 g) were observed in F<sub>3</sub>. Kayess *et al.* (2017) investigated performance of ten tomato hybrids in open field condition and observed that maximum plant height (86.00 cm) and marketable fruits per plant (64.56) were recorded in Hybrid -10. Hybrid-8 took minimum days to flowering (21.86) and recorded maximum fruit weight (45.83 g) and fruit diameter (17.89 mm), whereas yield per plant (2003.15 g) was highest in Hybrid-6. Mamatha *et al.* (2017) carried out a study to evaluate parents and hybrids of tomato in open field condition and observed maximum plant height (98.93 cm), number of branches (10.13) at peak harvesting stage in Arka Samrat. The minimum days to first flowering (19.16) in Anaga, number of fruits per plant (40.06) in Anaga x Arka Meghali, number of clusters per plant (14.13), average fruit weight (99.50 g) and yield per plant (2.96 kg) were observed in Arka Rakshak. Bharathkumar *et al.* (2017) crossed nine parental lines and obtain 18 F<sub>1</sub> hybrids, these hybrids were evaluated along with their parents and 2 commercial check hybrids to know their performance under the conditions of Bengaluru. Among the parents and hybrids maximum plant

height was recorded in IIHR2848 x IIHR2853 (91.08 cm), number of branches (7.2) in IIHR977 x IIHR2890, number of fruits per cluster (3.47) and maximum yield per plant (4.55 kg) in Arka Rakshak, whereas highest fruit weight (177.75 g) was shown IIHR2850.

Jatav *et al.* (2017) evaluated performance of twenty-three tomato genotypes for yield and quality traits. Among all the genotypes, AVT-1-2 had highest plant height (140.33 cm), whereas maximum number of branches per plant was observed in AVT-24 (7.60). Maximum fruit diameter (6.24 cm) was found in genotype Punjab Kesari and fruit weight (64.03 g) was recorded for H-86. The genotype Hisar Arun had the maximum number of fruits per plant (38.33) and genotype DVRT-3 was on the top in fruit yield per plant (1540.00 g). Singh and Kumar (2017) carried out a study on the off-season performance of tomato hybrids under natural ventilated polyhouse conditions in northern plains of India. It was observed that earliest to flowering (35 days), maximum fruits per plant (41.3), yield per plant (4557g ) were recorded in San Marzano (cv. UG-8122).

Kumar *et al.* (2017) evaluated hybrids of tomato along with parents for yield attributes in open field condition and observed that hybrid DVRT-1 × CHFT-50 was earliest in flowering (50.67 days) and harvesting (70.00 days), whereas the highest fruit yield was recorded in DVRT-2 × CHFT-77 (9.13 kg). Dhyani *et al.* (2017) studied comparative performance of 11 tomato cultivar in open field condition and observed that hybrid Marglobe X Pusa Sadabhar was the earliest in picking (43.0 DAT) and recorded highest fruit weight (106.74 g). The number of fruit per plant (79.82), number of flower cluster per plant (14.13), number of flowers per cluster (8.0) and fruit set percentage (85.71%) were recorded in Utkal Urwasi X Palam Pink, whereas fruit yield per plant (6935.08 g) was highest in Utkal Urwasi X Gujrat Tomato-3.

Bhati (2017) studied the performance of eight tomato genotype in open field condition and concluded that genotype TODVAR-8 was found superior in maximum plant height (64.75 cm), number of branches per plant (14.22), number of leaves per plant (47.81), fruit length (4.24 cm), fruit diameter (5.28 cm), number of fruits per plant (34.01), fresh weight of fruit (37.00 g) and yield per hectare (46.62 MT). Murkute *et al.* (2017) grown tomato varieties under polyhouse condition and observed that Arka Saurabh recorded highest fruit weight (52.25 g) and fruit volume (73.33 cc),

whereas Pusa Hybrid-2 gave significantly maximum fruit length (4.35 cm), individual fruit weight (41.44 g) and yield per hectare (87.45 MT).

Elizabeth *et al.* (2018) carried out an experiment to study the performance of twenty tomato genotypes under water stress condition. Among the genotypes, the highest plant height (77.00 cm) was recorded in Akshay. The maximum number of fruits per plant (19.90) and the yield per plant (603.67 g) were recorded from Kottayam Local.

## **2.2 Quality parameter**

Kumar (2009) studied the performance of different varieties of tomato. Results revealed that Naveen 2K+ recorded maximum total soluble solids (4.93°Brix), titrable acidity (0.82%) was maximum in Sartaj and ascorbic acid content was maximum for SH-7711 (24.39 mg/100g). Sima *et al.* (2011) evaluated tomato hybrids under polyhouse and observed maximum total soluble solids (6.18°Brix) in Marissa, ascorbic acid (23.23 mg/100g) in Tolstoi and highest titrable acidity (0.99 %) was observed in Monroe.

Dar *et al.* (2012) studied the performance of different germplasm for quality characters. The results revealed that maximum polygalacturonase activity (68.11) was observed in genotype EC-521059, total soluble solids (5.04°Brix) found in genotype EC-521041, alcohol insoluble solids (39.14 mg/100 g) as well as highest fruit pH (4.59) were observed in VTG-86. Cheema *et al.* (2013) investigated twenty six tomato hybrids under the net house conditions. The maximum total soluble solids (6.25 °Brix) was found in To-Ind Hyb/5, fruit acidity (0.65g/100ml) in TH-13, ascorbic acid content (21.25mg/100g) in ARTH-128 and Lycopene content (6.40gm/100g) was recorded from G-600.

Raju *et al.* (2014) evaluated 22 hybrids of tomato for yield and quality. Among the hybrids, highest total soluble solids ( 5.21°Brix) were found in T1224, titrable acidity (0.49) from COTH 2 and ascorbic acid (19.74) was observed maximum in NS 816. Sharma and Singh (2015) carried out a study on tomato hybrids under varied agro-climatic conditions especially in protected conditions. In the study, the hybrid Heem Sohna had the highest Vitamin C content (15.63 mg/100g), total soluble solids (7.98 °Brix) was found in hybrid Himraja and titratable acidity (0.623

%) was observed maximum in hybrid Rupali. Lekshmi and Celine (2015) evaluated twelve tomato hybrids which were obtained from public and private sectors and grown under polyhouse conditions. The highest total soluble solids (5.36°Brix) was found in INDAM 3003, ascorbic acid (25.46 mg/100 g) from Naveen and lycopene content (11.94 mg/100 g) was recorded from INDAM 9802.

Jindal *et al.* (2015) carried out an experiment for the performance of different tomato hybrids for economic traits under polyhouse conditions during 2008-09, 2009-10 and 2010-2011. The maximum mean total soluble solids (4.72 °Brix), titrable acidity (0.56 %), and ascorbic acid content (20.65 mg/100g) was observed in HS-18 and lycopene content (5.49 mg/100g) in G-600 during all the three years. Rai *et al.* (2016) carried out an experiment to study the performance of fifty six genotypes of tomato for yield and quality traits and observed maximum total soluble solids (6.42 °Brix) in KS-254 and lycopene content (13.26 mg/100 g) were recorded in Best of All. Spaldon and Hussain (2017) studied performance of tomato genotypes for yield, quality and reaction against biotic stress and observed that highest fruit pH (4.49), beta-carotene (7.06 mg/100 g) and total soluble solids (5.02 °Brix) were obtained from Arka Vikas. The Genotype Aditya gave highest lycopene content (5.22 mg/100 g), whereas maximum ascorbic acid (27.96 mg/100 g) was recorded from Arka Meghali. Bharathkumar *et al.* (2017) studied performance of a set of tomato parental lines and their hybrids for quality and yield under open conditions. Among the parents, IIHR 2890 showed the highest total soluble solids (5.17 °B), highest ascorbic acid content (20.06 mg/100g) was found in IIHR 1816 and maximum lycopene content (12.9 mg/100g) was obtained from Arka Rakshak.

Kumar *et al.* (2017) carried out a study for evaluation of sixteen tomato germplasm for horticultural traits under Lucknow conditions. The maximum total soluble solids (5.70 °Brix), ascorbic acid (50.52 mg/100g) were recorded from Pusa Hybrid-2 and highest titrable acidity (0.76%) was observed in Pusa Rohini. Mamatha *et al.* (2017) evaluated parent and hybrids of tomato in open field condition and reported maximum total soluble solids (3.90 °Brix) in Arka Rakshak, whereas total acidity (0.58%) was recorded in Arka Sourabh.

Jatav *et al.* (2017) carried out an experiment to study the performance of twenty-three tomato genotypes for yield and quality traits. The highest total soluble solids content (8.43 °Brix) was recorded in genotype PKM-1, titrable acidity (0.90%)

was maximum in genotype H-86, whereas ascorbic acid content (28.67mg/100g) was maximum in Arka Sourabh at marketable stage. Kumar *et al.* (2017) investigated tomato hybrids along with parents for yield and quality in open field condition. The maximum total soluble solids (4.47 °Brix) was reported in DVRT-2 x CHFT-60, lycopene content (21.36 mg/100g) was observed in CHFT-70 x CHFT-50, whereas highest  $\beta$ - carotene content (3.62 mg/100g) was recorded in DVRT-2 x CHFT-50.

Bhati (2017) conducted an experiment to study the performance of eight tomato genotype for yield and quality in open field condition and observed that maximum vitamin C content (52.73 mg/100g) as well as total soluble solids (5.13 °Brix) was obtained in genotype TODVAR-8. Murkute *et al.* (2017) studied the performance of tomato varieties grown under polyhouse and observed that maximum total soluble solids (5.31 °Brix) and ascorbic acid (12.35 mg/100g) were recorded in Arka Alok and acidity per cent (0.54) was found maximum in Pusa Hybrid-2.

### 3. MATERIALS AND METHODS

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The present investigation entitled “**Performance of Tomato (*Solanum lycopersicum* L.) Hybrids Under Polyhouse Condition**” was conducted August 2017 to February 2018 at Hi-Tech Horticulture Unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. The details of experimental techniques, materials used and criteria adopted for evaluation of treatments during the entire course of investigation are described in this chapter.

#### 3.1 EXPERIMENTAL SITE

The experiment was conducted during the year 2017-2018 at the 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 with the 200 micron thickness. Udaipur is situated at 24° 34' N latitude and 73° 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.

### 3.2 CLIMATE AND WEATHER CONDITION

Udaipur has a typical sub-tropical climate, characterized by winters and summers. The average rainfall of this tract ranges from 760 to 900 mm per year. More than 90 percent rainfall is received during mid-June to September with scanty showers during winter months. Data recorded for mean weekly weather parameters during the period of field experimentation have been presented in Table- 3.1

### 3.3 SOIL CHARACTERISTICS OF THE EXPERIMENTAL FIELD

In order to determine the physico-chemical properties and fertility status of experimental site, the soil samples were collected from different spots in the field with the help of screw auger up to the depth of 45 cm before the commencement of experiment. The collected soil samples were mixed thoroughly on a clean piece of cloth and the bulk reduced by quartering so that about 500 g of composite sample was obtained.

Composite samples were brought to the laboratory and spread on a thick brown paper. Stones, pieces of roots, leaves and other undecomposed organic residues were removed. Large lumps of moist were broken by hand. It was air dried at 20-25<sup>0</sup> C and 20 to 60 per cent relative humidity (Jackson, 1973).

After air drying soil samples were crushed gently by pastel mortar and sieved through 92 mm sieve. Grounded samples were stored in glass containers. The grounded samples were mixed well before a sample was weighed for analysis. The soil was analyzed according to the method given in Table (3.2) and data of available N, P and K obtained in the experimental sample prior to the start of experiment are given in Table 3.2.

**Table 3.2: Chemical properties of experimental soils**

Characteristics of soil	Content	References
<b>Chemical Parameters</b>		
Organic Carbon (%)	0.85	Rapid Titration method (Walkely and Black, 1947)
Available N ( kg ha <sup>-1</sup> )	246.5	Alkaline KMNO <sub>4</sub> method (Subbiah and Asija, 1956)
Available P ( kg ha <sup>-1</sup> )	23.70	Olsen` s method (Olsen <i>et al.</i> , 1954)

Available K ( kg ha <sup>-1</sup> )	251.4	Flame photometer method (Richards, 1968)
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### 3.4 EXPERIMENTAL DETAILS

The experiment entitled “Performance of Tomato (*Solanum lycopersicum* L.) Hybrids Under Polyhouse Condition” was conducted at the Hi-Tech Horticulture Unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur from August, 2017 to March, 2018. The details of proposed plan of work are given as follows:

#### (A) Details of treatments with their notations

Notations	Treatments
T <sub>1</sub>	Mahy-302
T <sub>2</sub>	TO-1057
T <sub>3</sub>	KSP-1154
T <sub>4</sub>	Arka Samrat
T <sub>5</sub>	Emerald
T <sub>6</sub>	Shahenshah
T <sub>7</sub>	Dev
T <sub>8</sub>	Sarthi-044
T <sub>9</sub>	Rajesh

### 3.5 EXPERIMENTAL DESIGN AND LAYOUT

#### 3.5.1 Plan of Work

The experiment was laid out in a Completely Randomized Design with four replications. The details are as under:

1	Condition	Naturally ventilated polyhouse
2.	Experimental design	Completely Randomized Design
3.	No. of replications	04

4.	No. of treatments	9
5.	Total number of plots	36
6.	Plot size	7 m x 1m
7.	Total experimental area	500 square metre
8.	Date of transplanting	1 <sup>st</sup> August, 2017
9.	Spacing	45cm × 30cm

**3.5.2 Layout:** For conducting experiment layout was prepared as polyhouse.

	<b>T<sub>1</sub></b>	<b>T<sub>2</sub></b>	<b>T<sub>3</sub></b>	<b>T<sub>4</sub></b>	<b>T<sub>5</sub></b>	<b>T<sub>6</sub></b>	<b>T<sub>7</sub></b>	<b>T<sub>8</sub></b>	<b>T<sub>9</sub></b>
<b>R<sub>1</sub></b>	<b>T<sub>1</sub>R<sub>1</sub></b>	<b>T<sub>2</sub>R<sub>1</sub></b>	<b>T<sub>3</sub>R<sub>1</sub></b>	<b>T<sub>4</sub>R<sub>1</sub></b>	<b>T<sub>5</sub>R<sub>1</sub></b>	<b>T<sub>6</sub>R<sub>1</sub></b>	<b>T<sub>7</sub>R<sub>1</sub></b>	<b>T<sub>8</sub>R<sub>1</sub></b>	<b>T<sub>9</sub>R<sub>1</sub></b>
<b>R<sub>2</sub></b>	<b>T<sub>9</sub>R<sub>2</sub></b>	<b>T<sub>8</sub>R<sub>2</sub></b>	<b>T<sub>7</sub>R<sub>2</sub></b>	<b>T<sub>6</sub>R<sub>2</sub></b>	<b>T<sub>5</sub>R<sub>2</sub></b>	<b>T<sub>4</sub>R<sub>2</sub></b>	<b>T<sub>3</sub>R<sub>2</sub></b>	<b>T<sub>2</sub>R<sub>2</sub></b>	<b>T<sub>1</sub>R<sub>2</sub></b>
<b>R<sub>3</sub></b>	<b>T<sub>6</sub>R<sub>3</sub></b>	<b>T<sub>7</sub>R<sub>3</sub></b>	<b>T<sub>8</sub>R<sub>3</sub></b>	<b>T<sub>9</sub>R<sub>3</sub></b>	<b>T<sub>1</sub>R<sub>3</sub></b>	<b>T<sub>2</sub>R<sub>3</sub></b>	<b>T<sub>3</sub>R<sub>3</sub></b>	<b>T<sub>4</sub>R<sub>3</sub></b>	<b>T<sub>5</sub>R<sub>3</sub></b>

<b>R<sub>4</sub></b>	<b>T<sub>4</sub>R<sub>4</sub></b>	<b>T<sub>5</sub>R<sub>4</sub></b>	<b>T<sub>6</sub>R<sub>4</sub></b>	<b>T<sub>7</sub>R<sub>4</sub></b>	<b>T<sub>8</sub>R<sub>4</sub></b>	<b>T<sub>9</sub>R<sub>4</sub></b>	<b>T<sub>1</sub>R<sub>4</sub></b>	<b>T<sub>2</sub>R<sub>4</sub></b>	<b>T<sub>3</sub>R<sub>4</sub></b>
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### **3.6 DETAILS OF CROP OPERATION**

#### **3.6.1 Nursery Raising**

The seeds of tomato were sown on 20<sup>th</sup> June, 2017 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. One seed was sown in each cell. Regular watering, fertigation and plant protection measures were adopted under shed net to raise healthy seedlings.

#### **3.6.2 Bed Preparation**

The beds were prepared having 30 cm above from ground level and 1 meter width along with length of polyhouse. Basal dose of vermicompost @ 100 quintals per hectare was applied and thoroughly mixed in the soil one week before transplanting.

#### **3.6.3 Transplanting**

After five weeks seedling became ready for transplanting and attained a height of 10-12 cm, healthy seedlings have been transplanted at a spacing of 45 × 30 cm as per layout and transplanting was done in evening and irrigation was applied.

#### **3.6.4 Fertilizer Application**

Fertigation schedule was followed with nitrogen, phosphorus and potassium as per recommended dose of tomato for Udaipur region which is 200: 120: 120 kg NPK ha<sup>-1</sup>, respectively along with micronutrient.

#### **3.6.5 Stacking and Training**

Tomato plants were trained at 30 DAT with plastic sutli fixed on hanging wires at the top of plant and growing tomato stem was tied at 10 cm above ground level. Then after tomato plants were pruned uniformly.

#### **3.6.6 Intercultural Operations**

Timely hoeing and weeding operations were performed as and when it was needed to keep experimental field weed free.

### **3.6.7 Irrigation**

Regular irrigation was applied through drip system of irrigation having discharge capacity of 4 litre per hours emitters through drip system of irrigation having in tomato crop under the protected condition.

### **3.6.8 Plant protection measures**

In order to protect the crop from disease, copper oxychloride @ 3 g / litre and mancozeb @ 2.0 g /litre of water were sprayed, to protect the crop from sucking pest imidacloprid @ 0.6 ml / litre of water and mitigate @ 1g/litre was applied in order to protect the crop from mites.

### **3.6.9 Harvesting**

The fruits were harvested manually at horticultural maturity.

## **3.7 OBSERVATIONS RECORDED**

For recording the observations on different aspects of the study, five plants were randomly selected in each plot and were tagged.

### **3.7.1 Vegetative Growth Characteristics**

#### **3.7.1.1 Plant height (cm)**

The height of tagged plant was measured with the help of meter scale from ground level to extreme growing tip of the plant at 90 DAP and at first harvest expressed in cm.

#### **3.7.1.2 Stem diameter (cm)**

Five randomly selected plants were marked at 2 cm above the ground level in each treatment and diameter of stem was measured with the help of vernier calipers at 90 DAP and final harvest and expressed in cm.

#### **3.7.1.3 Branches per plant**

Total numbers of branches coming out of the main stem were counted on all the tagged plants at the stage of final harvesting.

#### **3.7.1.4 Leaf area (cm<sup>2</sup>)**

Total leaf area per plant was determined using leaf area meter, LICOR-3100 USA. Leaf area of five tagged plants was measured at the time of fruiting 120days after transplant and average leaf area was measured and expressed as cm<sup>2</sup>.

#### **3.7.1.5 Days to flowering**

The number of days taken from the date of transplanting to flower initiation was recorded and the mean value was expressed in days to first flowering.

#### **3.7.1.6 Fruit set (%)**

The fruit set (%) was calculated with the following methods.

$$\text{Fruit set (\%)} = \frac{\text{Total number of fruits per plant}}{\text{Total number of flowers per plant}} \times 100$$

#### **3.7.1.7 Days to first harvesting**

The days from the date of transplanting to the date of first harvesting in each treatment were recorded. The difference of the date of transplanting and date of first harvesting was calculated for the number of days required for first harvesting.

#### **3.7.1.8 Clusters per plant**

Total numbers of clusters were counted on all the five tagged plants in each plot and averages were computed.

#### **3.7.1.9 Fruits per plant**

The numbers of fruits were counted separately on the five randomly selected plants on each harvesting till final stage. Then average numbers of fruits per plant were calculated.

#### **3.7.1.10 Fruit weight (g)**

Fruits were taken from the pooled product of tagged plant at every picking, their weight was recorded and then average fruit weight was calculated and expressed in gram.

#### **3.7.1.11 Fruit diameter (cm)**

Same five fruits which were used for recording weight of fruits were used for measuring fruit diameter. The diameter of the fruit was measured with the help of vernier callipers in centimeter and average fruit diameter was calculated and expressed in cm.

#### **3.7.1.12 Fruit volume (cc)**

Same five fruits which were used for recording weight of fruits were used for measuring fruit volume. Volume was measured by water displacement method. For this purpose, fruits were dipped in a full filled jar of water and the water displaced by the fruits was collected and measured by graduated glass jar and average volume of fruit was calculated.

#### **3.7.1.13 Fruiting span**

The period from first harvesting to last harvesting formed the base for ascertaining the harvest duration in days and fruiting span was calculated.

### **3.7.2 Yield parameters**

#### **3.7.2.1 Yield per plant (g)**

The fruits harvested from five tagged plants were weighed separately with the help of digital balance on each harvest and sum total of each harvesting was computed for getting total yield per plant and expressed in gram.

#### **3.7.2.2 Yield per square meter (kg)**

The yield of fruits per square meter was calculated by multiplying the average yield of plant and number of plants per square meter including path and other area in polyhouse and expressed in kilogram per square meter.

### **3.7.3 Quality Characteristics**

#### **3.7.3.1 Specific gravity (g/cm<sup>3</sup>)**

Specific gravity of the fruit was worked out by dividing the weight of the fruit by the volume of the same fruit and was expressed as gram per cubic centimeter.

#### **3.7.3.2 Titrable Acidity (%)**

The acidity of the fruit juice was determined by diluting a known volume of the extracted juice and titrating the same against standard N/10 NaOH solution using phenolphthalein as an indicator until faint pink colour appeared. The volume of N/10 NaOH consumed in the titration was measured. The calculation was done on the basis that 1 ml of N/ 10 NaOH is equivalent to 0.006444 g of citric acid. The results were expressed in terms of per cent acidity of the fruit juice (A. O. A. C., 1995).

$$\text{Acidity (\%)} = \frac{\text{Titrate} \times \text{Normality of alkali} \times \text{Eq. weight of acid}}{\text{Weight of sample}} \times 100$$

#### **3.7.3.3 Ascorbic acid content (mg / 100 g)**

Ascorbic acid content of fruit was determined by diluting the known volume of clean juice filtered through muslin cloth with 3 per cent meta phosphoric acid to appropriate volume. 10 ml of aliquot was titrated against 2, 6- dichlorophenol indophenol dye solution till a stable light pink color appeared. The results were expressed as mg ascorbic acid / 100 ml juice of fruit (A. O. A. C., 1995). For

recording ascorbic acid content standardization of dye of dye solution was done as under.

#### **Standardization:**

Standardization of 2, 6- dichlorophenol indophenol dye was done by titrating against standard ascorbic acid solution. The standard ascorbic acid solution was prepared by dissolving 100 mg of L- ascorbic acid in 3 per cent meta phosphoric acid and 1 ml was used for titration.

The ascorbic acid content of fruit was calculated using following formula:

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

#### **3.7.3.4 Lycopene content (mg /100g)**

The lycopene content in tomato fruit was determined by extracting the 5 g pulp repeatedly with acetone until the colourless appearance of residue. This extract was pooled separating funnel containing about 20 ml 5 per cent sodium sulphate solution. The petroleum ether extract was poured into brown bottles, containing about 10 g anhydrous sodium sulphate and resulting absorbance was measured at 503 nm with the help of spectrophotometer (Seth and Khandelwal, 2008). The lycopene content of fruit was calculated using following formula:

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

#### **3.7.3.5 Total soluble solids (°Brix)**

Juice was extracted from fruit and total soluble solids of the juice was determined by using “Pocket Refractometer” of 0-53 per cent range at room temperature and values obtained were corrected at 20° C (A. O. A. C, 1995).

### **3.8 RELATIVE ECONOMICS OF TREATMENT**

In order to evaluate the most profitable treatment combination, economics of different treatments were worked out in terms of net returns and net returns per rupee investment. In calculating the economics, total yield per square meter was considered

as the economic value. First of all, cost of cultivation was calculated then a gross return was estimated on the basis of the total yield (kg) per 1000 m<sup>2</sup>. Thus, the net returns were obtained by adopting the following procedure

$$\text{Gross returns (₹ per 1000 m}^2\text{)} = \text{Returns from bulk yield}$$

$$\text{Net returns} = \text{Gross returns} - \text{Total cost of cultivation per 1000 m}^2 \text{ (₹)}$$

The cost of cultivation includes money spent on field preparation, seeds, organic manures, fertilizers, sowing, transplanting, irrigation, hoeing and weeding, plant protection measures, land rent, harvesting and transportation etc.

Net returns per rupee investment (B: C ratio) was calculated as follows:

$$\text{B: C ratio} = \frac{\text{Net returns (₹ / 1000 m}^2\text{)}}{\text{Total cost of cultivation (₹ / 1000 m}^2\text{)}}$$

### 3.9 Statistical analysis

The experimental data recorded during the course of investigation were subjected to appropriate analysis through statistical design CRD as per method suggested by Panse and Sukhatme (1985). The analysis of variance for different characters has been presented in the appendices. Skeleton of ANOVA for this have been given as below.

Source of variance	d.f.	SS	MSS	Fcal
Treatment	(t-1)	SST	MST	MST/MSE
Error	t(n-1)	SSE	MSE	
Total				

\*5 % level of significance. \*\* At 1% level of significance

**Table 3.1 Mean weekly meteorological data (2017-18)**

<b>Date</b>	<b>Temperature (°C)</b>		<b>Relative humidity (%)</b>	
	<b>Max.</b>	<b>Min.</b>	<b>Max.</b>	<b>Min.</b>
30 July-5 Aug	28.6	22.5	91.4	86.9
6 Aug-12 Aug	29.9	23.2	88.0	81.6
13 Aug-19 Aug	30.4	22.4	83.6	59.4
20 Aug-26 Aug	32.4	23.1	87.7	75.4
27 Aug-2 Sept	29.5	22.1	90.3	79.4
3 Sept -9 Sept	30.1	20.9	88.7	59.3
10 Sept-16 Sept	31.8	21.6	89.3	78.3
17 Sept - 23 Sept	31.7	20.9	80.1	50.1
24 Sept- 30 Sept	33.7	20.0	75.3	39.0
1 Oct – 7 Oct	34.8	18.5	63.4	25.3
8 Oct-14 Oct	34.7	18.7	68.3	24.6
15 Oct-21 Oct	35.6	18.7	61.4	18.9
22 Oct- 28 Oct	33.6	14.4	73.9	47.1
29 Oct- 4 Nov	32.3	13.9	79.7	59.1
5 Nov-11 Nov	30.0	13.0	83.3	64.0
12 Nov-18 Nov	28.6	12.0	84.1	59.3
19 Nov-25 Nov	26.2	9.3	79.9	59.7
26 Nov-2 Dec	28.6	8.8	80.1	58.0
3 Dec-9 Dec	23.5	12.2	93.7	80.1
10 Dec-16 Dec	24.9	9.6	89.3	68.3
17 Dec-23 Dec	25.4	7.8	83.6	58.0
24 Dec-31 Dec	26.2	6.3	91.5	52.4
1 Jan-7 Jan	24.2	5.2	89.9	44.6
8 Jan- 14 Jan	25.2	7.4	87.3	40.7
15 Jan- 21 Jan	27.8	7.3	90.4	35.1
22 Jan- 28 Jan	25.4	6.1	84.3	31.9
29 Jan- 04 Feb	28.6	7.7	80.4	30.4
05 Feb- 11 Feb	25.7	8.5	81.1	35.9
12 Feb- 18 Feb	26.9	9.1	78.3	40.3
19 Feb- 25 Feb	31.7	12.0	77.3	23.1

**Source: Meteorological Observatory, Instruction Farm, Deptt. Of Agronomy, RCA, Udaipur**

## 4. EXPERIMENTAL RESULTS

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The experiment observed on different aspect of the study entitled **"Performance of Tomato (*Solanum lycopersicum* L.) Hybrids Under Polyhouse Condition"** conducted at Hi-Tech Unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur during August 2017- february18 are presented in this chapter. The data pertaining to various yield and yield contributing traits used for evaluation of the treatments were statistically analyzed to test their significance and results of these data have been given in Table 4.1 to 4.6. The graphical depiction have been given figure 4.1 and 4.6 of various attributes also included for better understanding. The analysis of variance for different character study are presented in the Appendix- I to VI.

### 4.1 Vegetative Growth Parameters

It is evident from the data presented in the preceding chapter that of vegetative growth parameters like plant height, stem diameter, branches per plant, leaf area days to flowering, per cent fruit set days to first harvesting, cluster per plant, fruit per plant, fruit weight, fruit diameter, fruit volume and fruiting span are presented in Table 4.1, 4.2 and 4.3 and depicted in Fig. 4.1, 4.2, 4.3 & 4.4. The analysis of variance is given in Appendix I, II, III and IV.

#### 4.1.1 Plant height at 90 days (cm)

The mean plant height was given in Table 4.1 and depicted in Figure 4.1, showed that the highest mean value for plant height (246.90 cm) at 90 days was recorded in Mahy-302 which was highly significant and followed by KSP-1154 (221.40 cm) and TO-1057 (211.88 cm). The lowest value (161.00 cm) was recorded in hybrid Shahenshah.

#### 4.1.2 Plant height at final harvest (cm)

The data for mean plant height was given in Table 4.1 and depicted in Figure 4.1, showed that the highest mean value for plant height (352.90 cm) at final harvest (cm) was recorded in Mahy-302 which was highly significant and followed by KSP-1154 (307.60 cm) and TO-1057 (301.65 cm). The lowest plant height (263.15 cm) was observed in Dev.

#### **4.1.3 Stem diameter at 90 days (cm)**

The mean stem diameter was given in Table 4.1 and depicted in Figure 4.2, showed that the highest mean value for plant stem diameter (0.75 cm) at 90 days was recorded in Dev which was highly significant and followed by Shahenshah (0.73 cm) and Arka Samrat (0.73 cm). The lowest stem diameter (0.62 cm) was found in TO-1057.

#### **4.1.4 Stem diameter at final harvest**

The mean stem diameter at final harvest was given in Table 4.1 and depicted in Figure 4.2, showed that the highest mean value for stem diameter (1.21 cm) at final harvest was recorded in Dev which was highly significant and followed by Emerald (1.17 cm) and Shahenshah (1.15 cm). The lowest value (0.93 cm) was found in TO-1057.

#### **4.1.5 Branches per plant**

However, data for mean branches per plant showed significant influence among nine hybrids of tomato are in given table 4.2 and depicted in Figure 4.3. The maximum number of branches per plant were recorded in hybrids Mahy-302 (8.00) followed by Shahenshah (7.85) and Dev (7.35), whereas, the minimum number of branches were recorded in hybrids Rajesh (6.60).

#### **4.1.6 Leaf area per plant (cm<sup>2</sup>)**

The mean leaf area per plant was given in Table 4.2 and depicted in Figure 4.3, showed the significant influence among tomato hybrids. The highest mean value for leaf area per plant was recorded in Dev (321.95 cm<sup>2</sup>) and followed by Rajesh (319.25 cm<sup>2</sup>) and Sarthi - 044 (312.65 cm<sup>2</sup>). The lowest leaf area per plant (286.40 cm<sup>2</sup>) was found in TO-1057.

#### **4.1.7 Days to Flowering**

The mean days to flowering was given in Table 4.2 and depicted in Figure 4.3, showed that the least mean value for days to flowering (35.55) was recorded in Sarthi-044 followed by Dev (39.70) and Mahy-302 (41.35), Whereas hybrid Rajesh took maximum days to flowering with value of 47.60.

#### **4.1.8 Per cent Fruit Set**

The mean per cent fruit set was given in Table 4.2 and depicted in Figure 4.3, showed that the maximum fruit setting (82.45 %) was observed in hybrid Dev followed by Sarthi-044 (80.60 %) and Shahenshah (80.20 %). The lowest value (74.15 %) was observed in KSP-1154.

#### **4.1.9 Days to First Harvesting**

The mean days to first harvesting was given in Table 4.3 and depicted in Figure 4.4, showed Sarthi-044 was earliest hybrid with least mean value for days to first harvesting (77.75) was recorded followed by Shahenshah (89.15) and Dev (90.95). Hybrid Rajesh took maximum days (97.95).

#### **4.1.10 Cluster Per Plant**

The mean cluster per plant was given in Table 4.3 and depicted in Figure 4.4 showed that the maximum cluster per plant (9.15) were born on Shahenshah and followed by Emerald (8.50) and Dev (8.40). The lowest value (6.800) was found in TO-1057.

#### **4.1.11 Fruits Per Plant**

The mean fruit per plant was given in Table 4.3 and depicted in Figure 4.4, showed that the hybrid Dev was on the top by producing maximum fruits per plant (59.59), whereas hybrid Shahenshah and Mahy-302 were at par with Dev having value of (58.14 and 48.20) respectively. The lowest value (30.26) was found in KSP-1154.

#### **4.1.12 Fruit Weight (g)**

The mean fruit weight was given in Table 4.3 and depicted in Figure 4.4, showed that heaviest fruit (93.00 g) were produced of Sarthi-044 and followed by Dev (92.25 g) and Rajesh (91.38 g). The lowest value (82.50 g) was found in hybrid TO-1057.

#### **4.1.13 Fruit Diameter (cm)**

The mean fruit diameter of plant was given in Table 4.4 and depicted in Figure 4.4, showed that the highest mean value for fruit diameter (5.82 cm) was recorded in

Rajesh and followed by Dev (4.98 cm) and Arka Samrat (4.92 cm). The least value (4.35 cm) was observed for KSP-1154.

#### **4.1.14 Fruit Volume (cc)**

The mean fruit volume was given in Table 4.4 and depicted in Figure 4.5, 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.

#### **4.1.15 Fruiting Span**

The mean fruiting span of plant was given in Table 4.4 and depicted in Figure 4.5, 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.

### **4.2 Quality Parameters**

It is evident from the data presented in the preceding chapter that of quality parameters like specific gravity, titrable acidity, ascorbic acid, lycopene and total soluble solids are presented in Table 4.1, 4.2 and 4.3 and depicted in Fig. 4.6 and 4.7. The analysis of variance is given in Appendix IV and V.

#### **4.2.1 Specific Gravity ( $\text{g/cm}^3$ )**

The mean specific gravity of fruit was given in Table 4.4 and depicted in Figure 4.6, showed that the highest mean value for specific gravity ( $1.038 \text{ g/cm}^3$ ) was recorded in Dev which was highly significant and followed by Shahenshah ( $1.025 \text{ g/cm}^3$ ) and Arka Samrat ( $1.020 \text{ g/cm}^3$ ). The lowest value ( $0.870 \text{ g/cm}^3$ ) was found in TO-1057.

#### **4.2.2 Titrable Acidity (%)**

The mean titrable acidity of fruit was given in Table 4.5 and depicted in Figure 4.7, showed that the highest mean value for titrable acidity (0.509 %) was recorded in Arka Samrat which was highly significant and followed by Emerald (0.402 %) and Mahy-302 (0.396 %). The lowest value (0.304 %) was found in Rajesh.

#### **4.2.3 Ascorbic Acid (mg/100g)**

The mean ascorbic acid of fruit was given in Table 4.5 and depicted in Figure 4.7, 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.

#### **4.2.4 Lycopene Content (mg/100g)**

The lycopene content of fruit was given in Table 4.5 and depicted in Figure 4.7, 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.

#### **4.2.5 Total Soluble Solids (°Brix)**

The total soluble solids of fruit was given in Table 4.5 and depicted in Figure 4.7, showed that the highest mean value for total soluble solids (5.19 °Brix) was recorded in Sarthi-044 which was highly significant and followed by Dev (4.91 °Brix) and Arka Samrat (4.50 °Brix). The lowest value (3.47 °Brix) was found in Shahenshah

### **4.3 Yield Parameter**

It is evident from the data presented in the preceding chapter that of quality parameters like yield per plant and yield per square meter solids are presented in Table 4.6 and depicted in Fig. 4.8. The analysis of variance is given in Appendix V.

#### **4.3.1 Yield per plant (kg)**

The mean yield per plant of fruit was given in Table 4.6 and depicted in Figure 4.8, showed maximum yield per plant (5.50 kg) was recorded in Dev which was highly significant and followed by Shahenshah (5.15 kg) and Arka Samrat (4.32 kg). TO-1057 was observed least yielder among the hybrids studied. The lowest value (2.62 kg) was found in TO-1057.

#### 4.3.2 Yield per square meter (kg)

The mean yield per square meter of fruit was given in Table 4.6 and depicted in Figure 4.8, 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.

#### 4.4 Economics analysis of the treatments

The relative economics of the different treatments were calculated as per formula given in the material and methods. On the basis of the results obtained treatment Dev was found best for highest gross return of (₹ 242200), net return of (₹ 168155) and net return per rupee investment (2.27) and followed by Shahenshah gross return of (₹ 228700), net return (₹ 154655) and net return per rupee investment (2.09). While minimum gross return, net return and B:C (₹ 116000, ₹ 41955 and 0.57 respectively) in treatment KSP-1154 (Appendix VII).

**Table 4.1: Mean value of plant height at 90 days, plant height at final harvest, stem diameter at 90 days, stem diameter at final harvest of tomato hybrids.**

Sr. No.	Treatments	Plant height at 90 days (cm)	Plant height at final harvest (cm)	Stem diameter at 90 days (cm)	Stem diameter at final harvest (cm)
1	Mahy-302	246.90	352.90	0.71	1.14
2	TO-1057	211.88	301.65	0.63	0.93
3	KSP-1154	221.40	307.60	0.68	0.99

4	Arka Samrat	198.35	299.55	0.73	1.03
5	Emerald	185.25	287.75	0.65	1.17
6	Shahenshah	161.00	260.50	0.73	1.15
7	Dev	180.00	263.15	0.75	1.21
8	Sarathi-044	189.75	276.30	0.66	1.11
9	Rajesh	182.90	279.10	0.70	0.95
11	<b>SEm±</b>	11.367	8.477	0.005	0.056
12	<b>CD (P = 0.05)</b>	33.161	24.728	0.014	0.164

**Table 4.2: Mean value of branches per plant, leaf area per plant, days to flowering and per cent fruit set of tomato hybrids.**

<b>Sr. No.</b>	<b>Treatments</b>	<b>Branches per plant</b>	<b>Leaf area per plant (cm<sup>2</sup>)</b>	<b>Days to flowering</b>	<b>Percent fruit set</b>
1	Mahy-302	8.00	297.90	41.35	78.25
2	TO-1057	6.95	286.40	43.70	76.25
3	KSP-1154	7.15	291.85	45.25	74.15

4	Arka Samrat	7.30	299.65	46.25	79.50
5	Emerald	7.30	300.85	41.80	78.00
6	Shahenshah	7.85	307.60	41.53	80.20
7	Dev	7.35	321.95	39.70	82.45
8	Sarathi-044	7.35	312.65	35.55	80.60
9	Rajesh	6.60	319.25	47.60	79.75
11	<b>SEm±</b>	0.234	0.429	0.194	0.891
12	<b>CD (P = 0.05)</b>	0.682	1.251	0.566	2.600

**Table 4.3: Mean value of days to first harvesting, cluster per plant, fruit per plant and fruit weight of tomato hybrids**

<b>Sr. No.</b>	<b>Treatments</b>	<b>Days to first harvesting</b>	<b>Cluster per plant</b>	<b>Fruit per plant</b>	<b>Fruit weight (g)</b>
1	Mahy-302	92.95	7.90	48.20	83.75
2	TO-1057	96.80	6.80	34.06	82.50
3	KSP-1154	95.35	6.95	30.27	86.50
4	Arka Samrat	96.90	7.90	47.80	90.50
5	Emerald	94.50	8.50	47.98	86.75
6	Shahenshah	89.15	9.15	58.14	88.55
7	Dev	90.95	8.40	59.59	92.25
8	Sarthi-044	77.75	6.95	45.53	93.00
9	Rajesh	97.95	7.65	46.70	91.38
11	<b>SEm±</b>	0.402	0.159	1.364	1.398
12	<b>C.D. (P = 0.05)</b>	1.173	0.465	3.979	4.077

**Table 4.4: Mean value of fruit diameter (cm), fruit volume (cc), specific gravity (g/cm<sup>3</sup>) and fruiting span of tomato hybrids.**

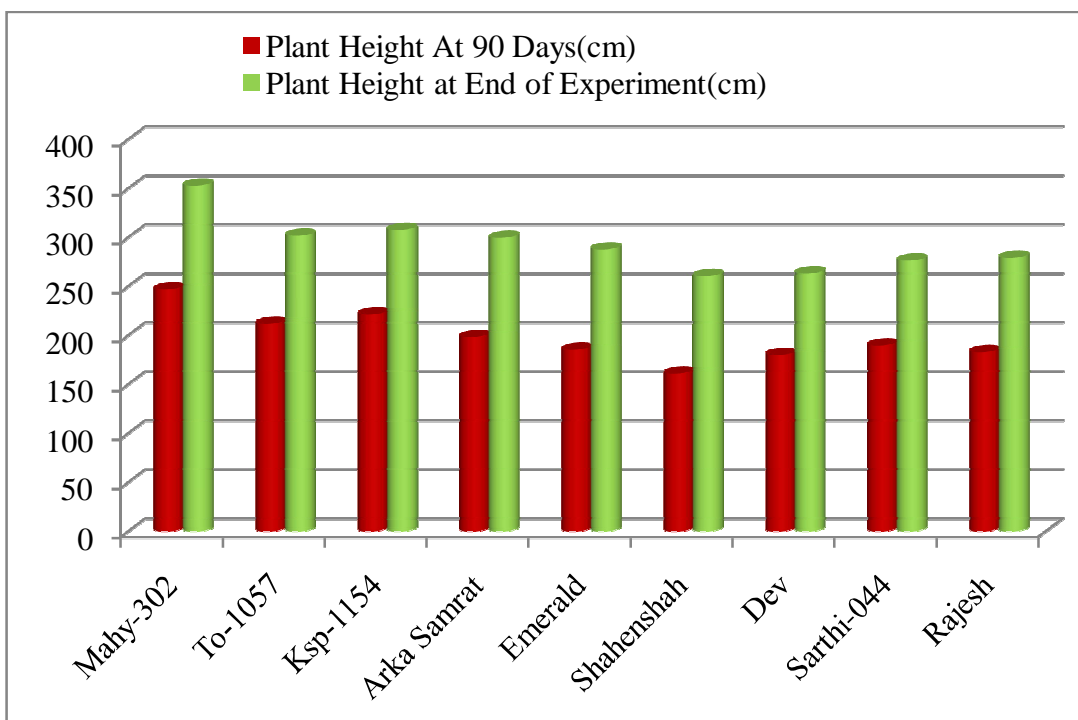
<b>Sr. No.</b>	<b>Treatments</b>	<b>Fruit diameter (cm)</b>	<b>Fruit volume (cc)</b>	<b>Specific gravity (g/cm<sup>3</sup>)</b>	<b>Fruiting span</b>
1	Mahy-302	4.46	86.58	0.968	113.75
2	TO-1057	4.39	94.84	0.870	110.25
3	KSP-1154	4.35	92.03	0.940	112.00
4	Arka Samrat	4.92	88.74	1.020	110.25
5	Emerald	4.61	86.10	1.008	112.75
6	Shahenshah	4.26	86.39	1.025	118.00
7	Dev	4.98	88.92	1.038	116.25
8	Sarathi-044	4.47	97.89	0.950	129.75
9	Rajesh	5.82	91.19	1.003	110.00
11	<b>SEm±</b>	0.113	1.550	0.006	0.597
12	<b>C.D. (P = 0.05)</b>	0.329	4.523	0.016	1.742

**Table 4.5: Mean value of titrable acidity, ascorbic acid, lycopene content, and total soluble solids of tomato hybrids.**

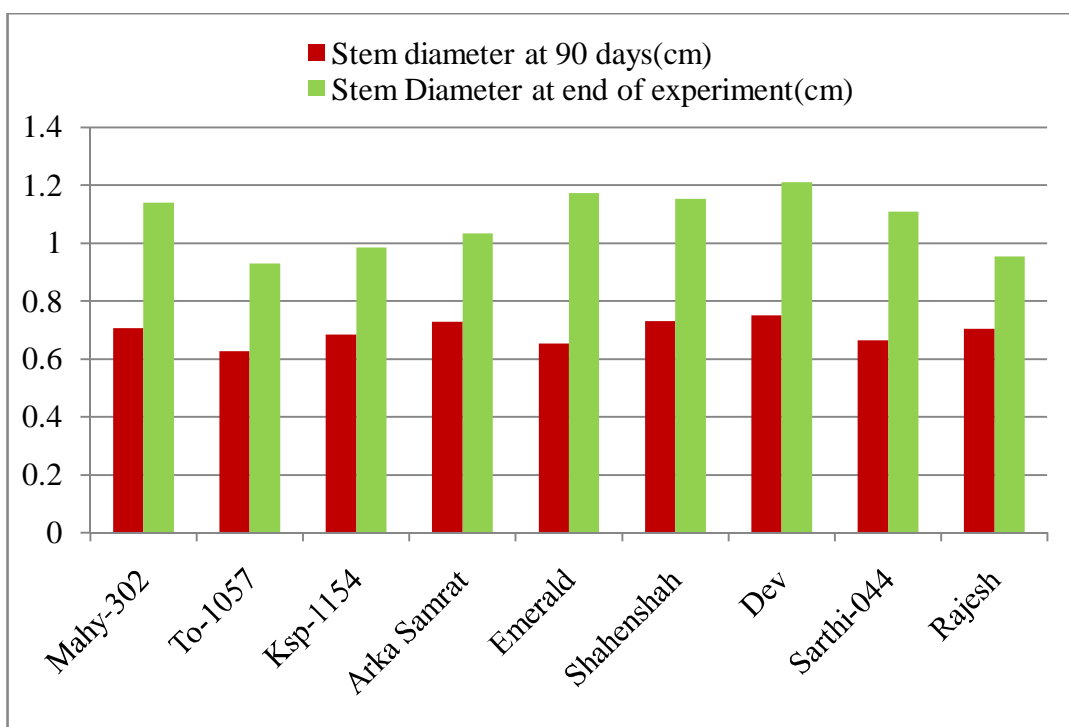
<b>Sr. No.</b>	<b>Treatments</b>	<b>Titrable acidity (%)</b>	<b>Ascorbic acid (mg/100g)</b>	<b>Lycopene content (mg/100g)</b>	<b>Total soluble solids (°Brix)</b>
1	Mahy-302	0.396	12.55	3.15	4.00
2	TO-1057	0.364	10.99	3.40	4.17
3	KSP-1154	0.309	12.28	3.74	3.72
4	Arka Samrat	0.509	17.77	5.80	4.51
5	Emerald	0.402	11.00	3.62	4.41
6	Shahenshah	0.351	11.05	3.79	3.48
7	Dev	0.365	15.38	4.21	4.92
8	Sarathi-044	0.310	12.44	3.90	5.19
9	Rajesh	0.304	13.28	3.59	3.68
11	<b>SEm±</b>	0.004	0.240	0.207	0.084
12	<b>C.D. (P = 0.05)</b>	0.012	0.700	0.604	0.244

**Table 4.6: Mean value of yield per plant and yield per square meter of tomato hybrids**

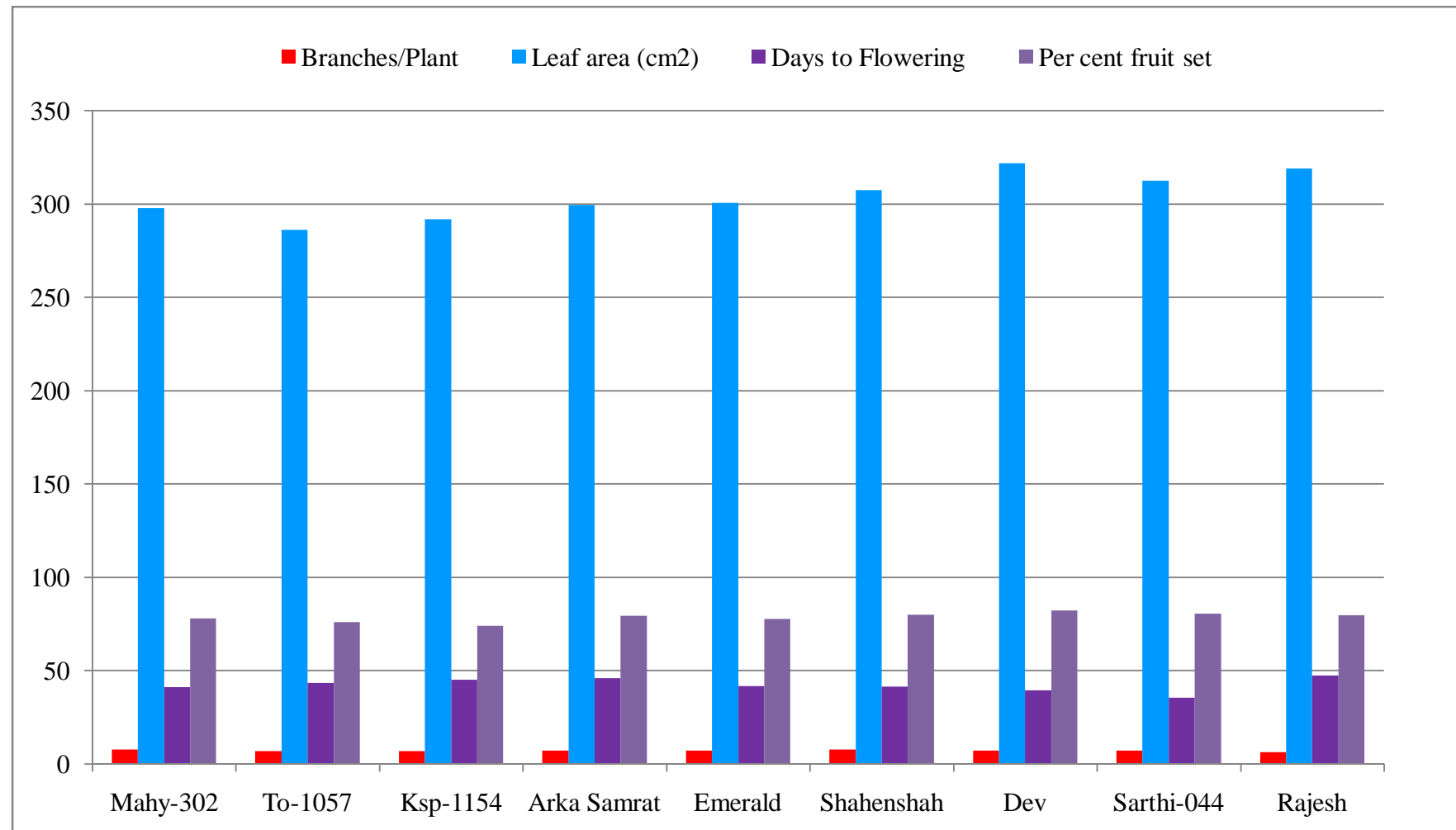
<b>Sr. No.</b>	<b>Treatments</b>	<b>Yield per plant (g)</b>	<b>Yield per square meter (kg)</b>
1	Mahy-302	4,035.31	17.93
2	TO-1057	2,813.00	12.50
3	KSP-1154	2,615.01	11.62
4	Arka Samrat	4,323.35	19.21
5	Emerald	4,161.78	18.49
6	Shahenshah	5,146.06	22.87
7	Dev	5,496.47	24.42
8	Sarthi-044	4,233.46	18.81
9	Rajesh	4,271.20	18.98
11	<b>SEm±</b>	130.884	0.582
12	<b>C.D. (P = 0.05)</b>	381.816	1.697



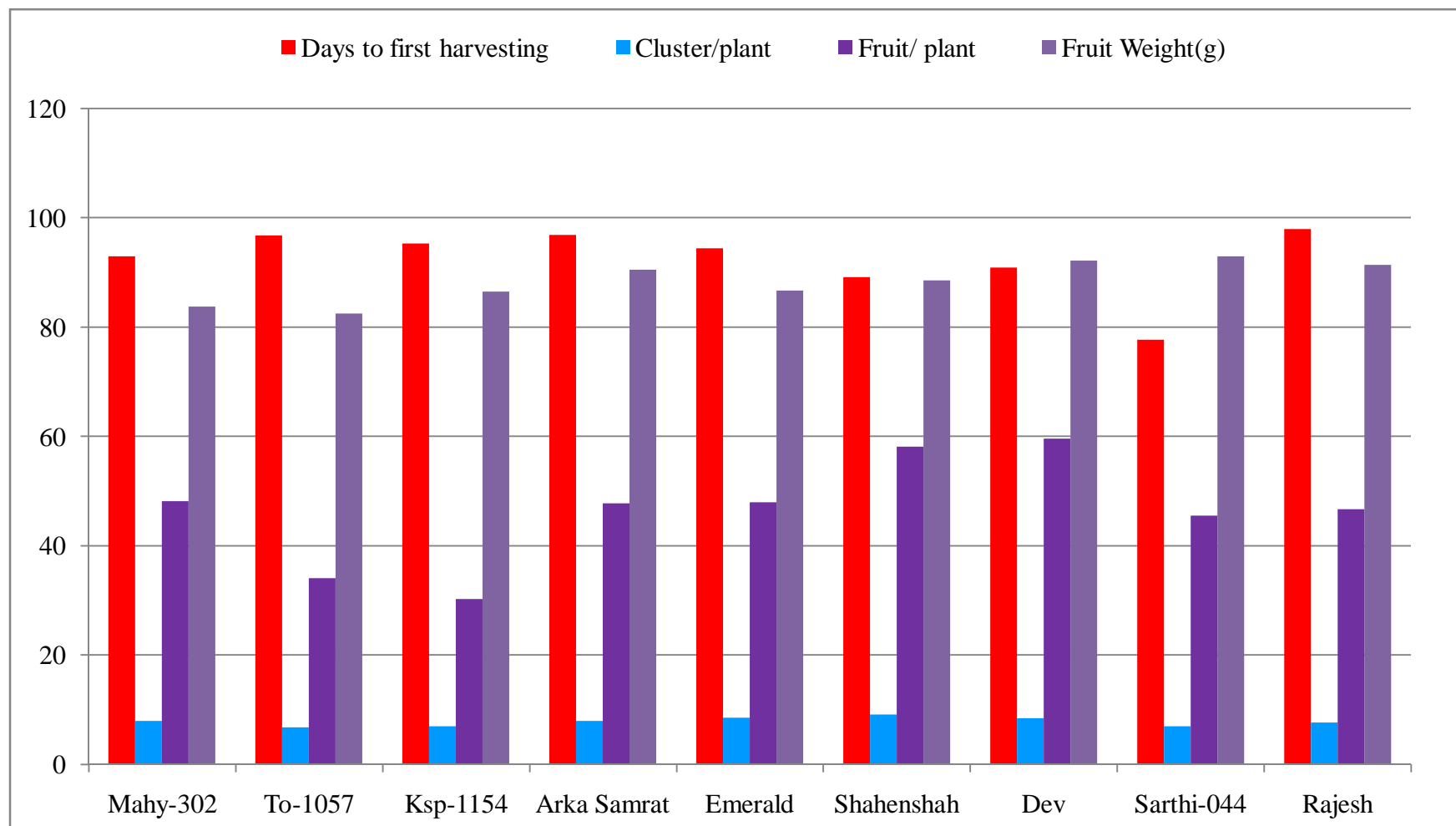
**Fig 4.1: Mean value of plant height at 90 days (cm), plant height at final harvest (cm)**



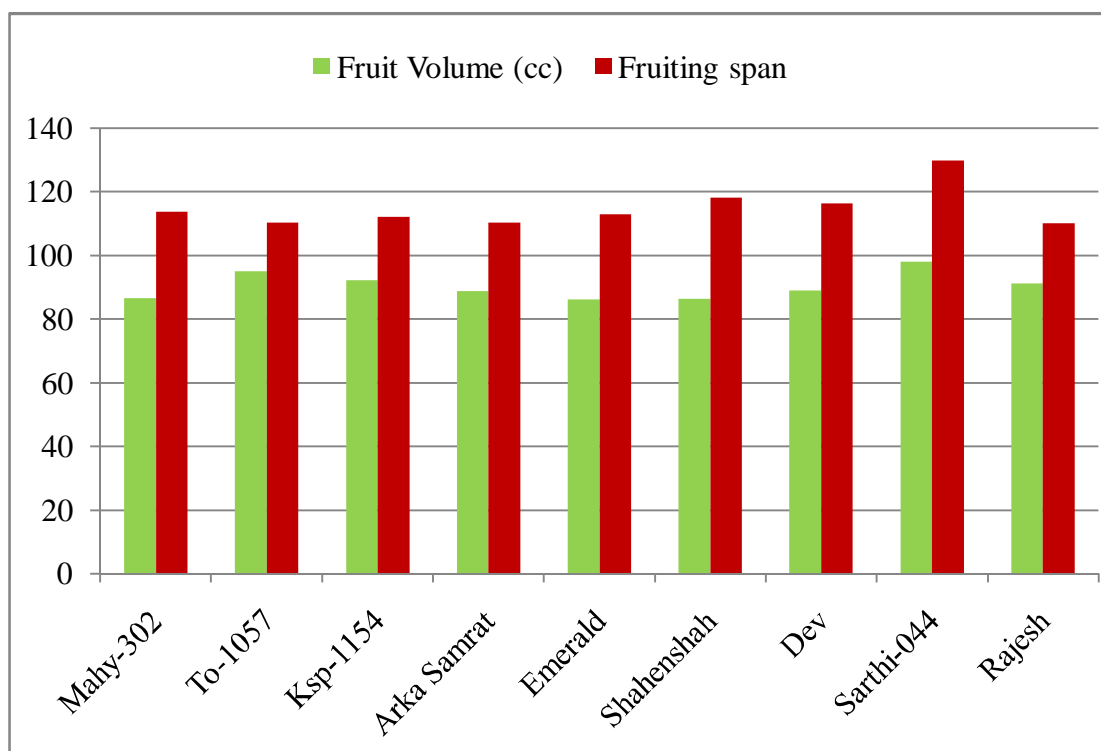
**Fig. 4.2: Mean value of stem diameter at 90 days (cm), stem diameter at final harvest (cm)**



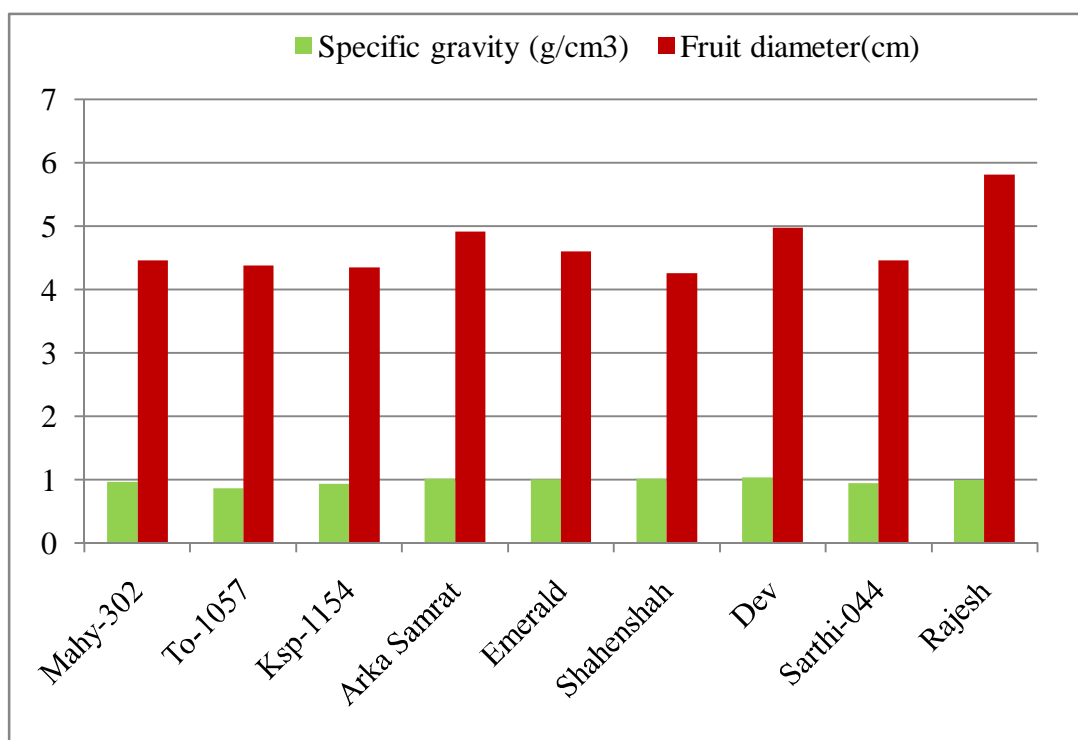
**Fig 4.3: Mean value of branches per plant, leaf area, days to flowering and per cent fruit set of nine hybrids of tomato.**



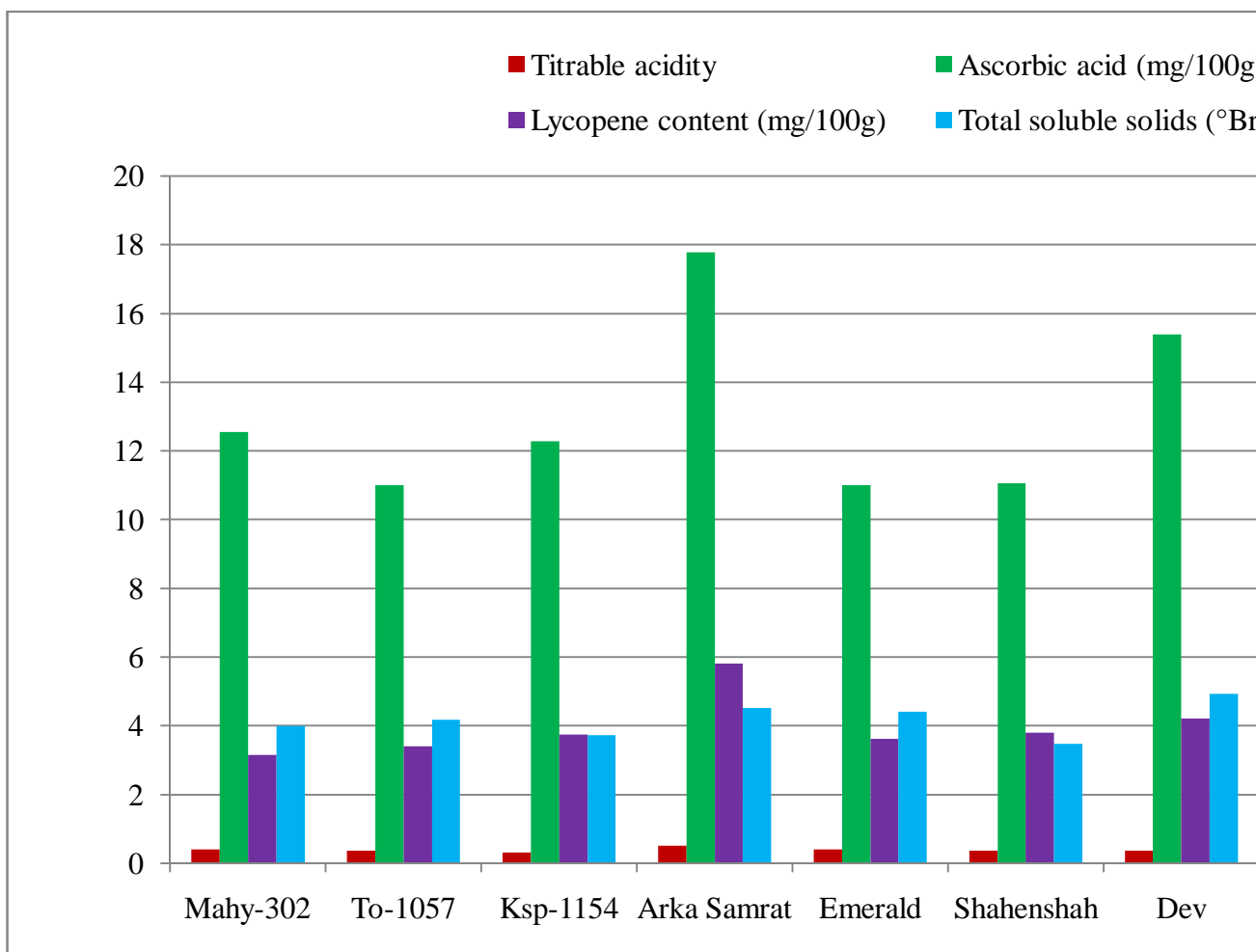
**Fig 4.4: Mean value of days to first harvesting, cluster per plant, fruit per plant and fruit weight (g) of nine hybrids of tomato**



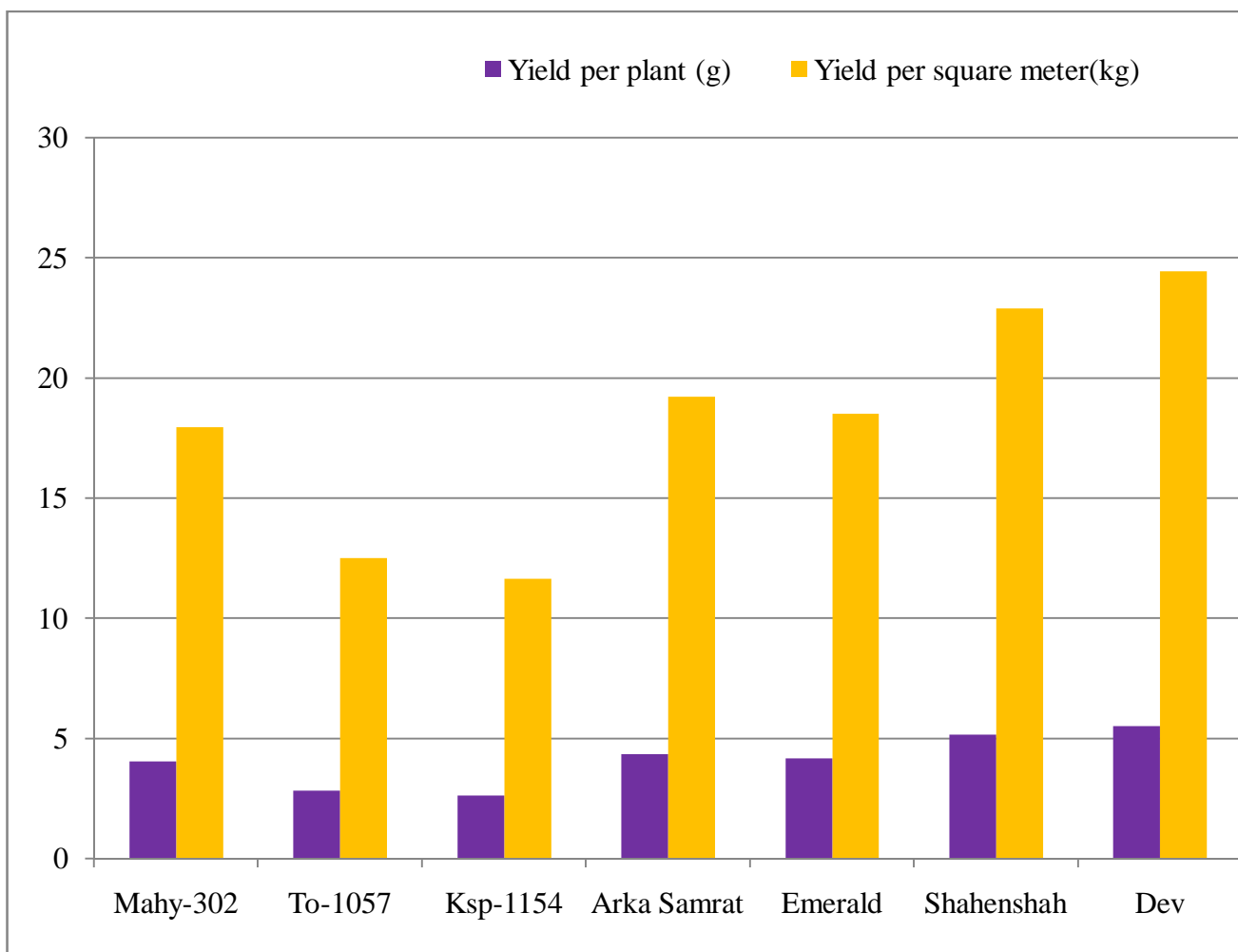
**Fig. 4.5: Mean value of Fruit Volume (cc), and fruiting span of nine hybrids of tomato**



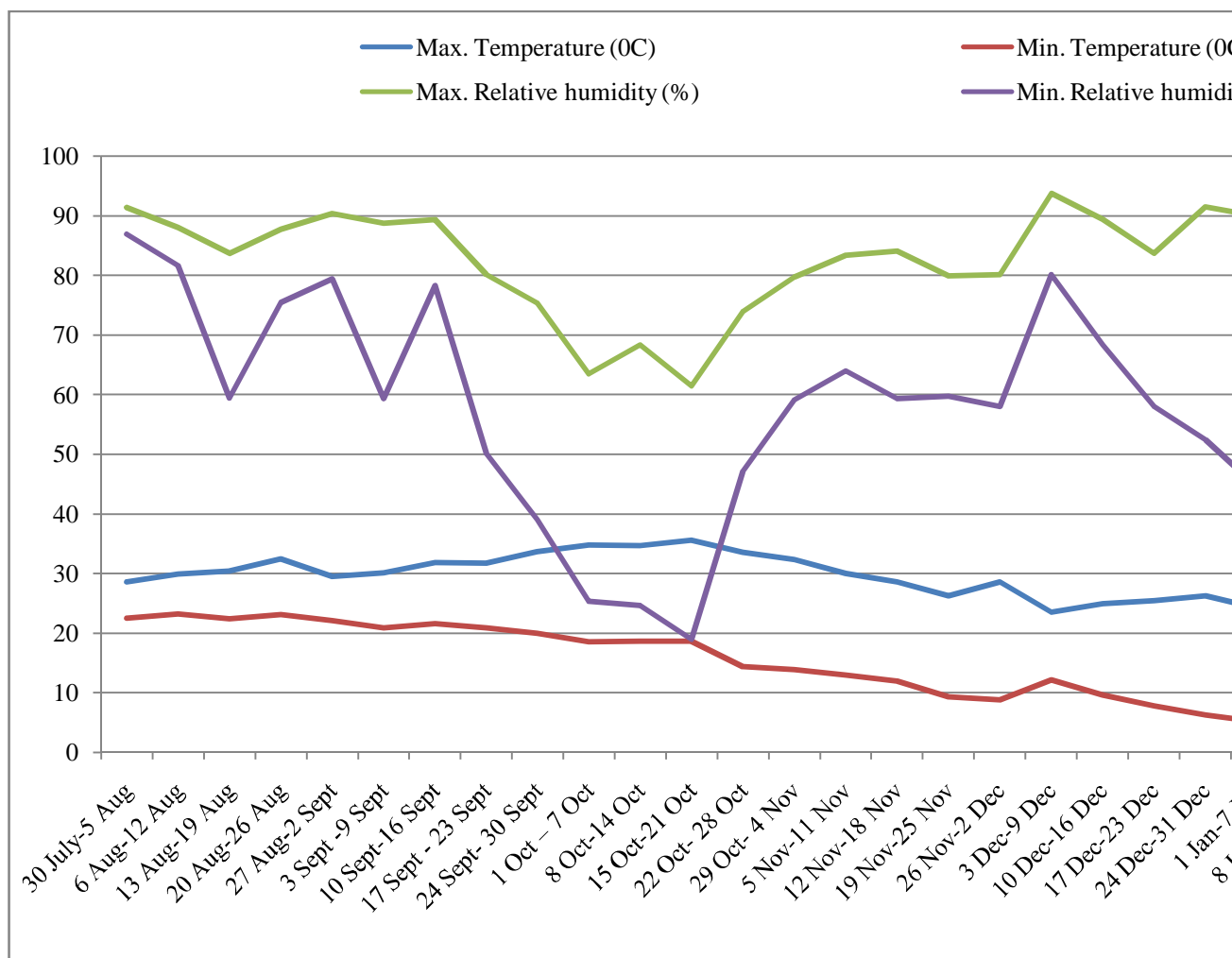
**Fig 4.6: Mean value of fruit diameter (cm) and specific gravity (g/cm<sup>3</sup>) of nine hybrids of tomato**



**Fig.4.7: Mean value of titrable acidity (%), ascorbic acid (mg/100g), lycopene content (mg/100g) and total soluble solids (°Brix) of nine hybrids of tomato**



**Fig 4.8: Mean value of yield per plant (g) and yield per square meter (kg) of nine hybrids of tomato**



**Fig. 3.1 Mean weekly meteorological data 2017-18)**

## 5. DISCUSSION

The results of the present investigation entitled **“Performance of Tomato (*Solanum lycopersicum* L.) Hybrids Under Polyhouse Condition”** showed significant variation among the treatments in most of the traits studied. Efforts have

been made to discuss the findings of the experimental results in this chapter. Pertinent literatures of other workers have been also cited in order to support the findings of the present investigation.

### **5.1 Vegetative Growth Parameters**

It is evident from the data presented in the preceding chapter that various characteristics had significant effects on vegetative growth parameters like plant height, stem diameter, branches per plant, fruit weight, fruit volume, per cent fruit set, yield per plant and yield per square meter of polyhouse grown tomato. The critical analysis of the findings of the present investigation clearly indicates that the genotypes differed among themselves in growth, flowering, fruit characters and yield. Growth and vigour of the plant depended to a great extent on environmental factors or under which they grown. The significant differences were found for vegetative growth parameter among the hybrids might be due to genetic makeup of hybrids.

The height of plant at 90 days ranged from 161.00 cm to 246.90 cm. The mean value for plant height at 90 days was recorded maximum in Mahy-302 (246.90 cm) followed by KSP-1154 (221.40 cm) and TO-1057 (211.88 cm), whereas height of plant at final harvest ranged from 263.15 cm to 352.90 cm. Mahy-302 produced tallest plant (352.90 cm) at final harvest followed by KSP-1154 (307.60 cm) and TO-1057 (301.65 cm). The presence of variation in plant height is the result of inherent genetic capacity of hybrids. Variation in plant height was also reported by Sharma and Singh (2015), while working with tomato hybrids and observed maximum plant height (315.00 cm) in Himraja under polyhouse condition. Ganesan (2001) revealed that tomato hybrid Pusa Ruby attained maximum plant height (2.11m) under greenhouse conditions. Jindal *et al.* (2015) concluded that tomato hybrid G-600 recorded maximum plant height (202.83 cm). Chapagain *et al.* (2011) seen maximum plant height (268.7cm) in tomato cultivar Srijana. Findings of Laxmi and Celini (2015) indicated that tomato hybrid Naveen had maximum plant height of 2.80 m under the polyhouse conditions.

The data regarding to the stem diameter at 90 days showed a range of 0.62 cm to 0.75 cm. The thickest stem at 90 days was seen in Dev (0.75 cm) which was highly significant and followed by Shahenshah (0.73 cm) and Arka Samrat (0.72 cm). The highest mean value for stem diameter at final harvest was recorded in Dev (1.21 cm)

which was highly significant and followed by Emerald (1.17 cm) and Shahenshah (1.15 cm).

The number of branches per plant ranged from 6.60 to 8.00. The maximum branches per plant (8.00) were born by hybrids Mahy-302 followed by Shahenshah (7.85) and Dev (7.35). Variation in number of branches was also seen by Gautam *et al.* (2013), who observed maximum branches per plant (9.34) cultivar Navoday in open field condition while working with tomato. The data regarding the leaf area per plant ranged from 286.40 to 321.95 cm<sup>2</sup>. The maximum leaf area was recorded in Dev (321.95 cm<sup>2</sup>) and followed by Rajesh (319.25 cm<sup>2</sup>) and Sarthi - 044 (312.65 cm<sup>2</sup>).

The data pertains to days to first flowering ranged from 35.55 to 47.60. Results showed that hybrid Sarthi-044 was earliest in commencement of flowering with value of 35.55 followed by Dev (39.70) and Mahy-302 (41.35), whereas hybrid Rajesh took maximum days (47.60 days). Earliness is highly desirable attribute in all the vegetables in the sense that the prevailing price in the market invariably higher early in the season. It is also considered to be economically important trait and therefore, assumes significance in crop improvement programme since the early flowering hybrids and varieties with high yield are usually sought for the commercial cultivation. This trend of earliness was also seen by Panday *et al.* (2006) in tomato cultivar NSITH-162 which took the shortest period of 36 days under plastic house condition. The findings of Chapagain *et al.* (2011) observed minimum days to first flowering (31) in tomato cultivar Srijana. Lekshmi and Celine (2015) concluded that tomato hybrid INDAM 9802 was the earliest to flower (26.27 days) under polyhouse condition.

Results revealed that per cent fruit set was ranged from 74.15 to 82.45. maximum fruit setting was recorded in Dev (82.45 %) and followed by Sarthi-044 (80.60 %) and Shahenshah (80.20 %). Alam *et al.* (2010) also observed a range of 32.96 % to 52.86 % while working with tomato. Pollen viability is one of the essential requirements for maximum fruit set. Maximum fruit setting of 84.09 per cent was reported by Sharma and Singh (2015) in the tomato hybrid Himraja unded polyhouse condition; whereas Panday *et al.* (2006) reported highest fruit setting of 93.9 per cent in tomato cultivar NSITH-162 under plastic house condition. Findings of Singh *et al.* (2014) were also in conformity, who reported highest fruit set (80.50%) in tomato

cultivar Laxmi. The data regarding days to first harvesting ranged from 77.75 to 97.95 and hybrid Sarthi-044 stood on first position and earliest hybrid with value of 77.75 followed by Shahenshah and Dev which took 89.15 and 90.95 days, respectively. Hybrid Rajesh took maximum days for first harvest with value of 97.95. Panday *et al.* (2006) observed that tomato cultivar NSITH-162 took the shortest period of 66 days from transplanting to first harvest, whereas Chapagain *et al.* (2011) reported that hybrid Srijana was earliest hybrid which took 77 days. The number of clusters per plant ranged from 6.80 to 9.15. The highest mean value for cluster per plant was recorded in Shahenshah (9.15) followed by Emerald (8.50) and Dev (8.40). Similar range of clusters per plant (6.00 to 8.33) have also been reported by Singh *et al.* (2014) while working with tomato, whereas Chapagain, *et al.* (2011) reported highest number of clusters (36.23) in tomato hybrid Srijana.

Number of fruits per plant is an important yield contributing trait and directly contributes to yield per plant and yield per square, in present investigation it ranged from 30.26 to 59.59 fruits per plant. Hybrid Dev was on the top in order of bearing maximum fruits with mean value of 59.59, hybrid Shahenshah was *at par* with Dev with a value of 58.14. Findings of Cheema *et al.* (2013) was in close proximity with present results, who reported maximum of 58.40 fruits per plant in tomato hybrid *i.e.* TAI-687 under net house conditions. Fruit weight is also another important character contributing to yield per plant directly, 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. Jindal *et al.* (2014) reported maximum mean fruit weight for hybrid G-600 (96.83 g) and Mohanty and Prusti (2001) noticed that tomato genotype 'ET 35' large sized fruits (92.67 g) were in close proximity of present findings, whereas Chaudhary *et al.* (1993) reported maximum average fruit weight (163.33 g) in tomato hybrid 'Carmello' under the Plastic tunnel. Hossain *et al.* (2010) reported that range of fruit weight was varied from 21.54 to 60.92 g. Lekshmi and Celine (2015) concluded that tomato hybrid, INDAM 3001 had maximum fruit weight (102.19 g) under polyhouse condition.

The data pertains to fruit diameter ranged from 4.35 to 5.81 cm. 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 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. The data related to fruit volume ranged from 86.38 to 97.89 cc. The highest mean value for fruit volume was recorded in Sarthi-044 (97.89 cc) followed by To-1057 (94.84 cc) and Rajesh (91.19 cc). 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 highest mean value for fruiting span was recorded in Sarthi-044 (129.75) followed by Shahenshah (118.00) and Dev (116.25).

## 5.2 Quality Parameters

Results revealed that specific gravity had a range of 0.870 to 1.038 g/cm<sup>3</sup>. The fruits of hybrid Dev were most compact with maximum specific gravity of 1.038 g/cm<sup>3</sup> followed by Shahenshah and Arka Samrat with value of 1.025 g/cm<sup>3</sup> and 1.020 g/cm<sup>3</sup>, respectively. Finding of Shibli *et al.* (1995) were *at par* with present results, who reported that specific gravity ranged from 0.95 g/cm<sup>3</sup> to 1.095 g/cm<sup>3</sup> in tomato hybrids

The data pertains to titrable acidity ranged from 0.304 to 0.509 per cent. The maximum titrable acidity was recorded in Arka Samrat (0.509 %) followed by Emerald (0.402%) and Mahy-302 (0.396%). The variation in titrable acidity was seen by Sharma and Singh (2015) who reported maximum titrable acidity in tomato hybrid Rupali (0.623 %) grown under plastic house condition, whereas Jindal *et al.* (2015) reported highest titrable acidity (0.56 %) in tomato hybrid HS-18. Sourness of fruit is an important characteristic as it decides consumer's preference further ascorbic acid is precursor of vitamin C, hence it improves nutritive value of fruits. The ascorbic acid ranged from 10.99 to 17.76 mg/100g. The highest mean value for ascorbic acid was recorded in Arka Samrat (17.77 mg/100g) and followed by Dev (15.38 mg/100g) and Rajesh (13.28 mg/100g). 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) tomato hybrid HS-18. Results showed that lycopene content ranged from 3.14 to 5.80

mg/100g. The highest mean value for lycopene content was recorded in Arka Samrat (5.80 mg/100g) and followed by Dev (4.21 mg/100g) and Sarthi-044 (3.90 mg/100g). 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.

The data pertains to total soluble solids ranged from 3.47 to 5.19 °Brix. The highest mean value for total soluble solids (5.19 °Brix) was recorded in Sarthi-044 and followed by Dev (4.92 °Brix) and Arka Samrat (4.51 °Brix). 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 °Brix) in tomato. These results were supported by Sharma and Singh (2015), who observed maximum total soluble solids in tomato hybrid Himraja (7.98 °Brix). Jindal *et al.* (2015) reported that hybrid HS-18 recorded maximum total soluble solids (4.72 °Brix), whereas according to Lekshmi and Celine (2015) maximum total soluble solids (5.36 °Brix) was found in tomato hybrid INDAM 3003.

### **5.3 Yield Parameters**

Yield per plant is a trait of immense importance which decides profitability of crop grown. In present investigation it ranged from 2,615.01 to 5,496.46 g. Hybrid Dev was highest yielder with an average yield of 5,496.46 g per plant. Hybrid Shahenshah was on second position among the hybrids studied with mean value of 5,146.05 g, followed by Arka Samrat (4,323.35 g). 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. Although genetic constituents of the plant decides its yield potential, but the expression of the yield may be influenced by the environmental factors in which plant grows. Jindal *et al.* (2015) observed maximum yield per plant (3.19, 3.30 and 3.11 kg) in hybrid HS-18 during all the three years, respectively, under naturally ventilated polyhouse condition. Singh *et al.* (2006) reported maximum yield per plant *i.e.* 5.8 kg and 5.6 kg from cultivar R-144 during 2000-2001 and 2001-2002, respectively. Yield per square meter was derived from

yield per plant and calculated on the basis of gross area required for a plant in polyhouse which includes path and other spaces left in polyhouse. Yield per square meter ranged from 11.62 to 24.42 kg. Maximum production per unit area was recorded from hybrid Dev by producing 24.42 kg fruits per square meter. Hybrid Shahenshah ranked second with production of 22.87 kg fruits per square meter area, followed by Arka Samrat (19.21 kg). Variation in fruit yield per hectare was also reported by Singh *et al.* (2013) while working with tomato hybrids and reported maximum fruit yield per hectare 1287.6 q in tomato hybrid Avinash-2 under greenhouse condition, whereas Sima *et al.* (2011) reported maximum fruit yield per square meter (11.37 kg) in tomato hybrid Shanon F<sub>1</sub> under greenhouse condition.

#### **5.4 Economic feasibility**

The relative economics of the various hybrids grown under polyhouse condition was analyzed, results revealed that hybrid Dev was found best as it gave maximum gross return of ` 242200, net return of ` 168155 and net return per rupee investment of ` 2.27 per 1000 square meter area. Among the various hybrids studied, second best hybrid was Shahenshah, which gave gross return of ` 228700, net return of ` 154655 and net return per rupee investment 2.09.

## 6. SUMMARY

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The experiment entitled "Performance of Tomato (*Solanum lycopersicum* L.) Hybrids Under Polyhouse Condition" was conducted at Hi-Tech Unit, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur during the year 2017-18. The results obtained and discussed in the preceding chapters have been summarized as below:

1. The results showed that maximum plant height at 90 days (246.90 cm) and at final harvest (352.90 cm), branches per plant (8.00) were recorded in Mahy-302. Whereas maximum stem diameter at 90 days (0.75 cm) and at final harvest (1.21 cm), leaf area per plant (321.95 cm<sup>2</sup>), per cent fruit set (82.45 %) and fruits per plant (59.59) were recorded in hybrid Dev.
2. whereas hybrid Sarthi-044 was found earliest as took minimum days to flowering (35.55) and first harvesting (77.75), while maximum clusters per plant (9.15) was recorded in hybrid Shahenshah and whereas fruit volume (97.89 cc), and fruit weight (93.00 g). respectively in hybrid Sarthi-044.
3. Among the yield parameters *i.e.* yield per plant and yield per square meter were reported maximum in Dev *i.e.* 5496 g 24.42 kg, respectively. Economic analysis showed that hybrid Dev showed significantly highest gross return of (₹ 242200), net return of (₹ 168155) and net return per rupee investment (2.27) as compared to other hybrids under study.
4. For quality parameters the maximum titrable acidity (0.509%), ascorbic acid (17.76 mg/100g) and lycopene content (5.80 mg/100g) were recorded in hybrid Arka Samrat, whereas maximum total soluble solids (5.19 °Brix) and specific gravity (1.038 g cm<sup>-3</sup>) were reported in hybrids Sarthi-044 and Dev, respectively.

## 7. CONCLUSION

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On the basis of results obtained in the present investigation entitled **"Performance of Tomato (*Solanum lycopersicum* L.) Hybrids Under Polyhouse Condition"** it may be concluded that among the various treatments, cultivar Dev was found superior in vegetative growth and yield parameters such as stem diameter, leaf area, per cent fruit set, specific gravity, number of fruits per plant, 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, whereas maximum total soluble solids were recorded in hybrid Sarti-044.

The hybrid Dev was also found most economic feasible as it gave maximum gross return of ( ₹ 242200), net return of ( ₹ 168155) and net return per rupee investment (2.27) as compared to other hybrids studied. On the basis above findings it can be inferred that the hybrids Dev was high yielding among the hybrids studied, hence Dev can be indicative for commercial cultivation under polyhouse condition in Udaipur, Rajasthan.

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**Performance of Tomato (*Solanum lycopersicum* L.) Hybrids Under Polyhouse Condition**

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**ABSTRACT**

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An experiment entitled "Performance of Tomato (*Solanum lycopersicum* L.) Hybrids Under Polyhouse Condition" was conducted at Hi-Tech Unit, Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur during the year 2017-18 to find out the best tomato hybrid under polyhouse condition. The experiment was laid out in completely randomized design with nine hybrids replicated four times.

The hybrid Dev was found best in terms of vegetative and yield characteristics *i.e.* stem diameter (0.75 cm), leaf area (321.95 cm<sup>2</sup>), per cent fruit set (82.45 %) and yield characteristics like fruit per plant (59.59), yield per plant (5496 g) and yield per square meter (24.42 kg). Among the qualitative traits, maximum titrable acidity (0.509 %), ascorbic acid (17.76 mg/100g) and lycopene content (5.80 mg/100g) were recorded for hybrid Arka Samrat, whereas maximum total soluble solids (5.19°Brix) were found in Sarthi-044.

The hybrid Dev was also found best hybrid as it gave highest gross return of (₹ 242200), net return of (₹ 168155) and net return per rupee investment (2.27) as compared to other hybrids studied. On the basis of present investigation, it can be inferred that the hybrids Dev was high yielding, hence that hybrid can be recommended as better hybrids for commercial cultivation under polyhouse condition in Udaipur, Rajasthan.

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#### APPENDIX -I

**Analysis of variance for plant height at 90 days, plant height at final harvest, stem diameter at 90 days and stem diameter at final harvest (cm) of nine hybrids of tomato**

Source of variance	MS				
	d. f.	Plant height At 90 days (cm)	Plant height at final harvest (cm)	Stem diameter at 90 days (cm)	Stem diameter at final harvest (cm)
<b>T</b>	8	2640.346**	3178.884**	0.007**	0.042**
<b>Error</b>	27	516.852	287.408	0.0001	0.013
<b>Total</b>	35				

\* Level of significance at 5% & \*\* level of significance at 1%

#### APPENDIX-II

**Analysis of variance for branches per plant, leaf area, days to flowering and per cent fruit set of nine hybrids in polyhouse grown tomato**

Source of variance	MS				
	d. f.	Branches per plant	leaf area per plant (cm <sup>2</sup> )	Days to flowering	Per cent fruit set
<b>T</b>	8	0.715**	582.721**	53.986**	24.494**
<b>Error</b>	27	0.219	0.735	0.151	3.177
<b>Total</b>	35				

\* Level of significance at 5% & \*\* level of significance at 1%

**APPENDIX-III**

**Analysis of variance for days to first harvesting, cluster per plant, fruit per plant and fruit weight of nine hybrids in polyhouse grown tomato**

Source of variance	MS				
	d. f.	Days to first harvesting	Cluster per plant	Fruit per plant	Fruit weight (g)
<b>T</b>	8	155.531**	2.580**	366.400**	56.007**
<b>Error</b>	27	0.647	0.101	7.440	7.813
<b>Total</b>	35				

\* Level of significance at 5% & \*\* level of significance at 1%

**APPENDIX-IV**

**Analysis of variance for fruit diameter (cm), fruit volume (cc), specific gravity (g/cm<sup>3</sup>) and fruiting span of nine hybrids in polyhouse grown tomato**

Source of variance	MS				
	d. f.	Fruit diameter (cm)	Fruit volume (cc)	Specific gravity (g/cm <sup>3</sup> )	Fruiting span
<b>T</b>	8	0.952**	66.603**	0.011**	156.715**
<b>Error</b>	27	0.051	9.616	0.0001	1.426
<b>Total</b>	35				

\* Level of significance at 5% & \*\* level of significance at 1%

#### APPENDIX-V

**Analysis of variance for titrable acidity, ascorbic acid, lycopene content and total soluble solids of nine hybrids in polyhouse grown tomato**

Source of variance	MS				
	d. f.	Titrable acidity (%)	Ascorbic acid (mg/100g)	Lycopene content (mg/100g)	Total soluble solids (°Brix)
<b>T</b>	8	0.017**	20.666**	2.373**	1.347**
<b>Error</b>	27	0.0001	0.231	0.171	0.028
<b>Total</b>	35				

\* Level of significance at 5% & \*\* level of significance at 1%

#### APPENDIX-VI

**Analysis of variance for yield per plant and yield per square meter of nine hybrids in polyhouse grown tomato**

Source of variance	MS		
	d. f.	Yield per plant (g)	Yield per square meter (kg)
<b>T</b>	8	3503344.44**	69.20**
<b>Error</b>	27	68522.089	1.354
<b>Total</b>	35		

\* Level of significance at 5% & \*\* level of significance at 1%

## APPENDIX VII

### **Economics of tomato cultivation under polyhouse condition (for 1000 m<sup>2</sup> area).**

#### **(A) General cost per 1000 m<sup>2</sup> area**

S. No	Particulars	Units	Cost Per Unit (₹)	Amount (₹)
<b>A.</b>	<b>VARIABLES:</b>			
(a)	Labour cost			
<b>I</b>	<b>Nursery</b>			
(i)	Nursery preparation and sowing	2 man/days	@190	380.00
(ii)	Nursery management (Two hour for 30 days)	5 man/days	@190	950.00
<b>II</b>	<b>Main field</b>			
(i)	Bed preparation	4 man/days	@190	760.00
(ii)	Transplanting	02 man/days	@190	380.00
(iii)	Manuring and fertilization	05 man/days	@190	950.00
(iv)	Intercultural operations (Hoeing, weeding, earthing up, pruning and irrigation)	30 man/days	@190	5700.00
(v)	Spraying (insecticides and pesticides)	50 man/days	@190	9500.00
(vi)	Picking and harvesting (Two hours for 90days)	30 man/days	@190	5700.00
	<b>Total</b>			<b>24320.00</b>
<b>B.</b>	<b>FIXED COST/ INFRASTRUCTURE</b>			
(i)	Depreciation on fixed cost + interest on invested money			<b>25000.00</b>
<b>C.</b>	<b>MATERIAL INPUTS</b>			
(i)	Vermicompost	500 kg	₹ 4/ kg	2000.00
(ii)	Seed	4444 seed/ 1000m <sup>2</sup>	1800	1800
(iii)	Soil treatment	formaldehyde @ (100 lit./10,00 m <sup>2</sup> area)	₹ 20/ litre	2000.00
(iv)	Insecticide and fungicide and fertilizer			
(v)	Imidachlorprid 17.8% SL	1000 ml	₹ 150/100 ml	1500.00
(vi)	Mancozeb 75% WP (Indofil M-45)	1500 g	₹ 45/100g	675.00
(vii)	19:19:19 grade	42/ kg	₹ 100/kg	4200
(viii)	0:52:34 grade	7 kg	₹ 100/kg	700

(ix)	Calcium nitrate	77 kg	` 100/kg	7700
(x)	Potassium sulphate	4.17 kg	` 36/kg	150
(xi)	Micronutrient mixture	25 kg	` 100/kg	2500
(xii)	Plastic ropes			1500.00
	<b>Total</b>			<b>24725</b>
	<b>Total general cost (D) = A+B+C = 24320+25000+24725</b>			<b>` 74045</b>

**(C) Net returns and b: c ratio per 1000 m<sup>2</sup> area of tomato in polyhouse**

<b>Treatment</b>	<b>General cost ( )</b>	<b>Gross returns ( )</b>	<b>Net returns ( )</b>	<b>B C Ratio</b>
Mahy-302	74045	179300	105255	1.42
TO-1057	74045	125000	50955	0.69
KSP-1154	74045	116000	41955	0.57
Arka Samrat	74045	192100	118055	1.59
Emerald	74045	184900	110855	1.50
Shahenshah	74045	228700	154655	2.09
Dev	74045	242200	168155	2.27
Sarathi-0044	74045	188100	114055	1.54
Rajesh	74045	189800	115755	1.56



**Plate-1 : A view of experimental site (polyhouse)**



**Plate- 2 : Fruits of hybrid Emerald**

**Plate- 2 : Fruits of hybrid Emerald**

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