GROWTH AND YIELD COMPONENT OF TOMATO (*Solanum lycopersicon* L.*)* UNDER PROTECTED CONDITION

M.Sc. (Ag.) Thesis

by

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GROWTH AND YIELD COMPONENT OF TOMATO (*Solanum lycopersicon* L.*)* UNDER PROTECTED CONDITION

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur

by

RAJESH SINGH

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FOR THE DEGREE OF

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In

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(Plant Physiology)

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JULY, 2017

CERTIFICATE - I

This is to certify that the thesis entitled **"Growth and yield component of tomato *(Solanum lycopersicon* L.) under protected condition"** submitted in partial fulfillment of the requirement for the degree of **"Master of Science in Agriculture"** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a recorded of the bonafide research work carried out by **Rajesh Singh** under my guidance and supervision. The subject of the thesis has been approved by the student's Advisory committee and Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

21/07/17

Date : 21/07/17

Chairman

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member: Dr. Hemant Kumar Panigrahi

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Member: Dr. R. R. Saxena

CERTIFICATE – II

This is to certify that the thesis entitled **"Growth and yield component of tomato *(Solanum lycopersicon* L.) under protected condition"** submitted **Rajesh Singh** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture** in the Department of Plant Physiology, Agricultural Biochemistry, Medicinal & Aromatic Plants has been approved by the external examiner and Student's Advisory Committee and External Examiner after oral examination.

Signature External Examiner

Date: (Name R. S. Kaja)

Major Advisor

Head of the Department

Dean/ Dean Faculty

Director of Instructions

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When heart speaks in seclusion…

At last the moment has come to look in to deeper layer of heart, which is filled with the feeling of togetherness, loveliness, consolidation, satisfaction, a sign of relief and fulfillment. Some are momentary and some are permanent, but both involve a member of near and dear persons to whom I acknowledge my warm regards and take this opportunity to express my feeling in black and white.

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me. There is no match to the affection and cooperation given to me by brothers ***Vijay Singh*** *and my sister* ***Tillo Singh****.*

"Friends are one who loves you more than you". I fail in my duty if I do not express my thanks to my innumerable friends their companionship and spontaneous help enabled me to complete this mammoth task. To name few ***Nutan, Krishna, lokhnath, tarun, siddharth, rakesh, anil, rahul, ravi, shikher, bikram, manendra, bhagwat, rahul, zeenat, vrishali, rajni, gopal, satish and santhosh.***

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Place: Raipur
Date: 21/07/17

Rajesh Singh

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LIST OF ABBREVIATIONS

%	:	Percent
^{0}C	:	Degree Celsius
CD	:	Critical difference
CG	:	Chhattisgarh
cm	:	Centimetre
DAT	:	Days after Transplanting
et al.	:	And co-worker/ and others
Fig	:	Figure
kg	:	Kilogram
ha	:	hectare
ha^{-1}	:	per hectare
i.e.	:	That is
LA	:	leaf area
m^{-2}	:	per metre square
Mix.	:	Maximum
Min.	:	Minimum
NS	:	Non significant
Plant^{-1}	:	Per plant
M	:	meter
CRD	:	Completely randamized design
RH	:	Relative humidity
ml	:	Milli leter
/	:	per
spp.	:	Species
SEm±	:	Standard error of mean
EC	:	Emulcifiable concentration
Fig.	:	Figure
TSS	:	Total soluble solids
	:	Tonnes
viz.	:	For example
Mg 100 g^{-1}	:	Milligram per hundred gram
UV	:	Ultra violet
SG	:	Soluble granules

LIST OF PLATES

THESIS ABSTRACT

a)	Title of the Thesis	:	"Growth and yield component of tomato (*Solanum lycopersicon* L.) under protected condition"
b)	Full Name of the Student	:	Rajesh Singh
c)	Major Subject	:	Plant Physiology
d)	Name and Address of the Major Advisor	:	Dr. S. P, Tiwari. Asst. Professor, Department of plant Physiology, Agriculture biochemistry, Medicinal and Aromatic Plants. College of Agriculture, IGKV, Raipur (C.G.)
e)	Degree to be awarded	:	Master of Science in Agriculture (Plant Physiology)

Signature of the Student

Signature of the Major Advisor

Date: 22/07/17

Signature of Head of the Department

ABSTRACT

The present investigation entitled "Growth and yield component of tomato (*Solanum lycopersicon* L.) under protected condition" was carried out during *kharif* season 2016- 2017 at Research Farm of Center of excellence on protected cultivation and precision farming, College of Agriculture, IGKV, Raipur (C.G), with the objectives to study the Morphological and Phenological parameters of

different varieties of tomato & to assess the varieties for physiological, efficient traits contributing for polyhouse conditions to analysized by morphological, phenological, physiological and yield attributing for fruit yield its contributing under polyhouse conditions.

Among varieties Youvraj 1003, Roja, Laila and Sheeja had better performance under polyhouse conditions. Leaf area, days to first flowering, number of flower plant^{-1}, days to first fruit set, were noticed superior in Youvraj 1003. Starch and chlorophyll contents were maximum found in variety Sheeja. Acidity, TSS, ascorbic acid, reducing sugar, total sugar were found superior in Youvraj 1003 but maximum lycopene content was observed under the variety Roja. Fruit diameter, days to first fruit picking ,average fruit yield kg plant^{-1}, fruit yield tones ha^{-1} were noticed superior in Youvraj 1003.

Correlation coefficient analysis related that exhibited positive and significant association with leaf area, fruit diameter, starch content, chlorophyll content, ascorbic acid, reducing sugar, total sugar, average fruit yield.

शोधग्रंथ सारांश

अ.	शोध शीर्षक	:	"संरक्षित वातावरण में टमाटर (*सोलेनम लाइकोपर्सिकम* एल.) के वृद्धि तथा उपज अवयवों पर प्रभाव"
ब.	विद्यार्थी का पूरा नाम	:	राजेश सिंह
स.	मुख्य विषय	:	पादप कार्यिकी
द.	मुख्य सलाहकर का नाम व पता	:	डॉ. एस. पी. तिवारी, सहा. प्राध्यापक पादप कार्यिकी, कृषि रसायन, औषधीय एवं सुगंधित विभाग कृषि महाविद्यालय, इं. गा. कृषि वि. वि. रायपुर (छ.ग.)
य.	सम्मानित किये जाने वाली उपाधि	:	एम.एस.सी. कृषि, पादप कार्यिकी

मुख्य सलाहकार के हस्ताक्षर

विद्यार्थी के हस्ताक्षर

दिनांक : 21/7/17

विभागाध्यक्ष के हस्ताक्षर

सारांश

इंदिरा गॉधी कृषि विश्वविद्यालय के उत्कृट केन्द्र एवं यर्थात खेती के अनुसंधान प्रक्षेत्र पर सत्र 2016–17 के अन्तर्गत अनुसंधान किया गया । जिसका शीर्षक "संरक्षित वातावरण में टमाटर (*सोलेनम लाइकोपर्सिकम* एल.) के वृद्धि तथा उपज अवयवों पर प्रभाव" जिसका उद्देश्य टमाटर के अकारिकी एवं पुष्पयिविज्ञान के प्रमाप के द्वारा प्रजातियों का अध्ययन करना तथा संरक्षित वातावरण में विभिन्न किस्मों का कार्यिकीय दक्षता के आधार पर प्रदर्शन तथा आकरिकी, कार्यिकी, पुष्पीय विज्ञान का उपज में योगदान का विश्लेषण किया गया ।

संरक्षित वातावरण में युवराज 1003, रोजा, लैला एवं शीजा प्रजातियों का उत्कृष्ट प्रदर्शन रहा । पत्तियों का क्षेत्रफल, प्रथम पुष्पन, प्रति पौधा फूलों की संख्या, प्रथम फल दिवस किस्मों में युवराज 1003 उत्कृष्ट रहा । अम्लीयता, एस्कार्बिक अम्ल, कुल शर्करा भी युवराज 1003 किस्म में अधिक मिला जबकि लाइकोपिन की मात्रा सबसे अधिक रोजा में प्राप्त हुआ तथा स्टार्च एवं पर्णहरित सबसे अधिक शीजा में प्राप्त हुआ ।

फल परिधि, प्रथम तुड़ाई दिवस, प्रति पौध उपज तथा प्रति हेक्टेयर उपज सबसे अधिक युवराज 1003 में प्राप्त हुआ । सह–सम्बन्ध गुणांक के विश्लेषण में यह पाया गया कि फल उपज के लिए पत्तियों का क्षेत्रफल, फल परिधि, पर्णहरित कुल शर्करा का सकारात्मक सम्बन्ध रहा।

CHAPTER - I
INTRODUCTION

Tomato (*Solanum lycopersicon* L.), belong to the family solanaceae. Its center of origin was Peruvian and Mexican region. It is one of the most popular vegetable widely grown in the world. It's known as protective food, because of its special nutritive value and also its wide spread production.

The estimated area of tomato in the world is 44, 21,734 hectares with an annual production of about 12, 03, 84,017 metric tons (Anonymous 2004), whereas in India, tomato has become an important vegetable crop and occupies an area of 882 thousand ha with a production of 18735.9 thousand MT with a productivity of 21.2 MT/ha (Anonymous 2014) whereas, major production state are Andhra Pradesh, Orissa, Gujarat, West Bengal, Maharashtra, Chhattisgarh, Tamilnadu and Jharkhand. Andra Pradesh occupies first position in production. It ranks third in priority after potato and onion in india but rank after potato in the world. India rank third in the area but fourth in production.

It is rich source of vitamin A and C. also contains minerals like iron, phosphorus, lycopene and Beta- carotene pigment. Tomato fruit is used as salad or cooking and preparation of processed products such as in soup, sauce, catch-up and preparation of pickle and chutney.

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 peru-urban areas for production of high value 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. Protected cultivation has tremendous potential in increasing production, productivity and quality of vegetable crops like tomato, cherry tomato, coloured capsicum, cucumbers, muskmelon and summer squash, some rare vegetables, medicinal and ornamental plants even under adverse agro-climatic conditions.

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). The intent is to grow crops where otherwise they could not survive by modifying the natural environment to prolong the harvest period often with earlier maturity, to increase yield, improve quality, enhance the stability of production and make commodities available when there is no outdoor production.

Training the plants to two shoots or three shoots will not only facilitate easy training operation, but also permit closer planting, early ripening of fruits and get higher yields of larger sized fruits. Training methods vary with different growth habits of tomato cultivars and for different plant densities. Training the plant to two shoots or three shoots is generally practiced for indeterminate and semi-determinate cultivars in some foreign countries like Europe and Japan either in open field or glass house conditions. In India there is no practice of training except removing of lower leaves and branches.

A number of factors may affect the response of greenhouse crops to CO_2 enrichment. Thus, for example, optimum temperatures and high light intensities greatly increase the effectiveness of CO_2 enrichment although some yield increase may be obtained even under low light conditions. Diffusion resistance at the plant canopy and individual leaf levels determines the plant's capability to utilize supplementary CO_2. The field, CO_2 addition would produce maximal effects on photosynthetic rates in a canopy with upright leaves, where canopy diffusion resistance in low. In greenhouse, the rate of CO_2 supply has been demonstrated to be a more important determinant of crop photosynthesis rate.

The other important component of growing crops under protected conditions is growing media. An ideal growing medium should have good water holding capacity, high porosity for better aeration, good drainage and high rate of diffusion of oxygen to roots. It should also be biologically and chemically stable. A well decomposed growing medium provides organic matter and humus to the soil, which helps in improving physical conditions of soil. Several growing media such as rockwool, cocopeat, foam, perlite, wood chips, vermicompost and sawdust have been found suitable for tomato production.

Another important component of protected cultivation, which influences productivity and quality of tomato, is application of fertilizers with the irrigation water called fertigation. Fertigation seems to incorporate desirable features, which can improve water as well as nutrient use efficiency. Fertigation permits application of various fertilizer formulations directly in low concentration at the site of active roots, thus improving the efficiency of nutrients and saving fertilizer application costs. This is a regular and widely accepted fertilizing practice in growing of crops under protected conditions. This practice is becoming more popular because of availability of high-grade completely water-soluble fertilizer materials. Very few attempts have been made to work out the optimum fertigation schedules for different tomato hybrids especially under protected cultivation. It is a well established fact that macro nutrients such as nitrogen, phosphorus and potassium have profound effect on crop productivity and quality. Among these three essential nutrients nitrogen is an integral part of chlorophyll (the only energy synthesizing apparatus of plants), protoplasm, proteins and nucleic acids. Consequently its deficiency checks the growth and reduces the yield significantly. Phosphorus on the other hand, participates in energy transfer, early and prolific flowering, stimulates root growth, seed and fruit development, whereas, potassium is essential for number of biological reactions. It also helps in translocation of food material to different parts of plant as well as it enhances disease and drought tolerance (Devlin 1969).

At present, cultivation of tomato in open fields is a wide spread practice in Chhattisgarh. But, the tomato crop grown in open fields is exposed to various abiotic and biotic stresses and therefore, it is not possible to produce high quality tomato in terms of size, shape, and colour and free from diseases and pests as compared to tomato produced under protected environment. Therefore, it makes imperative to take up tomato cultivation under green house, particularly, when production of tomato is done for export purpose.

Tomato is also a very important off-season vegetable crop that fetches great remuneration to the farmers. It can be cultivated in open as well as in protected conditions. But, its cultivation under open field conditions is not very profitable because of unfavorable weather. Thus, there is huge scope of tomato cultivation

under polyhouse conditions especially in Chhattisgarh. At present there are number of hybrid varieties are being growing under the open field condition, but fewer varieties have evaluated under the protected structures. There is a great possibilities of growing tomato under polyhouse to harvest the quality produce even in off season. Production and yield potential of crop is much better under polyhouse.

The research work on evaluation of tomato under protected structure is still measure especially in Chhattisgarh; therefore the present investigation entitled **"Growth and yield component of tomato *(Solanum lycopersicon* L.) under protected condition"** was under taken with the following objectives.

Objectives:

1. To study the morphological and phenological parameters of different varieties of tomato.
2. To study the physiological and bio-chemical parameters of different varieties of tomato.
3. To find out the inter relation between variables.

CHAPTER - II

REVIEW OF LITERATURE

2.1 To study the morphological and phenological parameters of different varieties of tomato

2.2 To study the Physiological and Bio-chemical parameters of different varieties of tomato

2.3 To study the yield and yield component of different varieties of tomato

2.4 To find out the inter relation between variables

2.1 To study the morphological and phenological parameters of different varieties of tomato

Singh *et al*. (2001) reported that the performance of indeterminate tomato F_1 hybrids under open field conditions during spring summer season and maximum plant height was observed with ATH-1 (110.1 cm) followed by Naveen (102.3 cm).

Ganesan (2001) observed that the performance of tomato cultivars under green house and open field conditions and highest plant height recorded with the cultivar Pusa Ruby (211 and 146 cm) in both green house and field conditions.

Dudi and Sanwal (2004) evaluated that the performance of 150 F1 hybrids of tomato under Haryana conditions and observed maximum and minimum plant height in HTH-18 (156.8 cm) and Rupali (53.8cm) respectively. While evaluating 27 tomato cultivars for growth, yield and quality under plastic rain shelter during summer season,

Singh *et al*. (2005) reported that the while studying the effect of NPK levels on growth and yield of tomato hybrids under poly house during early-winter seasons of 2000-02 recorded maximum plant height in the hybrid, Sun 7611 (3.13 m) followed by Naveen (3.06 m).

Arora *et al.* (2006) evaluated those eighteen hybrids of tomato under greenhouse conditions during the winter season of 2002 and reported highest plant height in Rakshita and lowest plant height in NTH-2004.

Arora *et al*. (2007) reported that performance of thirtheen hybrids under green house conditions of Haryana revealed that the hybrid Indam-2012 (190 cm) recorded the maximum plant height, while NTH-2002 (110 cm) recorded the lowest plant height.

Thangam and Thamburaj (2008) was studied that the comparative performance of six varieties and fourteen hybrids of tomato under agro shade net (50%) and in open field during consecutive summer seasons at Coimbatore condition and reported highest plant height under shade over the open field conditions in all the cultivars and hybrids. Among the cultivars, Naveen was the tallest (307.58 cm) both under shade and open field condition (88.45 cm).

Kumar and Arumugam (2010) observed that the testing the suitability of poly house grown tomato for growth and yield at Madurai conditions reported significantly maximum plant height (245.68 cm) under poly house conditions compared to open field conditions (115.76 cm).

Pervej *et al*. (2010) observed that the better growth of tomato in terms of plant height under poly house conditions as against open field conditions in Bangladesh. Among the two varieties tested, Ratan is the tallest under poly house condition compare to BARI Tomato-3.

Prema *et al.* (2011) reported that the six genotypes (Tomy Toe, Stupice Harry, Red Pear, Podland Pink, Broad Ripper and EC-1) of cherry tomato for growth, yield and quality attributes under poly house revealed extremely semi determinate to indeterminate growth habit in all the cultivars. The highest plant height recorded in Red Pear at both 60 and 90 DAP (126.66 cm, 146.80 cm).

Sima *et al*. (2011) was investigated the yield potential and quality of six tomato hybrids under greenhouse conditions of Romania, and reported maximum plant height with Monroe F_1 (248.33 cm) followed by Tolstoi F_1 (245 cm).

Chapagain *et al.* (2011) observed by opinion that plant height is an important trait in tomato cultivation under plastic house conditions. Among the tomato varieties evaluated under plastic house conditions of Nepal for two consecutive years from 2009 to 2010, Srijana was the tallest variety (268.70 cm) followed by Manisha (232.3 cm).

Ishwarappa (2011) reported that the performance of tomato hybrids under shade house condition and recorded highest plant height in the hybrid STH-801(309.03 cm). While studying the response of tomato cultivars to partial shade on various growth parameters of tomato varieties.

Islam *et al*. (2012) was observed by Genetic variability and trait relationship was studied in 11 cherry tomato inbred lines collected from AVRDC. Results shows that, among the cultivars, inbred CLN15558A was the tallest in height (154cm) followed by CLN1558B (131 cm) and CLN1555B (129 cm).

El-Amin and Randa (2012) reported that the adaptability and productivity of four standard tomato varieties viz., Chanoa, Merel, Sensie and Yursa and two cherry varieties viz., Tomi and Elitrro under plastic house conditions of Sudan observed highest plant height for cherry tomato variety Elitrro (265.5 cm) Merel (255 followed by the normal tomato variety.1 cm).

Razzak *et al.* (2013) observed that the conducted a greenhouse experiment on response of cherry tomato to pruning systems and irrigation rates and reported that one branch pruning produced the tallest Plants (195.3 and 190.1 cm) in the first and second seasons respectively.

Wahundeniya *et al.* (2013) reported that fifteen tomato varieties were evaluated for growth and yield performance under controlled environment conditions. Among the fifteen varieties the maximum plant height was observed with variety Alambra F1 (185 cm) while the lowest plant height was recorded in the variety Red Boy (93 cm).

Singh *et al*. (2013) recorded that the performance of nineteen tomato hybrids under greenhouse conditions of Haryana during *Rabi* season. Results reveal that the hybrid Yash recorded maximum plant height (302.0 cm) followed by CTH-230 (294 cm).

Danie *et al.* reported that leaves are high enough in the canopy to accumulate starch and are adjacent to fruit of significant growth rate.

Nagalaxmi *et al.* (2001) reported that tomato variety S-41 grown under poly house was earlier in flowering (29.6 days) over open field condition (32.4 days). Pandey *et al.* (2006) evaluated by the four tomato varieties under polyhouse condition of Nepal and found significantly shortest period of days to

flowering in both the years of study with the cultivar, NSITH-162 (35 and 36 respectively).

Sumathi *et al*. (2013) evaluated the performance of 24 tomato genotypes under polyhouse and open condition for yield characters observed the earlier flowering in genotypes raised under open condition than in polyhouse condition. During the first season earliest flowering (28.35 days) was observed in the genotype NS-6666 and in second season, Meenakshi (23.80 days) was observed to be earlier under open condition.

Papadopoulos and Ormrod (1991) evaluated two tomato cultivars Jumbo and Ohio CR-6 under greenhouse conditions reported significantly higher rate of fruit set in Jumbo (44.00%) over Ohio CR-6.

Cheema *et al*. (2002) reported that maximum fruit set in IAHS-9502 under net house conditions when grown from December to March.

Hazarika and Phookan (2005) evaluated that the performance of twenty seven tomato cultivars under poly house conditions recorded significantly maximum fruit set percentage with the cultivar Yash (83.96) while, fruit setting was least in Karna (64.09).

Pandey *et al*. (2006) reported that compared four tomato varieties under polyhouse condition and found that fruit set was highest in NSITH-162 (93.90%) and the lowest in Avinash-2 (83.10%).

Arora *et al. (*2006) recorded significant difference in fruit set percentage in indeterminate tomato hybrids in green house. Maximum fruit set percentage was recorded in Avatar (88.0), while minimum was recorded in TH- 612 (62.0). Among the different semi-indeterminate tomato hybrids studied maximum percentage of fruit set (84.0) was recorded in NP-5003 and TH-977, while minimum (50.0) was recorded in ARTH-210 (Arora *et al.* 2007).

Prema *et al.* (2011) evaluated six genotypes (Tomy Toe, Stupice Harry, Red Pear, Podland Pink, Broad Ripper and EC-1) of cherry tomato for growth, yield and quality attributes. The per cent fruit set was maximum (88.54) in EC-1 followed by Stupice Harry (88.10). Whereas, Ishwarappa (2011) observed maximum per cent fruit set in STH-801 (93.17).

Jana and Bhattacharya (2001) recorded that maximum number of fruits cluster^{-1} in Avinash-2 when grown under polyethylene shade net.

Arora *et al.* (2006) evaluated eighteen tomato hybrids grown in greenhouse during the winter 2002 reported significant difference in terms of number of fruits truss^{-1} was observed among the hybrids. Maximum number of fruits truss^{-1} was recorded in Compary (12.2) followed by Danila (8.9), while minimum was recorded in INDAM-2 (4.3).

Arora *et al*. (2007) reported that maximum number of fruits truss^{-1} was recorded inTH-806 (11.9), while least number was recorded in NP-5 (3.5).

Aguirre and Cabrera (2012) reported that the most promising eight varieties of cherry tomatoes selected among 31 introductions with values above the overall average of 7.40 fruits raceme^{-1}, while introductions LA2710, IAC1622, and IAC2640 presented values below 4.50 fruits raceme^{-1}.

El-Amin and Randa (2012) evaluated that the adaptability and productivity of four standard tomato varieties viz., Chanoa, Merel, Sensie and Yursa and two cherry varieties viz., Tomi and Elitrro under plastic house conditions reported that cherry tomato varieties were superior to classic varieties for mean number of fruits cluster^{-1}.

Singh *et al*. (2013) conducted that the study during the *rabi* season for two consecutive years at Hissar to evaluate the performance of nineteen tomato hybrids under greenhouse conditions, recorded maximum number of fruits cluster^{-1} in hybrid Centurian (5.8).

Hussain *et al*. (1990) reported that the performance of eleven tomato hybrids grown under unheated plastic tunnel reported that fruit maturity period ranged from 108 to 111.3 days in different tomatoes.

Pandey *et al*. (2006) reported that four tomato varieties grown under polyhouse and found that NSTIH-162 took the shortest period of days to fruit maturity (66 days).

Donald and Gary (1979) evaluated that four cherry tomato varieties in spring and fall season for fruit length and found largest fruit with Large Cherry variety (1.4 inches). While, smallest fruit (0.8 inches) was produced by the variety

Small Cherry. Thangam and Thamburaj (2008) observed higher fruit length (7.86 cm) in Rashmi under shade compared to open field conditions (7.23 cm).

Prema *et al.* (2011) reported that maximum fruit length (3.56 cm) in cherry tomato cultivar, Podland Pink followed by Red Pear (3.13cm).

Chapagain *et al.* (2011) reported largest fruit size in US-04 with a diameter of 5.78 cm. Similarly Islam *et al*. (2012) found maximum fruit length (5.33 cm) in CLN1555A while, the line CH155 had the minimum fruit length (3.00 cm).

Sima *et al*. (2011) evaluated six tomato hybrids in greenhouse for yield potential and quality reported significantly highest fruit length for Monroe F1 (53.50 mm) followed by Menhir F1 (52.64 mm).

Oum (1995) reported that cherry tomato with CH 156 (31.22 mm) and narrowest fruit with CH 267 (19.07 mm). Ishwarappa (2011) conducted a field experiment to study the performance of tomato hybrids under shade house condition recorded the highest average fruit diameter with STH-39 (6.30 cm).

Prema *et al.* (2011).observed maximum fruit width was recorded in Podland Pink (2.83 cm) followed by Tomy Toe (2.45 cm) cherry tomatoes.

Sima *et al*. (2011) evaluated six tomato hybrids under greenhouse conditions for yield potential and quality of fruits observed maximum fruit width for Monroe F_1 (66.21mm) followed by Menhir F_1 (62.54 mm).

Islam *et al*. (2012) reported that maximum fruit width was noticed in CLN1555A (4.5 cm) while; the line CH155 had the minimum fruit width (2.05 cm).

2.2 To study the Physiological and Bio-chemical parameters of different varieties of tomato

Bajaj *et al*. (1990) compared thirty four tomato varieties for chemical compositions and recorded the TSS in the range of 3.5 to 7.5 ^{0}Brix. Oum (1995) revealed that the cherry tomato variety CH 155 given maximum (7.01^{0}B) TSS while, minimum was recorded by CH 156 (5.40 ^{0}B). The mean TSS content of 3.97 per cent was recorded in a variability study conducted on twenty seven tomato genotypes by Mittal *et al*. (1996).

John *et al*. (2005) recorded the maximum (7.7 ^{0}B) TSS in cherry tomato genotype 02LI1058 and minimum in Castlettle (5.7 ^{0}B).

Hazarika and Phookan (2005) observed the performance of tomato cultivars under polyhouse conditions of Assam reported maximum TSS (6.54 ^{0}Brix) in tomato cultivars, Pusa Ruby and Arka Shreshta.

Kumar *et al*. (2007) was recorded by 42 genotypes under green house and open field conditions reported that genotypes CH151, CH154, CH155 and CH157 recorded high total soluble solids under green house conditions over open field conditions.

Shivanand (2008) reported significantly varied TSS among the different tomato hybrids. The highest TSS was recorded in T 1224 (5.21 ^{0}B) followed by TH 1389 (5.19 ^{0}B), US 2175 (5.17 ^{0}B) TSI-48 (5.13 ^{0}B) US 1196 (5.03 ^{0}B) and Anup (4.98 ^{0}B). While the hybrid Surya (2.98 ^{0}B) recorded the lowest TSS.

Thangam and Thamburaj (2008) observed significant differences in respect of biochemical parameters between shade and open field conditions. Higher TSS was observed in all the cultivars under open field over shade. Among the cultivars highest TSS was recorded in the hybrid Ratna under open field (5.71 ^{0}Brix) as against 50 per cent shade net (4.50 ^{0}Brix).

Ilic and Milenkovic (2010) was reported that Results show that tomato fruits grown in the field had greater TSS content (5.42 ^{0}Brix) than tomatoes grown in a protected environment (5.10 ^{0}Brix).

Similarly Caliman *et al*. (2010) observed the quality of tomatoes under protected environment and field conditions also reveals that the fruits produced in the field had higher TSS than those produced in protected conditions.

Ishwarappa (2011) evaluated the performance of tomato hybrids under shade house condition. Among the hybrids, STH-801 possessed higher amount of TSS (5.47 ^{0}B).

Prema *et al*. (2011) reported that cherry tomato genotypes for quality traits reported that the TSS of fruit varied between 4.06 ^{0}Brix (Podland Pink) to 8.10 ^{0}Brix (EC-1).

Mazur *et al*. (2012) observed that the effect of growing medium in green house cultivation on the yield and fruit quality of two cherry tomato cultivars reported higher TSS content in Pareso cultivar over Dasher cultivar.

Islam *et al*. (2012) reported that the genetic variability studies in 11 inbred lines of cherry tomato and found highest total soluble solids from the line.CH155 (5.7 %) followed by CLN1555A (4.9 %).

Razzak *et al.* (2013) reported that the response of cherry tomato to pruning systems under green house conditions reported maximum TSS with one branch pruning system (10.47 ^{0}B) as against two branch pruning system (9.40 ^{0}B).

Sumathi *et al*. (2013) observed that the performance of 24 tomato genotypes under polyhouse and open condition for quality characters reported high TSS values for the hybrids Meenakshi, NS-6666 and HY-7611 under open condition(4.24, 3.94 and3.74 ^{0}B) as against polyhouse condition (4.08, 3.91 and 3.50 ^{0}B).

Singh *et al*. (2001) conducted the performance of indeterminate tomato hybrids during the summer reported maximum acidity in Pant Bahar (1330 mg $100g^{-1}$) followed by ATH-1 (850 mg $100g^{-1}$). Similarly John *et al*. (2005) reported maximum acidity in the cherry tomato genotype 02L1058 (0.46 %) and minimum in Mountain Belle (0.35%).

Hazarika and Phookan (2005) reported significant variation among the tomato cultivars for acidity percentage under polyhouse conditions. Punjab Chhuhara and BT-1 recorded the lowest titrable acidity (0.25%) while the highest acidity (0.96%) was recorded in the cultivar Hyb-621 under poly house.

Toor *et al*. (2006) found that the level of titrable acidity for flavouriono cherry tomato fruit was 0.45-0.55%. Jayaprakash narayan (2007) recorded maximum acidity in TP 35 (0.52%) and minimum in TP 26 (0.13%).

Kumar *et al*. (2007) screened 42 tomato genotypes under green house and field conditions reported that genotypes CH151, CH154, CH155 and CH157 exhibited high acidity under green house conditions over open field conditions.

Shivanand (2008) recorded the highest titrable acidity in the hybrid COTH 2 (0.49%) followed by Bhoomi (0.44%) and the lowest was found in Super Samaurai (0.21%) followed by TSI 48 (0.25%).

Ilic and Milenkovic (2010) reported that fruits produced in an open field were more acidic and had greater titrable acidity (0.37 %) compared to fruits from a plastic greenhouse (0.34%).

Prema *et al*. (2011) recorded highest titrable acidity (0.37 %) in the fruits of tomato genotype Podland Pink.

Razzak *et al.* (2013) studied the performance of cherry tomato to pruning systems reported maximum titrable acidity (0.60%) in one branch pruning system over two branch pruning system (0.54%) in both the years of study.

Wahundeniya *et al.* (2013) reported that the acidity percentage of tomato varieties under controlled environment conditions ranged from 0.78 (Red Boy) to 0.98 (HRD-2).

Sumathi *et al*. (2013) observed the comparative performance of 24 tomato genotypes reported lower acidity percentage in both hybrids and varieties under polyhouse conditions over open field conditions. The mean acidity percentage for hybrids and varieties (0.56 and 0.61 respectively) is lower under polyhouse conditions over open field conditions (0.59 and 0.63 respectively).

Singh *et al*. (2001) was recorded that the performance of indeterminate tomato hybrids during the summer reported maximum ascorbic acid (37.4 mg 100ml-1) in FM-1 followed by Pant Bahar (20.25 mg 100 ml-1).

Hazarika and Phookan (2005) reported that significant variation among different tomato cultivars for ascorbic acid content. Highest ascorbic acid content is reported in the cultivar DRD-8014 (16.56 mg 100g-1).

Thangam and Thamburaj (2008) reported higher ascorbic acid content under open field over the shade conditions in all the tomato cultivars. Ascorbic acid content ranged from 18.71 to 26.65 mg 100g-1 in open field condition as against 16.33 to 25.21 mg $100g^{-1}$ under shade.

Kumar *et al*. (2007) observed the 42 tomato genotypes under green house and open field conditions and results reveals that genotypes CH151, CH154, CH155 and CH157 exhibited highest ascorbic acid under open field conditions over green house conditions.

Shivanand (2008) observed the highest ascorbic acid in the hybrid US 2175 (22.85 mg 100g-1) followed by Surya (20.18 mg $100g^{-1}$) and minimum ascorbic acid was found in Bhoomi (9.62 mg $100g^{-1}$).

Prema *et al.* (2011) reported that the ascorbic acid content of six cherry tomato fruit varied between 21.22 mg 100 g^{-1} (EC-1) to 27.48 mg 100 g^{-1} (Podland Pink). Aguirre and Cabrera (2012) conducted the fruit quality of 30 cherry tomato introductions reported that the commercial check presented the highest value for vitamin-C content of 84.5 mg $100g^{-1}$ fresh weight followed by introduction, IAC445 with 72.5 mg $100g^{-1}$ fresh weight and LA2710 with 58.8 mg 100 g^{-1} fresh weight.

Razzak *et al.* (2013) reported that the cherry tomato to pruning systems under green house conditions reported maximum ascorbic acid in one branch pruning system (23.75 mg $100g^{-1}$) over two branch pruning system (20.69 mg $100g^{-1}$).

Sumathi *et al*. (2013) evaluated 24 tomato genotypes under polyhouse and open conditions for fruit quality parameters reported higher mean ascorbic acid content for both hybrids and varieties under open field conditions (27.61 and 26.66% respectively) in comparison with polyhouse conditions (27.20 and 26.32% respectively).

Stomova *et al.* (1998) reported lycopene concentration range of 2.10 to 6.95 mg $100g^{-1}$ fresh weight in 35 cherry tomato lines.

John *et al*. (2005) evaluated two cherry tomato breeding lines with high β-carotene content and reported maximum lycopene content (54.20 μg gfw^{-1}) with the cherry tomato line Castlettle and minimum (2.3 μg gfw^{-1}) with 02L1059.

Kuti and Konuru (2005) evaluated forty tomato varieties under green house and field conditions for their lycopene content reported that cherry tomato types with higher lycopene content in field grown tomatoes (91.90 mg kg^{-1}) than in green house grown (56.10 mg kg^{-1}) tomatoes. However the results were vice versa for cluster and round tomatoes.

Hernandez *et al*. (2007) reported that the lycopene content values ranging from 1.89 to 2.56 mg 100g-1 fresh weight in commercial cultivars, Dunkan and

Thomas. Similarly Lopez *et al*. (2007) reported lycopene content of 51 and 37 µg g^{-1} in tomatoes grown under red and pearl frame nets respectively.

Prema *et al.* (2011) reported highest (5.53 µg $100g^{-1}$) lycopene content in EC-1 and lowest (2.57 µg $100g^{-1}$) in Broad Riper cherry tomato cultivar.

Aguirre and Cabrera (2012) observed that significant differences in lycopene content among the different introductions evaluated. The highest lycopene content was observed in introductions LA1455 and LA2845 (0.32 mg/mL).

Sumathi *et al*. (2013b) evaluated by 24 genotypes of tomato under polyhouse and open conditions reported highest lycopene content under polyhouse conditions over open field conditions in both hybrids and varieties (45.91, 29.22 and 43.47, 26.71 respectively). Among the hybrids, Meenakshi, Beejaraja, Bilahi-2 recorded highest value for lycopene content under polyhouse conditions.

David and Hubson (1981) reported that reducing sugar contents around 2.05 g 100g-1 of fresh fruit for the protected environment and 2.93 g $100g^{-1}$ of fresh fruit for field cultivation. Causse *et al*. (2003) found significant variation in total sugars content of tomato fruits from 3.8 to 6.6 g $100g^{-1}$.

Kumar *et al*. (2007) observed that 42 genotypes under green house and field conditions and reveals that genotypes CH151, CH154, CH155 and CH157 exhibited higher total sugars.

Caliman *et al*. (2010) evaluated the quality of tomatoes both under protected and open field conditions reveals that the BGH-320 was superior in total sugars content in open field conditions compared with protected conditions.

Razzak *et al.* (2013) reported that maximum total sugars (10.7%) in one branch pruning system followed by two branch pruning system (8.1%) under green house conditions.

2.3 To study the yield and yield component of different varieties of tomato

Hussain *et al*. (1990) observed that the performance of eleven tomato hybrids in an unheated plastic tunnel reported maximum fruit weight plant^{-1} in Tobol (3.81 kg) followed by Adalyx (2.88 kg).

William *et al*. (1997) reported that an experiment with six cherry tomato cultivars and reported highest fruit weight of 3.7 kg plant^{-1} with CHT 104 cultivar followed by 2.6 kg in CHT 261 and CHT 264. However the remaining cultivars produced 1.9 to 1.5 kg plant^{-1}.

Ganesan (2002) observed that the experiment with four different poly green house models, observed highest yield plant^{-1} with four sides and triangular structured roof on both sides covered with 25 per cent shade net (2.18 kg) over the open field conditions (1.18 Kg).

Nagalaxmi *et al.* (2001) reported that tomato variety S-41 grown under poly house was observed to be higher fruit yield (1.83 kg plant^{-1},) when compared to the crop raised under open condition (1.02 kg plant^{-1}).

Sheferaw (2001) observed under Bangalore conditions, Arka Alok showed highest yield (1.93 kg plant^{-1}). While; Arka Ahuti yielded lowest (0.65 kg plant-1). Tomato cv. Shirley was grown under white (10%, 12% and 18% shade), black (30% and 40% shade) and green (40% shade) shade net.

Hazarika and Phookan (2005) reported that the twenty seven tomato cultivars under polyhouse conditions recorded higher yield plant^{-1} (1.76 kg) with the cultivar Yash followed by Arka Ahuti (1.31 kg).

Kacjan *et al.* (2005) observed by the influence of different climatic conditions on fruit yield and quality of ten determinate tomato cultivars, reported highest marketable yield among the salad tomatoes was obtained from Stormy F1 (4.05 kg plant^{-1}).

Singh *et al*. (2005) reported that maximum fruit yield plant^{-1} from Karnataka hybrid (2.85 kg) followed by Naveen (2.61 kg) under multi span polyhouse covered with UV stabilized polyethylene film conditions.

Kumar *et al*. (2007) evaluated by 42 tomato genotypes under green house and open field conditions. The genotypes COTH1, CLN14665 and CLN1352A,

were identified as the best under green house conditions based on yield plant^{-1} over the open field conditions.

Singh *et al*. (2009) reported that the Poly carbonate greenhouse produced maximum fruit yield (4.05 kg plant^{-1}) and superior over polyench (2.88 kg plant-1) and trench type (2.20 kg plant^{-1}). Among the varieties, Tolstoi recorded significantly higher yield (5.99 kg plant-1).

Prema *et al.* (2011) observed that the highest mean fruit yield plant-1 (4.25 kg) in Pod land pink followed by Tomy toe (3.64 kg).

Islam *et al*. (2012) observed that maximum fruit yield plant^{-1} (1.89 kg) in CLN1555A followed by CLN1555C (1.82 kg) among the 11 inbred lines of cherry tomatoes studied. Similarly Singh *et al*. (2013) studied the performance of different tomato hybrids under greenhouse conditions during the *rabi* 2008-09 and 2009-10 at Hissar. Results revealed that Avinash-23 recorded maximum yield plant^{-1} (2.90 kg) followed by Richa (2.88 kg).

Oum (1995) reported that eleven varieties of cherry tomatoes. Among the varieties, CH 156 produced the highest yield and marketable yield of 44.53 t ha^{-1} and 39.40 t ha^{-1}.

Munshi and Kumar (2000) conducted by six verities of tomato *viz*, Pusa early Dwarf, Rishi, Matri, Pusa Ruby and Pusa Guarav under plastic green house condition. Rishi and Pusa Guarav were found to be the most promising varieties under polyhouse, as they gave significantly higher yield of 488 q ha^{-1} and 411 q ha^{-1} respectively.

Singh *et al*. (2001) reported that maximum marketable yield in tomato hybrid Narita (285 t ha-1) followed by Naveen (148 t ha-1) under Tarai conditions of Uttar Pradesh. The tomato variety Arka Alok gave highest yield (53.26 t ha-1) and Arka Ahuti the lowest (19.72 t ha^{-1}) Sheferaw (2001) under Bangalore conditions in polyhouse conditions. The higher productivity of tomato (93.20 t ha-1) and capsicum (76.40 t ha^{-1}) inside greenhouse observed by Singh and Ram (2005) was mainly because of higher temperature (4-9 ^{o}C) than the outside observed during month of December to February and high rate of utilization of carbon-dioxide inside greenhouse. Microclimate inside greenhouse during winter

months was mainly responsible for better yield due to their beneficial effects on flowering and fruiting.

Pandey *et al.* (2006) compared four tomato varieties under polyhouse conditions of Nepal, found that NSITH-162 produced the highest marketable fruit yield (89.05 t ha^{-1}) and Avinash-2 produced the lowest yield (51.98 t ha^{-1}).

Arora *et al*. (2007) observed that the performance of 13 semi indeterminate tomato hybrids under green house conditions recorded maximum total fruit yield in TH-806 followed by NP-5016 whereas minimum total fruit yield was recorded in NP-5.

Chapagain *et al.* (2010) reported that 47.9 t ha^{-1} and 30.9 t ha^{-1} fruit yield in plastic house and in open field condition respectively in the farmers field of ARS Pakhribas.

Parvej *et al*. (2010) reported that the tomato plants grown with polyhouse climate produced 29 per cent higher fruit yield than the tomato plants grown at the outside of polyhouse.

Prema *et al.* (2011) observed the highest fruit yield (75.55 t ha^{-1}) in Podland Pink followed by Tomy Toe (59.91 t ha^{-1}). In another field investigation Chapagain *et al.* (2011) assessed the performance of tomato varieties under plastic house for two consecutive years from 2009 to 2010 in Nepal. The highest marketable yield was recorded from All Rounder (86.6 t ha^{-1}) followed by Srijana (80.8 t ha^{-1}).

Kanwar (2011) was recorded that the performance of all tested tomato genotypes is far superior in the polyhouse as compared to open field conditions. Cultivation of tomato in polyhouse produced 136.12 per cent more yield ha^{-1} and 188.93 per cent more fruits per plant compared to open field cultivation.

Islam *et al*. (2012) found maximum fruit yield (64.3 t ha^{-1}) in CH154 while it was lowest in CH151 (42.2 t ha^{-1}) among the 11 inbred lines of cherry tomatoes tested. Menezes *et al*. (2012) observed by a field experiment on fruit production and classification of four cherry tomato genotypes under organic cropping system reported highest commercial fruit yield $plant^{-1}$ in CLN1561A genotype.

2.4 To find out the inter relation between variables

Correlation studies provide information that the selection for one character will result in progress for all correlated characters. Genotypic and phenotypic correlation coefficient was calculated by standard procedures (Johnson *et al*., 1955). Correlation coefficient was further partitioned into components of direct and indirect effects by path analysis (Wright, 1921; Dewey and Lu, 1959).

The necessity of coefficient of correlation to describe the degree of association between independent and dependent variables which was first suggested by Galton (1888) and its theory was developed by Pearson (1904). Mathematical utilization at phenotypic, genotypic and environmental levels was described by Searle (1961).

Singh and Singh (1976) observed that the significant positive correlation of fruit yield plant"$_1$ with plant height and fruit size, but negative and significant with capsaicin content were observed in chillies.

Parsanna *et al*. (2005) reported that yield per plant the most important economic trait, exhibited positive association with average fruit weight (0.53) and number of fruits per plant (0.38). The negative correlation was observed for number of fruits per plant with average fruit weight (-0.54), number of locules (-0.45) and flesh thickness (-0.34). Therefore simultaneous improvement for all the traits associated with yield would be difficult in the population.

Ghosh *et al*. (2010) reported that the number of fruits per cluster, fruit clusters per plant and fruits per plant had positive and highly significant association with fruit yield. Number of branches per plant had positive correlation with number of flowers per plant and demonstrated positive association of number of fruits per cluster with number of fruit clusters per plant, number of fruits per plant and fruit yields per plant and number of fruit per plant.

Islam *et al.* (2010) conducted an experiment on thirty nine exotic tomato genotypes for nine yield contributing characters and studied that the correlation coefficients were determined to find out the inter relationship among the characters studied. Yield per plant was found highly significant and positively correlated with flowers per plant, fruits per plant, fruit length, fruit diameter and individual fruit weight which indicated that yield could be increased by improving a traits.

Dar *et al.* (2011) observed that yield q/ha was positively correrlated with lycopene content, fruit pH, total soluble solid, pericarp thickness, number of locules per fruit, number of fruits per plant, fruit yield per plant and average fruit weight at genotypic as well as phenotypic level. Negative correlation was observed with ascorbic acid and polygalacturonase activity at genotypic as well as phenotypic level.

Kaushik *et al.* (2011) evaluated the positive association of yield per hectare observed with number of leaves at 60 days after transplanting (0.78) followed by number of leaves at 30 days after transplanting (0.68), fruit length (0.66) and plant height (0.51).

Tiwari and Upadhyay (2011) conducted an experiment on nineteen genotypes along with two checks of tomato and reported that significant positive correlation therefore, fruit weight as an important character which may be included in selection criteria for improvement in fruit yield per plant

Manna and Paul (2012) reported that the correlation coefficient and result revealed that fruit yield per plant was positively and significantly correlated with pericarp thickness, fruit length, fruit weight and number of fruits per plant indicating relative 29 importance of these characters for yield improvement. Significantly positive and negative associations among different fruit quality parameters were also observed in the present study.

Mahapatra *et al*. (2013) reported that fruit yield had positive and significant correlation with plant height, number of primary branches per plant, number of flower clusters per plant, number of fruits per plant, fruit length, fruit width, pericarp thickness, number of locules per fruit, average fruit weight and fruit yield per plant. It was observed that with increase in plant height, there was corresponding increase in number of primary branches per plant, days to 50 % flowering and number of flower clusters per plant.

Saleem *et al.* (2013) reported that the plant height, number of fruits per plant and fruit weight revealed significant positive genotypic and phenotypic association along with direct positive effect on fruit yield per plant. It is therefore, recommended that fruit weight, number of fruits per plant and plant height should

recommended that fruit weight, number of fruits per plant and plant height should be given due importance in selection of promising crosses to develop commercial hybrid variety in tomato.

Srivastava *et al*. (2013) reported that the yield per plant was found highly significant and positively correlated with days to 50% flowering, days to 50% fruiting, plant height (cm), number of primary branches per plant, number of fruits per cluster, number of fruits per plant and average fruit weight (gm), which indicated that yield could be increased by improving a traits.

CHAPTER - III
MATERIAL AND METHODS

This chapter deal with the description of the material used and various techniques or methods adopted through out the course of investigation entitled " growth and yield component of tomato (*Solanum lycopersicon* L.) under protected conditions." Experiment conducted at the research farm of Center of Excellence on Protected Cultivation and Precision farming, IGKV, Raipur (C.G.) during *Kharif* 2016-17.

3.1 Experimental site

Experiment was carried out during the year 2016-17 at the center of Excellence on protected cultivation and Precision farming under polyhouse, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).

Raipur is situated in the central part of Chhattisgarh at 21°16' N latitude, 81°36' E longitude and at an altitude of 289.56 m from mean sea level.

3.2 Climate

The climate of Raipur is characterized as dry sub-humid agro-climatic region. It received annual rainfall of 1200-1400 mm out of the source of rainfall 49 south west monsoon which 80-85 prevent is received from June to September. The pattern of rainfall, particularly during June to September months has great variation from year to year. The maximum temperature goes as high as 46^0C during summer and minimum as below 6^0C during winter months. The atmospheric humidity is high from June to October. The meteorological data recorded at Agro meteorological observatory, IGKV, Raipur during the period of study are given in Appendix I and Appendix II illustrated through figure 3.1 and 3.2.

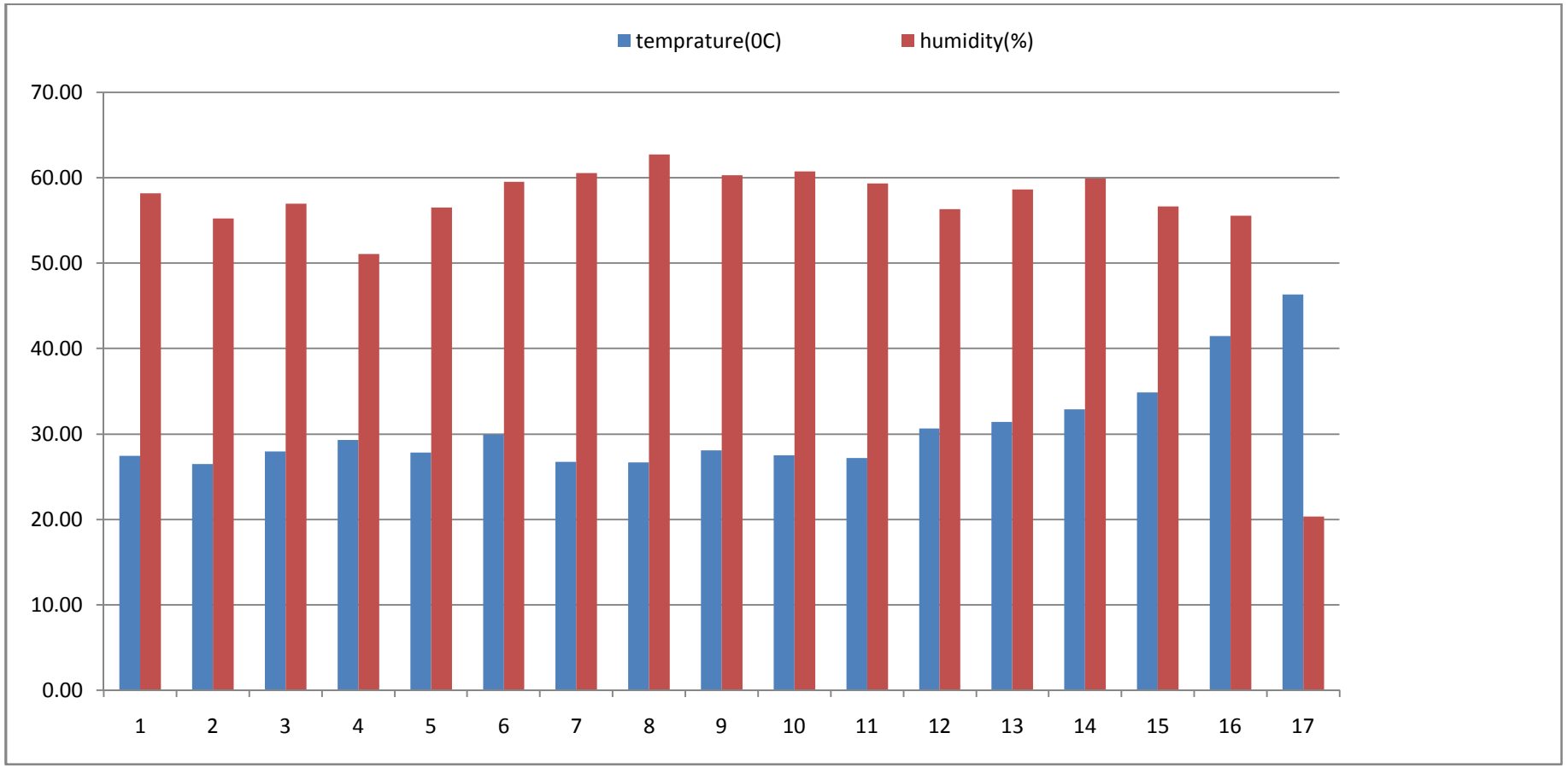

Fig.3.1: Meteorological data on temperature and relative humidity inside the naturally ventilated polyhouse during (17 Aug, 2016 to 28 April, 2017)

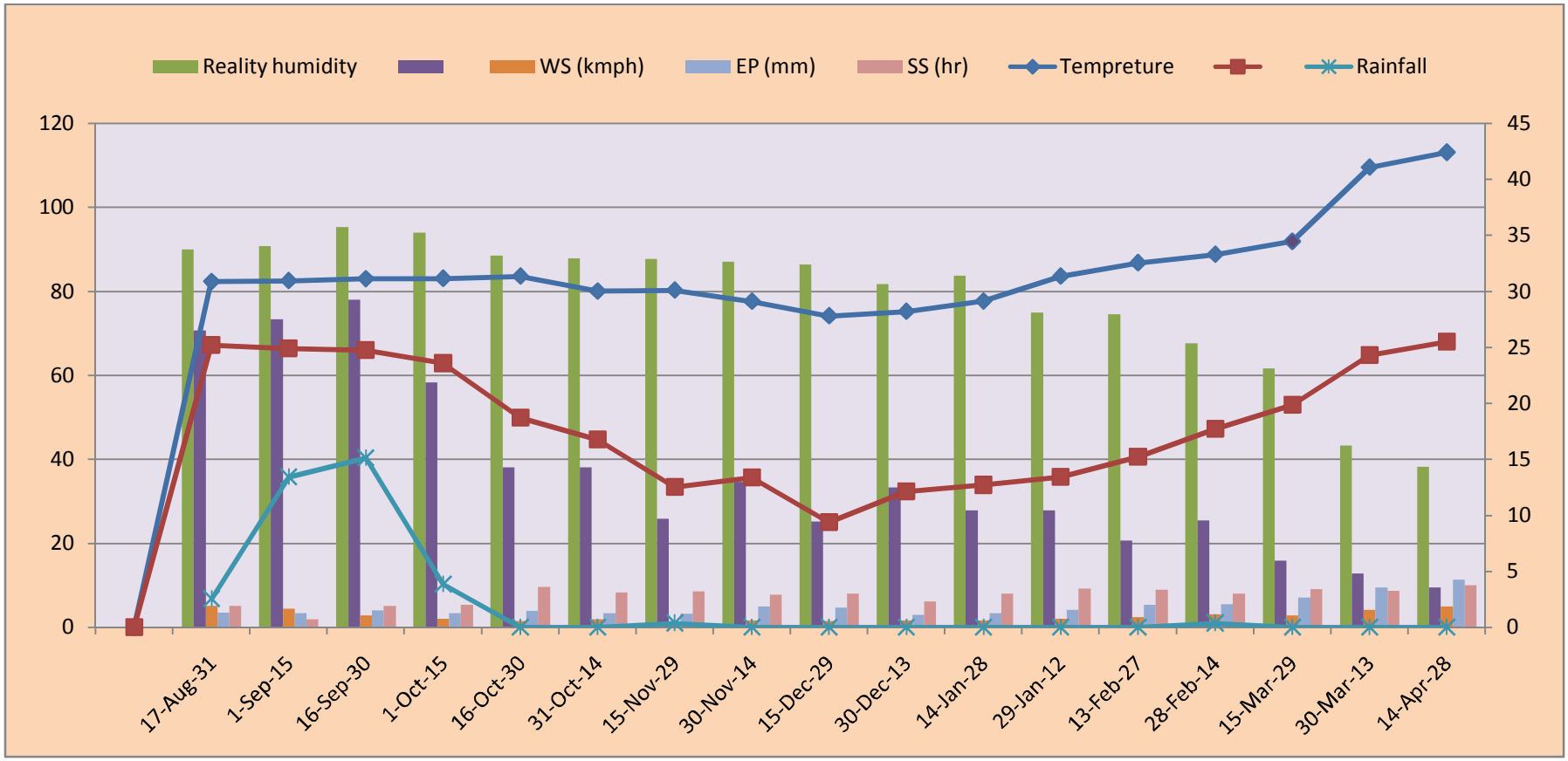

Fig. 3.2: Metrological observations during crop growth period in outside environment condition (From 17 Aug, 2016 to 28 April, 2017)

3.3 Experimental material

The material used for study comprised of fruit varieties. All seed material has collected from different places. Materials used have been given in Table 3.1.

Table 3.1: Details of tomato Varieties used in the study

SI. NO.	Varieties	Source of collection	Characteristic feature
1	Sheeja	Known-you seed co. Ltd.	This variety is very early, and can be cultivated all year round. Fruit is attractive orange yellow colour round, with very good crisp taste sweet and weighing 13 gm each.
2	Roja	Known-you seed co.Ltd.	Plants are semi-determinate. The pink fruit has a pointed end and is oblong in shape ,weighing around 12-16 g.
3	Laila	Known-you seed co. Ltd.	Plant is early, indeterminate. Fruit is shiny red, oblong shaped, around 17 g in weight and contains very few seeds inside.
4	Nowara	Tiwan seed co.Ltd	Indeterminate habit, oblong fruits
5	Youvraj 1003	Tiwan seed co. Ltd	Indeterminate habit

3.4 Experimental details

Crop	:	Tomato (*Solanum lycopersicon* L.)
No. of treatments	:	five
No. of replication	:	four
Tomato varieties	:	Nowara, Yovuraj 1003, Laila, Roza, Sheeja.
Spacing	:	120 × 45 cm.
Deign of experiment	:	Completely Randomized Design (CRD).

Plate 1: General view of the experimental field protected cultivation

3.4.1 Details of poly house used for the experiment

The poly house (4000 m^2) existing at research farm of center of excellence on protected cultivation and precision farming, college of agriculture, IGKV , Raipur (C.G.)

3.4.2 Crop raising/ growing

The seeds of the five hybrids were sown in plastic pro trays by using soilless media having coco peat, in the respectively inside the naturally ventilated polyhouse on 29 July 2016 to get healthy and disease free seedlings of tomato. The seedlings were ready for transplanting after one month of sowing and were subsequently transplanted inside the naturally ventilated polyhouse equipped with drip irrigation system.

3.4.3 Fertilizer application

The fertilization recommendation for a tomato is 120:100:60 N:P:K (kg/ha). In normal soil application method of fertilization to cherry tomatoes 1/3 nitrogen. Full phosphorus and 1/3 potash was applied before transplanting as basal dose. At 4^{th} week after transplanting 1/3 nitrogen and 1/3 potash was applied first split. Remaining 1/3 nitrogen and 1/3 potash was applied as second split at 8 weeks after transplanting.

3.4.4 Laying of drip line

Drip system with 18 mm in-line lateral was provided at the center of each poly tunnel bed having emitting points at every 30 cm interval with discharge rate of 4 lit. ha^{-1}.

3.4.5 Transplanting

Eighteen days old seedling was transplanted under naturally ventilated polyhouse by adopting a spacing of 120 cm x 45 cm.

3.4.6 Pruning and training

The tomato plants were pruned to two brances per plant. Starting from 15 to 25 days after transplanting and pruning was done at weekly intervals. The main stem of tomato plant branches into two branches into two after the first flower cluster and only these two branches were maintained and other branches were

removed. Any branch developing at the bottom was also pruned. The plant was topped before 5-6 weeks the crop is removed.

The plants were trained along the plastic twine. Each branch tied with separate plastic twine to train along it. The branches were tied to the plastic twines. Tying of plants to the plastic twine starts from 4th week after planting and tying was usually done at weekly interval along with the pruning operation simultaneously.

3.4.7 Lowering of plants

The plants were lowered periodically, to maintain the plants at workable heights. Provisions were made to have an extra length of plastic twine so that the plants were lowered to required length. Lowering was performed at 20-30 days interval starting from 70- 80 days after transplanting.

3.4.8 De-leafing

De-leafing of older leaves was done periodically starting from 70 days after transplanting and at least five feet of stems from growing point had leaves at any given point of time.

3.4.9 Irrigation and fertigation

Drip irrigation was given daily to replenish 50 per cent of open pan evaporation. Water soluble fertilizers were given through fertigation during entire crop growth period, starting three weeks after transplanting at the interval of two fertigation per week for 18 weeks with 19:19:19,12:61:00 and 0:52:34.

3.4.10 Plant protection measures

The following plant protection chemicals were sprayed to control pest and diseases during crop period in tomato under poly house. (Table 3.2).

Table 3.2: The details of pest and diseases and chemicals sprayed in tomato.

S.No	Pest/disease	Casual organism	Chemical sprayed	Dosage
1.	White fly	*Bemisia tabaci*	Triazophos	1 ml/L
2.	Thrips	*Scirtothrips dorsalis*	Fipronil 5%SC	2 ml/L
3.	Mites	*Polyphagotarssonemus latus*	Propargite 57% EC	0.6 ml/L
4.	Fruit borer	*Spodoptea litura*	Emamectin benzoate	1 g/L
5.	Leaf miner	*Liriomyza trifoli*	Hostathion	1.5 ml/L
6.	Cercospora leaf spot	*Cercospora capsici*	Mancozeb 75% WP	2.5 g/L
7.	Early blight	*Alternaria solani*	Dithane M -45	2 g/L

3.5 Observations recorded

3.5.1 Morphological and phenological parameters

3.5.1.1 Plant height (cm)

Five plants were selected randomly from each plot and tagged. Height of these tagged plants was measured from the ground level to the short tip of plant at 30,60 and 120 days after transplanting and at final harvest. The average height was calculated and expressed in meter..

3.5.1.2 Leaf area (cm^2)

Five plants were selected randomly from each plot was leaf area measured with Biovis equipment.

1.5.1.3 Number of leaf

Number of leaves were counted from five tag plants in each plot at different stages of tomato leaves after counting the average was to work out to get number of leaves per plants.

3.5.1.4 Days to first flowering

Number of days was counted by visual observation in each plot when days to first flowering.

3.5.1.5 Node to first inflorescence

Days to first inflorescence of first observed at the time of appearance of first inflorescence.

3.5.1.6 No. of flower per plant

Days to fruit initiation the total number of flower plant^{-1} was recorded at different stages after transplanting.

3.5.1.7 Days of fruit set

Days to fruit initiation were observed at the time of appearance of fruit initiation was recorded at the time of appearance.

3.5.1.8 Fruit diameter (cm)

Fruits from five tagged plants in each plot were randomly selected at each picking and their length (cm) was measured between two polar ends with the help of vernier caliper.

3.5.1.9 Days to first fruit picking

Days to first fruit picking P_1 were recorded at time of fruit ripening.

3.5.2. Biochemical parameters

3.5.2.1 Starch content (%)

Materials –

- Anthrone reagent: Dissolve 200 mg anthrone in 100 ml of ice cold 95 per cent sulphuric acid.
- SO percent ethanol.

- 52 per cent perchloric acid,
- Standard glucose stock -100 mg in 100 ml of water, working standard - 10 ml of stock diluted to 100 ml with water.

Procedure:

Homogenise 0.1 to 0.5 g of the sample in hot 80 per cent ethanol to remove sugars. Centrifuge and retain the residue .Wash the residue repeatedly with hot 80 per cent ethanol till the washings do not give colour with anthrone reagent. Dry the residue well over a water bath. To the residue add 5.0 ml of water and 6.5 ml of 52 per cent of perchloric acid than extract at 0°C for 20 min. Centrifuge it and save the supernatant. Repeat the extraction using fresh per choleric acid. Centrifuge and pool the supernatants and make up to 100 ml. Pipette out 0.1 or 0.2 ml of the supernatant and make up the volume to 1 ml with water. Prepare the standards by taking 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard and make up the volume to 1 ml in each tube with water. Add 4 ml of anthrone reagent in each tube. Heat for eight minutes in a boiling water bath and finally cool rapidly and read the intensity of green to dark green colour at 630 nm.

Calculation:

Multiply the value by a factor 0.9 to arrive at the starch content. (Hedge and Hofreiter, 1962).

3.5.2.2 Lycopene content (mg $100g^{-1}$)

The lycopene content for tomato fruit was analyzed by using the procedure outlined by Ranganna (2001).

One gram of blended fruit sample was taken into a mortar and pulp was extracted repeatedly with acetone until the residue turned colourless. The acetone extract was transferred to separating funnel containing 10 to 15 ml petroleum ether and mixed gently. Carotenoids pigments were taken into petroleum ether layer by diluting the acetone with water. Petroleum ether containing pigments were transferred to 25 ml volumetric flask and diluted to the mark with petroleum ether.

Then one ml of aliquot was further diluted to 10 ml with petroleum ether and the absorbance or OD was read in a Spectrophotometer at 503 nm. The lycopene content (µg/100g) in fruit was calculated by using the formula given by Ranganna (2001).

$$\text{Lycopene (mg/100g)} = \frac{3.126 \times \text{OD of sample} \times \text{Vol. of made up} \times \text{dilution}}{1 \times \text{weight of sample} \times 1000} \times 100$$

3.5.2.3 Acidity (%)

An aliquot of the prepared sample was titrated with 0.1 N NaOH using a few drops of 1% phenolphthalein indicator (Ranganna, 2001). Acidity was expressed as percent (%) citric acid.

$$\text{Titrable Acidity (\%)} = \frac{1 \times \text{T.V} \times \text{N. of NaOH} \times \text{equivalent weight of acid}}{10 \times \text{wt. of sample}} \times 100$$

N = Normality, T.V = Titret value

3.5.2.4 Total sugar and reducing sugars (%)

The sample extract or the test solution is heated with alkaline copper reagent and the reduced copper formed then reacts with arsenomolybdate reagent to produce molybdenum blue resulting in the formation of a violet colored complex which is estimated calorimetrically at 500 nm. Sodium sulphate is included in the copper reagent to prevent re-oxidation of cuprous oxide by atmospheric oxygen. (Somyogi method, 1944).

Equipments required**:** Hot plate, water bath, UV- Vis spectrophotometer

Chemicals:

- 45 % neutral lead acetate; dissolve 45 g of lead acetate in 100 ml of distilled water.
- Potassium oxalate: 3 spatulas full
- Concentrated HCL
- 0.1% phenolphthalein: 100mg of phenolphthalein dissolved in 100 ml of alcohol (95%).
- Standard glucose solution : 50 mg of glucose dissolved in 50 ml of distilled water.
- Copper reagent a A: 2.5 g anhydrous sodium carbonate, 25g sodium potassium tartarate, 20g sodium bicarbonate and 200g anhydrous sodium sulphate are dissolved in 1000ml of distilled water.
- Copper reagent B: 15g copper sulphate dissolved in 100 ml of distilled water , with 1 to 2 drops of H_2SO_4
- Alkaline copper reagent : 25 parts of reagent A and I part of reagent B are mixed before use.
- Arsenomolybdate reagent: 25g of ammonium molybdate is dissolved in 450ml of water and 21ml of Concentrated H_2SO_4 the solution is mixed well 3g of sodium arsenate is dissolved in 25ml of water and added to the above solution, mixed and incubated at 37^0C.

Procedure:

- Weigh 1 gram of the food sample add 25 ml of water and simmer for 20 minutes.
- After cooling add 5 ml of 45% lead acetate was added and keep for 30 minutes.
- Add 3 small spatulas of potassium oxalate is added and make the solution up to 50 ml with distilled water and filter. This is the reducing sugar extract.
- Take 10 ml of the reducing sugar extract and add 1 ml of con. HCL and boil for 5 minutes.

- After cooling, add few drops of phenolphthalein followed by 1N NaOH for neutralization.
- Make the solution up to 10 ml. this is the total sugar extract.
- Take 0.2 ml of the total sugar as well as reducing sugar extract, or different range of standards (0.05,0.1,0.2,0.3,0.4 and 0.5 ml) in test tubes, add 1ml of alkaline copper reagent and keep all the test tubes in a boiling water bath for 20 minutes.
- Cool the tubes and add 1ml of arsenomolybdate solution.
- Make all the solution up to 25 ml in a 25 ml volumetric flask.
- Read the solutions in a spectrophotometer at 520 nm wavelength.
- A standard graph is plotted or obtained directly from the spectrophotometer and from which the sample values are extrapolated. Observation recorded; optical density values from the standard graph in ug (X)

Quantity of total and reducing sugars are calculated based on the values obtained from the standard graph

$$\text{Total sugar} = \frac{X \times 10 \times 50 \times 100 \times 1}{0.2 \times 10 \times 1 \times 100} = \text{mg/100 g sample}$$

$$\text{Reducing sugars} = \frac{X \times 50 \times 100 \times 1}{0.2 \times 10 \times 1000} = \text{mg/100 g sample}$$

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

Ascorbic acid was estimated by using 2, 6-dichlorophenol-indophenol titration method. Two percent metaphosphoric acid was added to 20 ml of sample. The volume made up to 100 ml in a volumetric flask and filtered using what man no. 4 filter paper. Five ml of this filtrate was taken and titrated against 2, 6 dichlorophenol -indophenol dye.

The titration was carried out up to a light pink colour to be appeared. The dye was prepared using 50 mg of sodium salt of 2, 6-dichlorophenolindophenols dye in approximately 150 ml of double distilled water containing 2 mg of sodium

bicarbonate. It was slightly warmed and the volume was made up to 200 ml. This dye was used for titration and standardization of ascorbic acid (Ranganna, 2001)

$$\text{Ascorbic acid (mg } 100g^{-1}) = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Aliquot of extract taken for estimation} \times \text{Wt. or Volume of sample taken for estimation}} \times 100$$

Where, Dye factor = 0.5/ titre value

3.5.2.6 Total soluble solids (TSS) (^{0}Brix)

The TSS content of fruits was measured from five randomly selected fruits by squeezing the juice on hand refractometer (0-32 ^{0}B) platform and readings were observed at room temperature and mean was calculated.

3.4.2.6 Chlorophyll content (SPAD meter)

Chlorophyll content was calculated by SPAD meter (Chlorophyll meter, SPAD-502) at once during flowering period, chlorophyll content variable in controlled conditions. (Balasubramanian *et al.*1999)

3.5.3 Yield parameters

3.5.3.1 Number of fruits cluster $^{-1}$

Total number of fruits cluster -1 was recorded on five plants (from each plant five clusters were taken and means was computed) for each variety per replication and the mean of five clusters was computed.

3.5.3.2 Average fruit yield kg plant^{-1}

The fresh weight of five fruits was randomly selected from tagged plants per replication and the mean was computed and expressed in grams.

3.5.3.3 Total fruit yield (t ha^{-1})

The fruit yield of per plant calculated by add the weight of total picking. $P_1 + P_2 + P_3 +$ -------- the average yield per plant was worked out and expressed to tonnes.

3.6 Economics

Cost of cultivation for each treatment was calculated separately. Gross returns (Rs.ha^{-1}) was obtained by converting the harvest into monetary terms of the prevalling market rate during the course of studies for every treatment.Net return was obtained by deducing cost of cultivation form gross return. The benefit cost ratio was calculated with the help of following formula.

$$\text{Benefit cost ratio} = \frac{\text{Net return (Rs.ha-}^{1}\text{)}}{\text{Total cost of cultivation (Rs.ha}^{-1}\text{)}}$$

3.7 Statistical analysis

The data pertaining to vegetative, reproductive, quality and yield parameters of different varieties of tomato were tabulated treatment – wise and replication – wise. The data was subjected to statistical analysis as per the methods out lined by Panse and Sukhatme (1985) using the mean values of random plants in each replication from all the treatments to find out the significance of treatment effect.(Table 3.3).

Table 3.3 Skelton of ANOVA

Source of variation	**Degree of freedom**	**Sum of squares**	**Mean Squares**	**Computed *F*^{b}**	**Tabular F (0.05)**
Treatment	(t-1)	TrSS	**TrMS = $\frac{\text{TrSS}}{\text{df}}$**	**$\frac{\text{TrMS}}{\text{EMS}}$**	
Error	t(r-1)	ESS	**EMS=$\frac{\text{ESS}}{\text{df}}$**		
Total	rt-1	TSS			

The following formulae were used for standard error, critical difference and coefficient of variance estimations.

(a) $S.Em\pm = \sqrt{EMS/r}$

(b) $C.D. = S.Em \times \sqrt{2} \times t\ (p=0.01)$ at error d.f.

(c) $C.V. = \sqrt{EMS/GM} \times 100$

Where,

r = Number of replication M.S.S. = Mean sum of square

t = Number of treatment SEm± = Standard error of mean

d.f. = Degree of freedom EMS = Error mean squares

S.S. = Sum of square C.D. = Critical difference

3.8 Correlation analysis

The correlation between fruit yield and different traits like morphological, phenological, physiological, biophysical, biochemical and yield attributing traits under controlled conditions.

CHAPTER- IV

RESULTS AND DISCUSSION

The present chapter deals with experimental findings and discussion obtained during the course of Investigation entitled **"Growth and yield component of tomato *(Solanum lycopersicon* L.) under protected condition"** The field experiment was conducted during *Kharif* (2016-17) at research farm of center of excellence on protected cultivation and precision farming, IGKV, Raipur. The experimental findings were statically analyzed and presented in appropriate Tables, graphs and few also depicted through figure, the obtained results are presented below.

4.1. Morphological and phenological parameters

4.1.1 Plant height (cm)

Plant height differed significantly in different tomato varieties under polyhouse. The result related to plant height (cm) has been presented in (Table 4.1 and fig.1). It has been taken at 30, 60 and 120 DAT.

The mean value of maximum plant height was obtained in Roja (313.30 cm) followed by Laila (312.37 cm).

Table 4.1.1: Plant height at different days after transplanting in tomato grown under polyhouse conditions

		Plant height (cm)		
Treatment	**Varieties**	**30 DAT**	**60 DAT**	**120 DAT**
1	Sheeja	94.25	178.95	245.88
2	Roja	103.48	204.97	313.30
3	Laila	97.32	205.62	312.37
4	Nowara	84.24	179.09	293.88
5	Youvraj 1003	88.45	181.80	303.21
	SEm ±	**0.30**	**0.26**	**1.12**
	CD at 0.01	**0.89**	**0.76**	**3.30**

*Significant at 1% level of significance

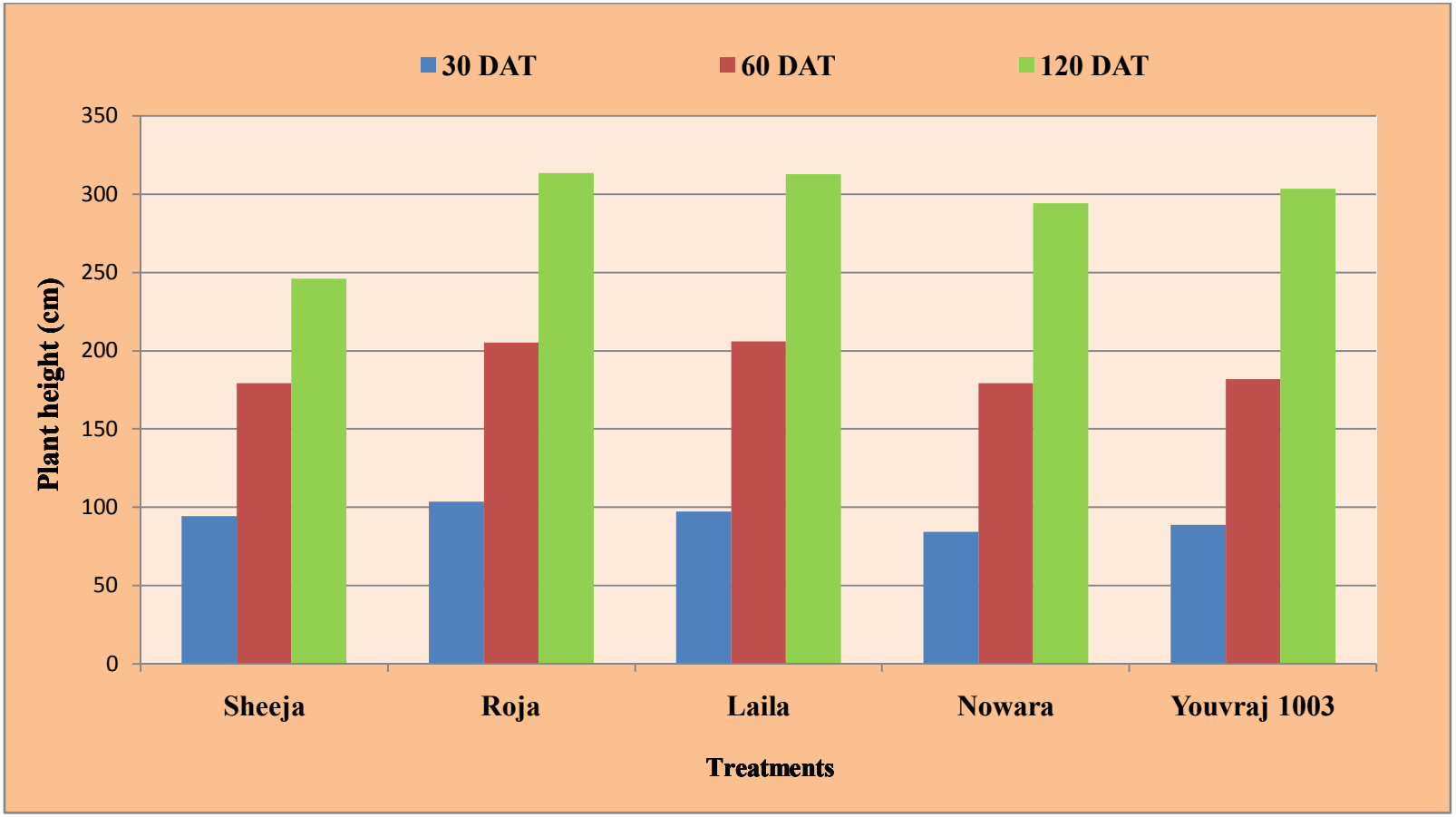

Fig. 1: Plant height at different DAT tomato varieties grown under polyhouse conditions

While minimum plant height was noticed in Sheeja (280.23 cm) in indeterminate varieties plant height was positively correlation with number of fruit plant^{-1} and fruit yield plant^{-1} Fayed *et al.*(2001) reported similar results of increase in plant height due to partial modification of natural environment and favorable micro climate condition surrounding the plant is in tomato under polyhouse condition.

4.1.2 Leaf area (cm^2)

The results related to leaf area differed significantly in different tomato varieties have been presented (Table 4.2 and Fig.2). The mean value of maximum leaf area was found in Youvraj 1003 (38.59 cm^2) followed by Sheeja (29.78 cm^2) while minimum leaf area observed in Laila (15.93 cm^2) due to leaf area depend upon the number and size of leaf. Leaves play an important role in absorption of light radiation and using it in photosynthesis process, leaf size is influenced by light moisture and nutrients, hence yield is depends on leaf area of crop. Similarly result found by Lakshmi and Mani (2004)

Table 4.1.2: Leaf area and days to first flowering after transplanting in tomatoes under polyhouse conditions

Treatment	Varieties	Leaf area (cm)^2	Days to first flowering
1	Sheeja	29.78	34.45
2	Roja	27.59	36.45
3	Laila	15.93	44.85
4	Nowara	21.20	37.97
5	Youvraj 1003	38.59	31.56
	SEm±	**4.14**	**1.27**
	CD at 0.01	**12.21**	**3.74**

*Significant at 1% level of significance

4.1.3 Number of leaves

The number of leaves plant^{-1} differed significantly in different tomato varieties under polyhouse condition. The mean performance of number of leaves plant^{-1} was highest in Laila (336.75) followed by Roja (284.10) while minimum number of leaves was recorded in Nowara (201.45) presented in (Table 4.3 and fig.3)

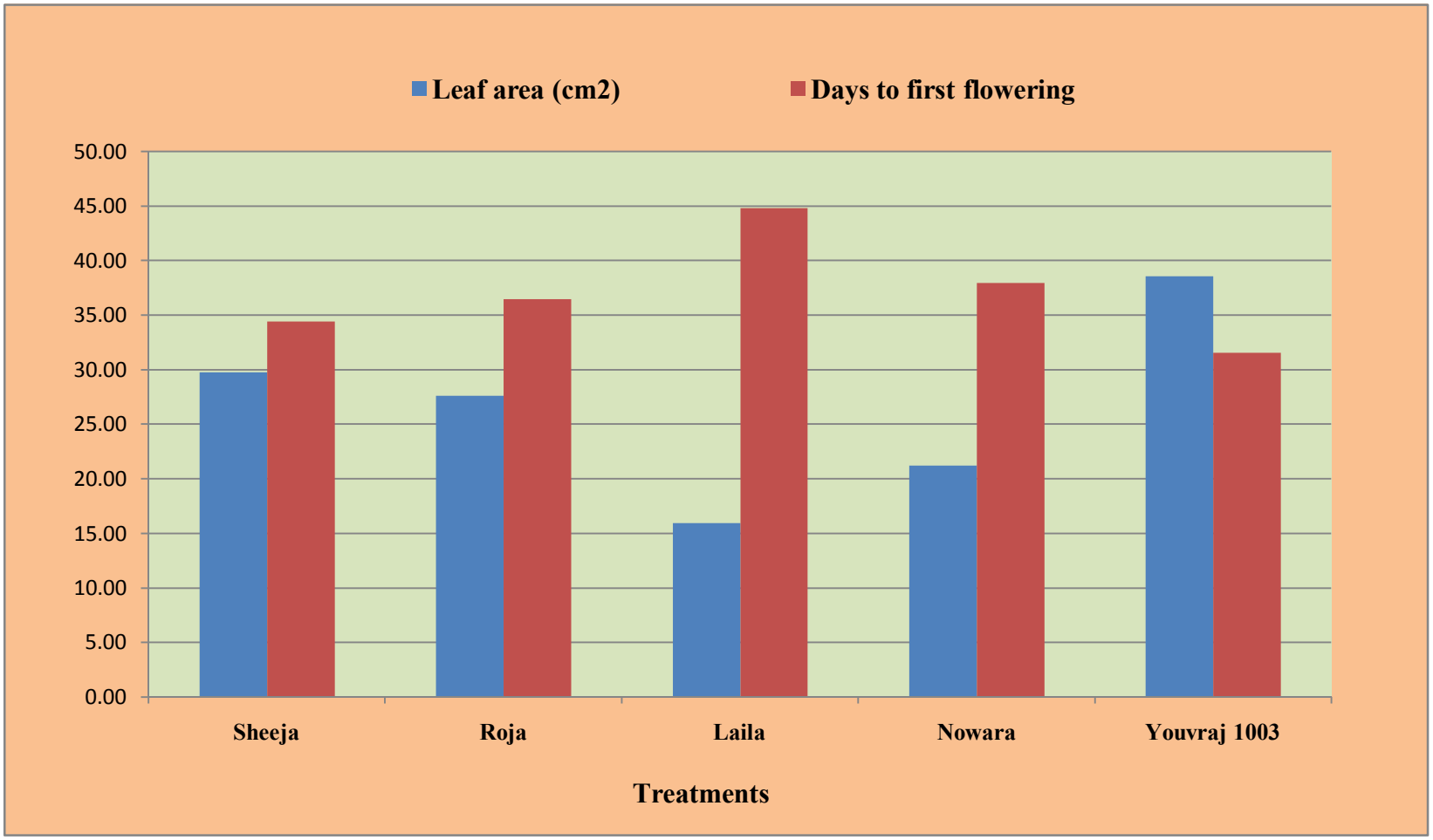

Fig. 2: Leaf area and days to first flowering in tomato varieties under polyhouse conditions

The different observed in number of leaves due to genetic variations existing in Varieties. Better acclimatization and adaptation to the natural ventilated polyhouse climate compared with inherent genetic potential of Laila hybrid resulting in maximum number of leaves plant^{-1}. Similar results were reported by Sharma and Tiwari (1993).

4.1.4 Days to first flowering

Days to first flowering differed significantly in different tomato varieties under polyhouse condition has been presented in (Table 4.2 and fig 2). The mean performance of days to first flowering was recorded Youvraj 1003 (31.56 days) followed by Nowara (34.45 Days). Lastest flowering was recorded by Laila (44.85).

Early flowering is an indication of early fruit formation and consequently helps in getting early and high yields. The early flower initiation in Laila might be due to higher capacity of these growing types to make available assimilates to the reproductive site during sensitive phase before flower initiation and congenial micro climate inside the controlled conditions. Similar results of significant differences for days to first flower among genotypes and potential use of these growing conditions for assimilation of photosynthates for early flower initiation was also reported by Oum (1995), Pandey *et al*. (2006).

Table 4.1.3: Number of leaves at different days after transplanting in tomato grown under protected conditions

		Number of leaves		
Treatment	**Varieties**	**90 DAT**	**120 DAT**	**190 DAT**
1	Sheeja	86.95	132.10	246.95
2	Roja	68.70	100.70	284.10
3	Laila	104.80	198.95	336.75
4	Nowara	56.90	89.50	201.45
5	Yovuraj 1003	58.90	114.45	222.70
	SEm ±	**6.15**	**15.02**	**29.33**
	CD at 0.01	**13.10**	**32.01**	**62.51**

*Significant at 1% level of significance

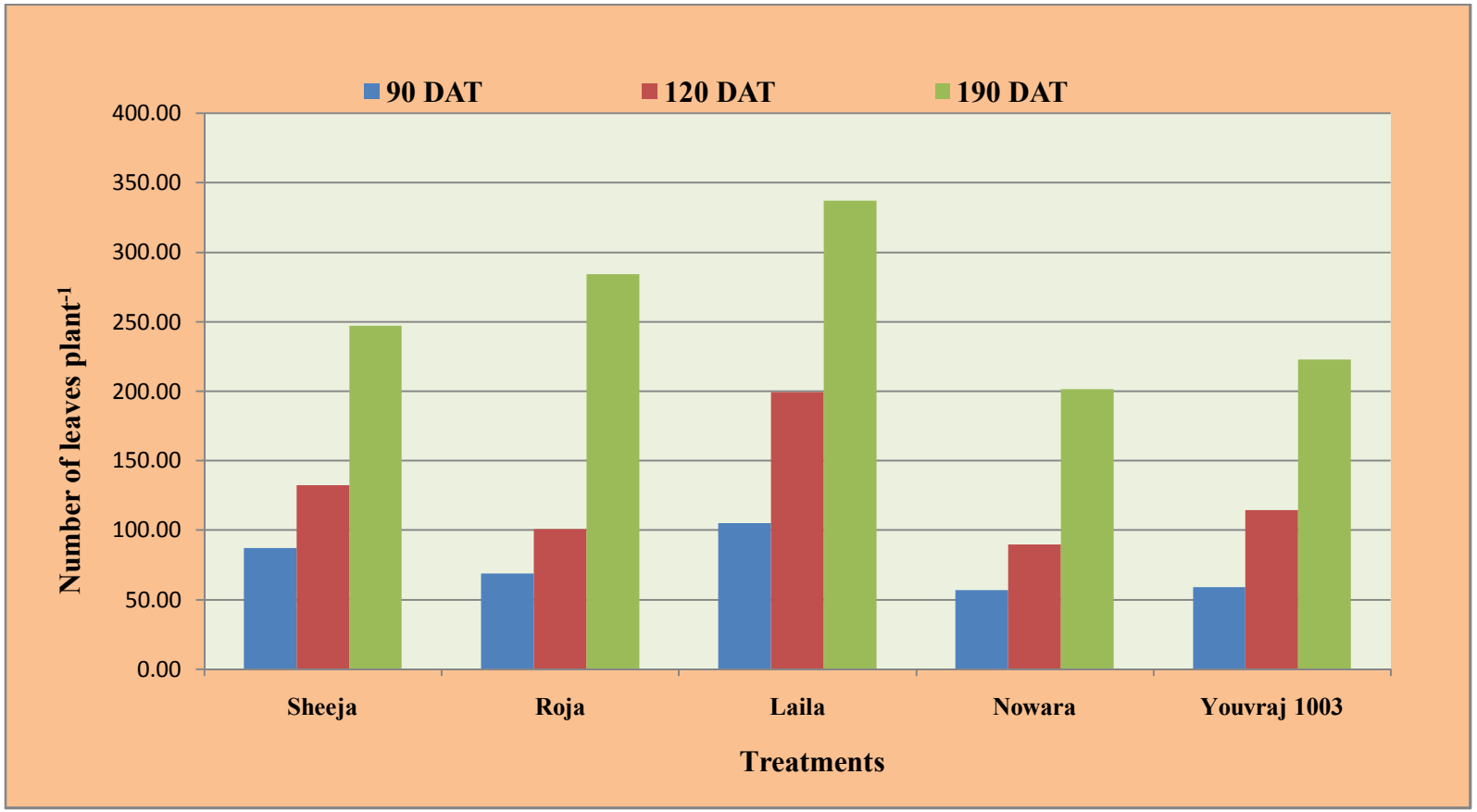

Fig. 3: Number of leaves at 90, 120 and 190 days after transplanting in tomato varieties grown under polyhouse conditions.

4.1.5 Number of flower plant^{-1}

The number of flower plant^{-1} differed significantly in different tomato varieties under polyhouse conditions have been presented in (Table 4.4 and fig 4). The Mean performance of number of flower plant^{-1} was highest in Sheeja (562.25) followed by Roja (552.25) while minimum number of flower plant^{-1} (388.98).

Highest number of flower in Sheeja and Roja could be attributed to the favourable micro climate inside the polyhouse condition, enhancing the fruit development by increasing the rate of morphological response to diffused light intensity inside the cantrolled condition by way of photosynthesis and respiration resulting in longer in fruit and increase in the growth and yield variables in terms of number of flower plant^{-1}. These results are in conformity those obtained by Papadopoulos and Ormrod (1991).

Table 4.1.4: Number of flowers per plant in tomato varieties under controlled conditions

Treatment	Varieties	90 DAT	160 DAT	220 DAT
1	Sheeja	134.80	308.75	562.25
2	Roja	106.50	281.80	552.25
3	Laila	122.10	270.46	462.35
4	Nowara	36.10	106.31	307.10
5	Youvraj1003	41.90	180.58	388.98
	SEm±	**16.52**	**31.05**	**33.23**
	CD at 0.01	**48.67**	**91.50**	**97.92**

*Significant at 1% level of significance

4.1.6 Node to first inflorescence

The node to first inflorescence differed significantly in different tomato varieties under polyhouse condition. The result related to node to first inflorescence has been presented in (Table 4.5 and fig 5).

The mean value of maximum node to first inflorescence was found in Roja (4.45). Thought the plants may produce a lot of inflorescence all of them may not bear fruits. The lowest inflorescence was recorded in Nowara (3.25). this is accordance with results of Singh *et al* (2005) and Cheema *et al* (2013).

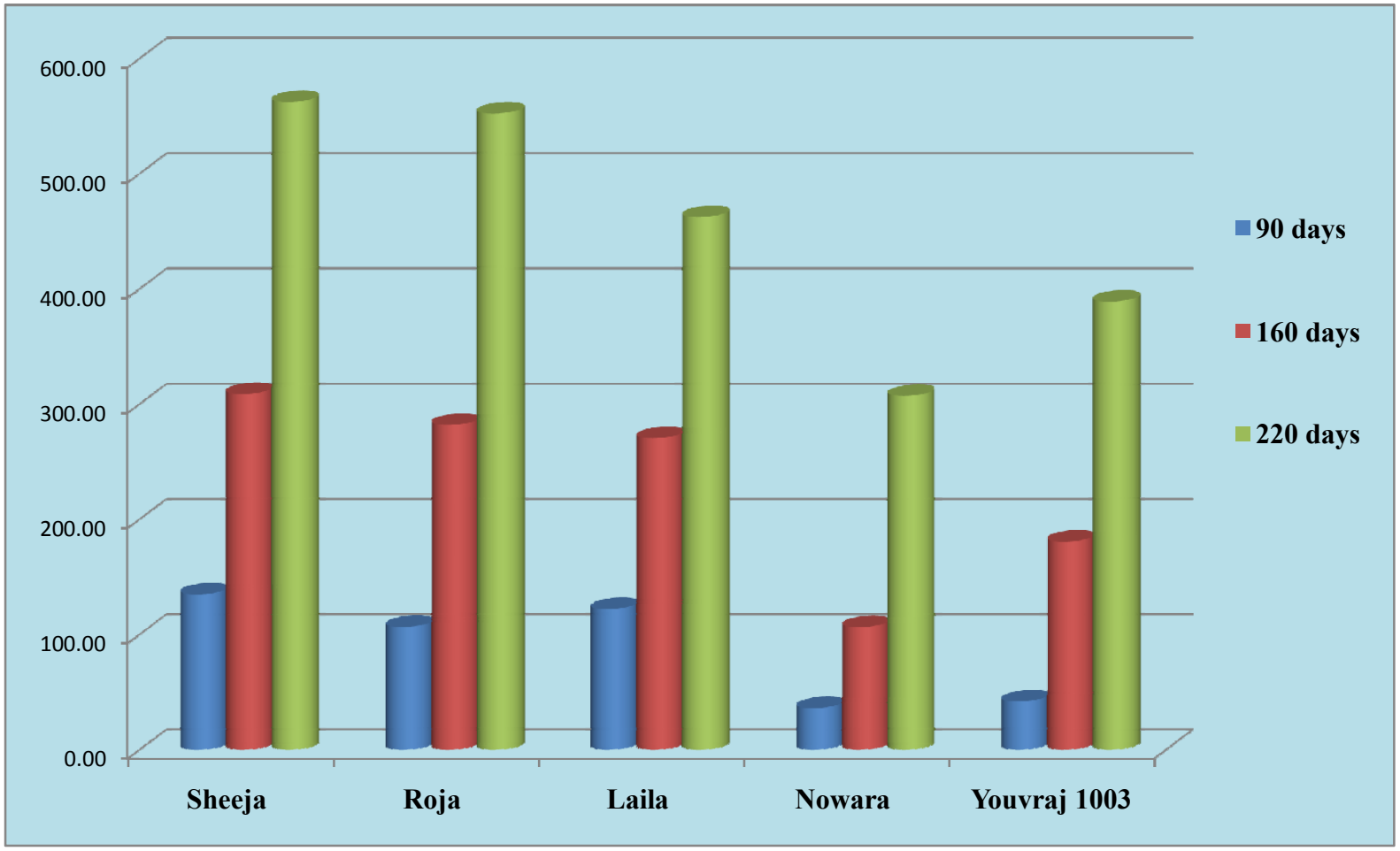

Fig. 4: Number of flower plant^{-1} at 90, 160 and 190 Days in tomato varieties grown under polyhouse conditions.

4.1.7 Days to first fruit set

Days to fruit set was observed in Sheeja (45.23 days) which is followed by Roja (46.41 days) a fruit set where least fruit set was observed in youvraj 1003 (41.59 days) presented in (Table 4.5 and fig.5)

The increased fruit set might be due to higher rate of anther dehiscence, higher number of flower and better response to polyhouse conditions. This also could be due to optimum light and temperature. Variation in the fruit set percentage might be due to reduced style elongation and exertion of the stigma below the mouth of the antheridia cone under low temperature. The difference in fruit set in different varieties might be due to the varied response of varieties to growing environment and genetic potentiality.

The results obtained in the present study are in line with the findings of, Pandey *et al*. (2006) and Ishwarappa (2011) in tomato under polyhouse house.

4.1.8 Fruit Diameter (cm)

The fruit diameter differed significantly in different tomato varities under polyhouse conditions. The result related to fruit diameter has been presented in (Table 4.5 and fig. 5). The mean value of maximum fruit diameter was obtained in Youvraj 1003 (13.66 cm) followed by Nowara (13.45 cm) while minimum fruit diameter was noted in Roja (6.81 cm).

Highest fruit length of Youvraj 1003, Sheeja and Laila varieties is mainly might due to their genetic character and the response of these varieties to acclimatize to the polyhouse conditions. Shortest fruit diameter observed in Roja was mainly due to the flattened and round nature of fruits. Similar results of significant variation in fruit diameter of tomato were obtained by Oum (1995).

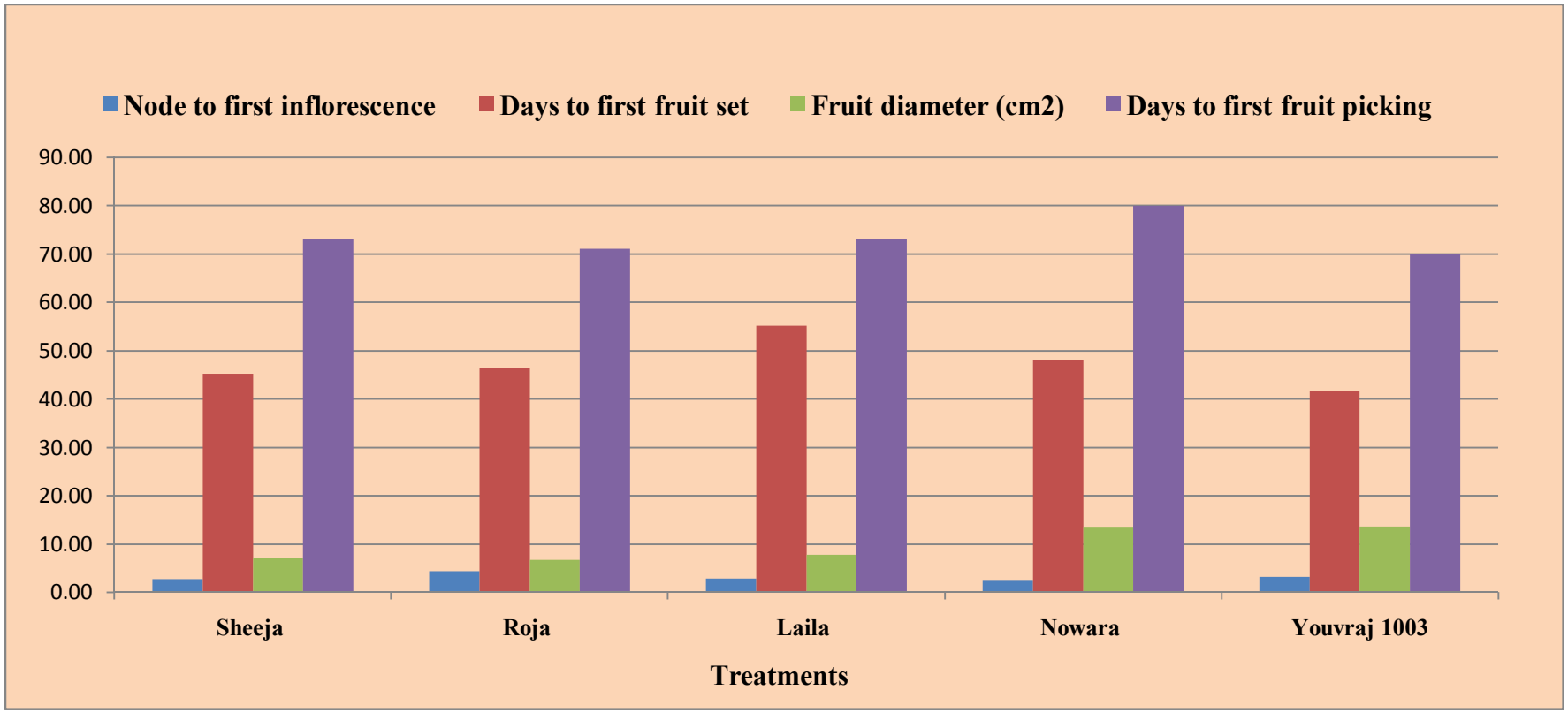

Fig. 5: Node to first inflorescence, days to first fruit set, fruit diameter (cm) and days to first fruit picking in tomato grown under polyhouse conditions.

Table 4.1.5: Node to first inflorescence, days to first fruit set, days to first fruit harvest and fruit diameter (cm) in tomato varieties

Treatment	Varieties	Node to first inflorescence	Days to first fruit set	Days to first fruit Picking	Fruit diameter (cm)
1	Sheeja	2.80	45.23	71.03	7.10
2	Roja	4.45	46.41	73.11	6.81
3	Laila	2.90	55.12	73.12	7.88
4	Nowara	2.40	48.09	79.94	13.45
5	Yovuraj 1003	3.25	41.59	70.05	13.66
	SEm ±	**0.34**	**1.31**	**0.12**	**0.12**
	CD at 0.01	**0.99**	**3.86**	**0.37**	**0.37**

*Significant at 1% level of significance

4.1.9 Days to first fruit picking

Highly significant differed were observed with respect to days to first fruit picking among the tomato (Table 4.5 and fig 5). The mean number of days taken for first fruit picking ranged from 70.05 to 79.94 days.

The variety Youvraj 1003 (70.05 days) took shortest period from transplanting to first fruit harvest followed by Roja (71.03 days), but both are statistically found at par with each other. While, Youvraj 1003 took maximum number of days (79.94 days) for first fruit harvest. Earliness plays important role on fetching higher price and more income. Therefore early varieties are generally preferred for cultivation on commercial scale.

Early harvest in this experiment might be due to the varietal response to the congenial growing environment in polyhouse and early flowering. Whereas delayed fruit ripening was due to late flowering. Similar results obtained Wahundeniya *et al. (* 2013) in tomato growing in poly house and Prema *et al.* (2011) in cherry tomato.

4.2 QUALITY PARAMETERS

4.2.1 TSS (^{0}Brix)

The data pertaining to total soluble solids (TSS) are presented in the (Table 4.6 and fig.6) data showed highly significant differences among the tomato varieties. TSS of tomatoes varied between 4.39 ^{0}B and 5.24 ^{0}B.

Significantly highest TSS was registered in Roja (5.25 ^{0} B) followed by Sheeja (5.24 ^{0}B).While the lowest TSS was recorded in Youvraj 1003 (4.39 ^{0}B).

High TSS and low acidity are the major factors considered for fruit processing products. One per cent increase in TSS content of fruits results in 20 per cent increase in recovery of processed product. Higher TSS in Roja and Sheeja hybrids might be due to the enhanced deposition of solids and more conversion of organic acids to sugars. similar studies conducted by the earlier workers Sucheta *et al*. (2004) in tomato and John *et al*. (2005), Kumar *et al*. (2007), Shivanand (2008), in tomato under polyhouse and Prema *et al*. (2011) and Islam *et al*. (2012) in tomato.

4.2.2 Acidity (%)

Highly significant differences among tomato varieties were observed with respect to acidity percentage (Table 4.6 and Fig.6). Acidity percentage ranged from Sheeja (0.81%) to Youvraj 1003 (0.68%).

The highest acidity was recorded in the fruits of variety Sheeja (0.81 %) followed by Roja (0.77%) and Lowest acidity registered in variety Nowara (0.62 %). The lower acidity in these cultivars might be due to rapid utilization of organic acids in respiration during maturity. Similar results of significant differences among varieties were also reported by Shilibi *et al.* (1995), John *et al*. (2005), Hazarika and Phookan (2005), Kumar *et al*. (2007), Prema *et al*. (2011) and Razzak *et al.* (2013) in cherry tomato.

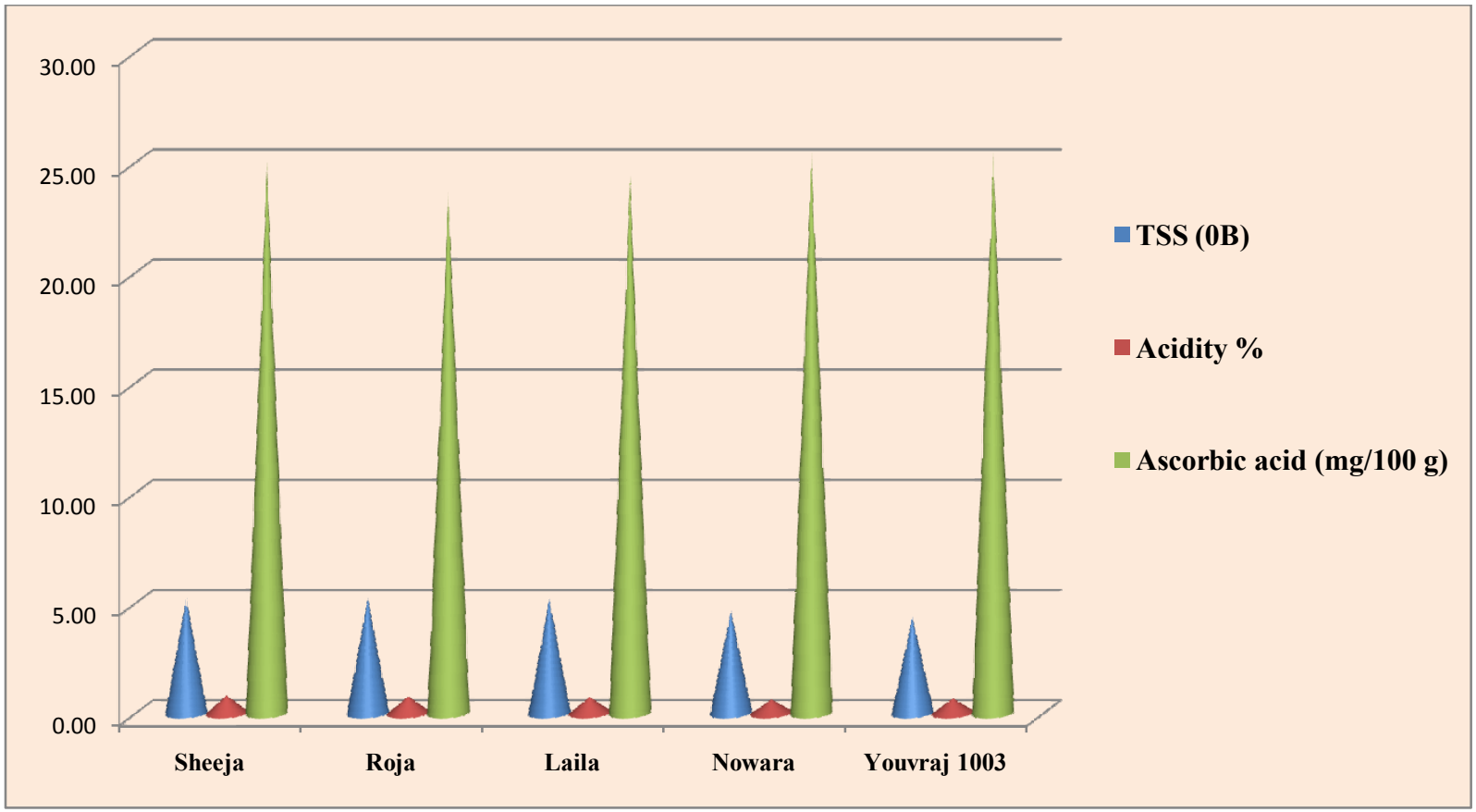

Fig. 6: Variation in TSS (^{0}B), Acidity (%) and Ascorbic acid (mg 100g^{-1}) in tomato grown under polyhouse conditions

Table 4.1.6: Quality parameters of tomatoes under protected condition in different varieties

Treatment	Varieties	TSS (^{0}B)	Acidity (%)	Ascorbic acid (mg 100 g^{-1})
1	Sheeja	5.24	0.81	25.05
2	Roja	5.26	0.77	23.73
3	Laila	5.21	0.74	24.41
4	Nowara	4.66	0.62	25.46
5	Youvraj 1003	4.39	0.68	25.41
	SEm±	**0.06**	**0.02**	**0.01**
	CD at 0.01	**0.17**	**0.05**	**0.03**

*Significant at 1% level of significance

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

Highly significant differed were observed with respect to ascorbic acid content of tomato in the presented in (Table 4.6 Fig.6).

The variety Nowara (25.46 mg 100g^{-1}) followed by Youvraj 1003 (25.41 mg 100g-1) recorded significantly highest ascorbic acid content while, Roja (23.73 mg 100g^{-1}) was recorded lowest ascorbic acid content.

This significantly varied ascorbic acid content in the present study might be due to immense variation among different tomato cultivars and their genetic makeup of the varieties to perform better under controlled environment conditions. These results are in agreement with the findings of Hazarika and Phookan (2005), Kumar *et al*. (2007), Shivanand (2008), Sumathi *et al*. (2013b) in tomato under poly house and Prema *et al*. (2011), Aguirre and Cabrera (2012) and Razzak *et al.* (2013) in cherry tomato.

4.2.4 Lycopene content (mg 100 g^{-1})

Lycopene content differed significantly in different tomato varieties under polyhouse condition presented in (Table no.4.7 and fig.7). Lycopene content has been estimated one time at 120 DAT. Highest lycopene content was recorded in Roja (8.33 mg100g^{-1}) followed by Laila (6.70 mg100g^{-1}) while least lycopene content was recorded in Sheeja (0.19 mg100g^{-1}) and varities in lycopene content

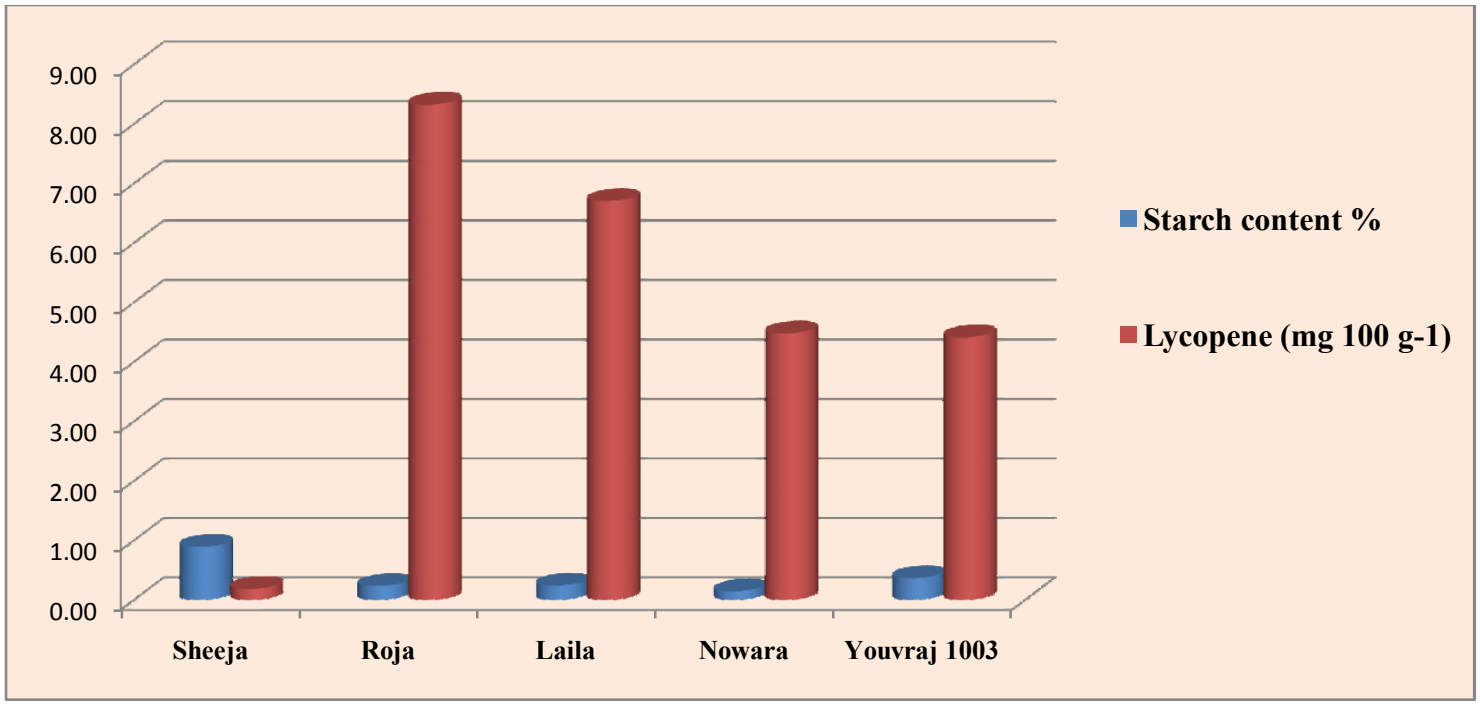

Fig.7: Variation in Starch content % and Lycopene content (mg 100 $^{g-1}$) in tomato grown under polyhouse conditions.

ranged between (0.19 mg100g^{-1}) and (8.33 mg100g^{-1}) might be varied lycopene content in the red coloured cherry tomatoes were also reported by John *et al*. (2005).

4.2.5 Starch content (%)

Starch content differed significantly in different tomato varieties under polyhouse conditions. Presented in (table 4.7 and fig.7) highest starch content was recorded at (0.89%) in Sheeja followed by (0.37%) by Youvraj 1003, while least starch content was recorded in Laila (0.24%) and variance in Starch content ranged between (0.24%) to (0.89%). In Sheeja had highly assimilatory starch content in leaf occurred in top third LMA (leaf mass per unit area) reported by John *et al*. (2005).

Table 4.1.7: Quality parameters of tomato under protected conditions Starch content (%) and lycopene content (mg 100 g^{-1})

Treatment	Varieties	Starch content (%)	Lycopene content (mg 100g^{-1})
1	Sheeja	0.89	0.19
2	Roja	0.23	8.33
3	Laila	0.24	6.70
4	Nowara	0.14	4.48
5	Youvraj 1003	0.37	4.42
	SEm±	**0.00**	**0.12**
	CD at 0.01	**0.01**	**0.37**

*Significant at 1% level of significance

4.2.6 Reducing sugars (%)

The data pertaining to reducing sugars among the varieties is highly significant and presented in (Table 4.8 and fig 8).

The varieties Youvraj 1003 (3.61 %) followed by Nowara (3.52 %) recorded significantly maximum reducing sugars content. Lowest reducing sugars Sheeja (2.30 %). Highly significant and varied results of reducing sugars in the present study could be attributed to the decreased acidity under lower light intensities causing degradation of acids during ripening and senescence in the polyhouse and genetic makeup of the varieties. Similar results were also reported

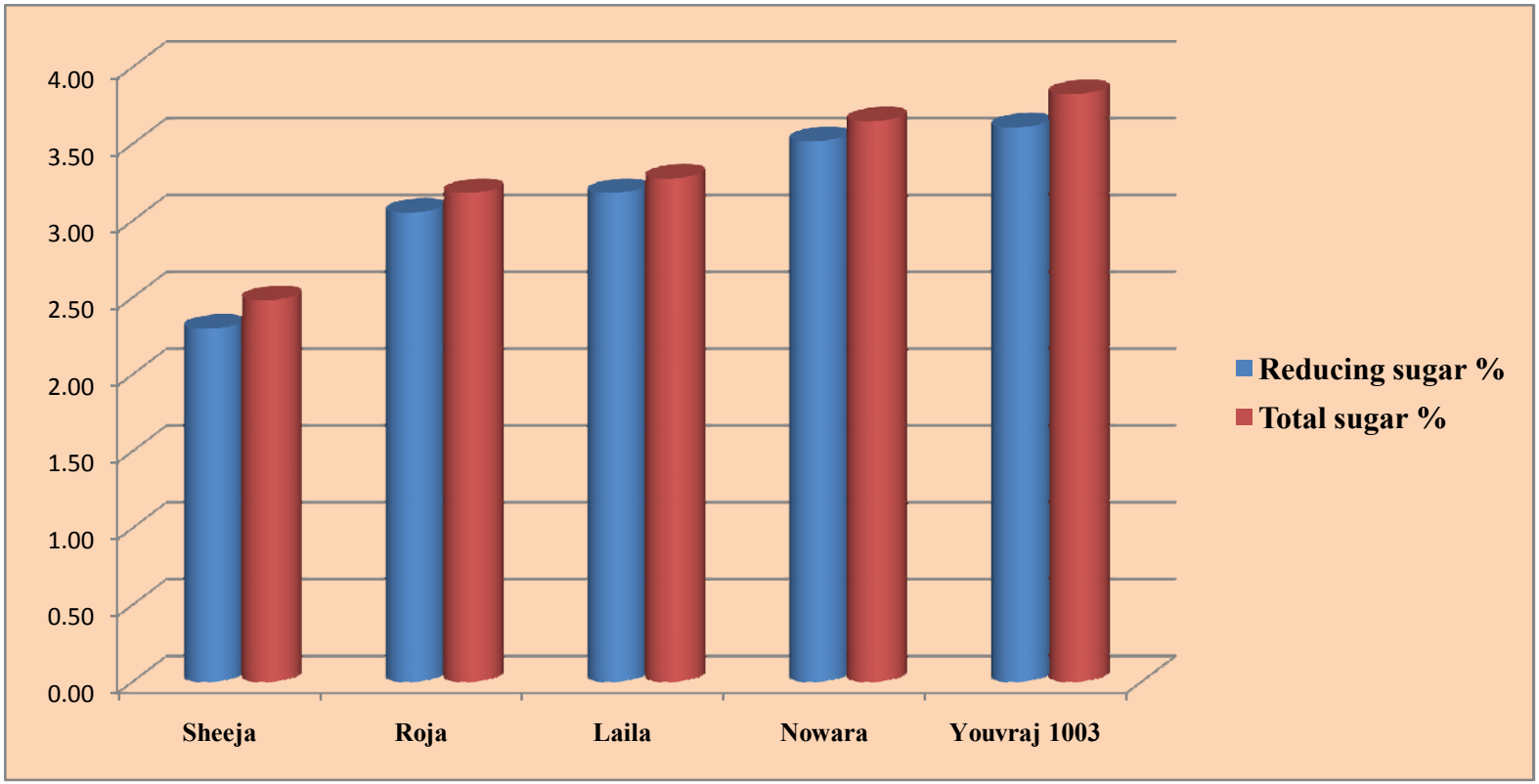

Fig. 8: Variation in Reducing sugar (%) and Total sugar (%) in tomato grown under polyhouse conditions.

by, Kumar *et al.* (2007), Caliman *et al.* (2010) and Razzak *et al.* (2013) in tomatoes produced under polyhouse.

Table 4.1.8: Quality parameters of different tomato varieties reducing sugar (%) and total sugar (%).

Treatment	Varieties	Reducing sugar (%)	Total sugar (%)
1	Sheeja	2.30	2.48
2	Roja	3.05	3.18
3	Laila	3.18	3.28
4	Nowara	3.52	3.65
5	Youvraj 1003	3.61	3.83
	SEm±	**0.05**	**0.04**
	CD at 0.01	**0.16**	**0.11**

*Significant at 1% level of significance

4.2.7 Total sugar (%)

The data pertaining to total sugar among the varieties is highly significant and presented in (Table 4.8 and fig 8).

The variety Youvraj 1003 (3.83 %) followed by Nowara (3.65 %) recorded significantly maximum total sugar content. Lowest total sugar was found in Sheeja (2.48 %). Highly significant and varied results of total sugar in the present study could be attributed to the decreased acidity under lower light intensities causing degradation of acids during ripening and senescence in the polyhouse and genetic makeup of the varieties. Similar results were also reported by, Kumar *et al.* (2007), Caliman *et al.* (2010) and Razzak *et al.* (2013) in tomatoes produced under polyhouse.

4.2.8 Chlorophyll content (SPAD value)

Chlorophyll content differed significantly in different tomato varieties under polyhouse conditions presented in (Table 4.9 and fig 9). Highest chlorophyll content was recorded at 120 DAT in Sheeja (43.50) followed by Youvraj 1003 (41.05), while least chlorophyll content was recorded in Laila (38.55) and variance in chlorophyll content ranged 43.50 to 41.05. In Sheeja had high assimilatory power but poor sink realization was due to less assimilatory distribution towards

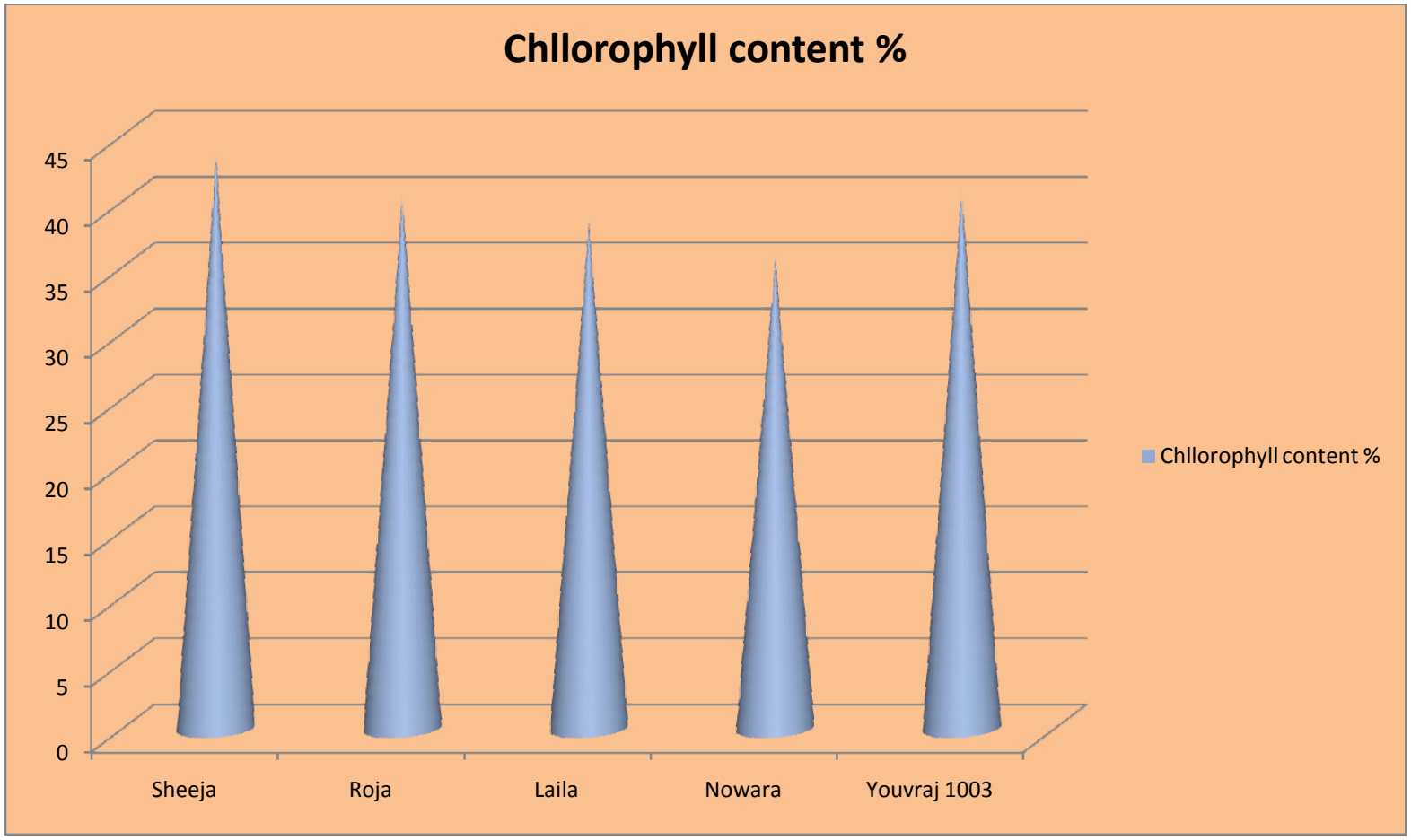

Fig. 9: Variation in Chlorophyll content (%) in tomato grown under polyhouse conditions.

the organs. Table (4.2.4). Chlorophyll fluorescence parameters reported by k. Rohacek (2002).

Table 4.1.9: Chlorophyll content (%) of tomato varieties under protected conditions.

Treatment	Varieties	Chlorophyll contents (%)
1	Sheeja	43.50
2	Roja	40.56
3	Laila	38.55
4	Nowara	35.78
5	Youvraj 1003	41.05
	SEm±	**0.86**
	CD at 0.01	**2.53**

*Significant at 1% level of significance

4.2.9 Number of fruits cluster^{-1}

Highly significant differences exist among different tomato varieties with respect to number of fruits cluster^{-1} presented in (Table 4.10 and Fig.10). The mean of number of fruits cluster^{-1} ranged from 9.27 (Sheeja) to 3.21 (Nowara).

Significantly highest number of fruits cluster^{-1} was recorded by the variety Sheeja (9.27) which is superior to all other genotypes like Laila, Youvraj 1003 and Roja with number of fruits cluster^{-1} of (9.27), (7.50) and (7.15) respectively. Least number of fruits cluster^{-1} was noticed in Nowara (3.21).

The significant variation among genotypes pertaining to number of fruits cluster^{-1} in the present study might be due to the genetic potentiality of varieties responding to the favourable micro climate under polyhouse. The number of fruits truss^{-1} is governed by temperature and solar radiation.

The increase in number of fruits cluster^{-1} might be due to number of flowers cluster^{-1}, higher fruit set percentage and similar results were obtained by Papadopoulos and Ormrod (1991), Sharma *et al.* (2011) and Aguirre and Cabrera (2012) in cherry tomato.

4.2.10 Average fruit yield(kg plant^{-1})

Average fruit yield showed highly significant values among all the tomato varieties presented in (Table 4.10 and fig.10). The mean fruit yield kg plant^{-1} ranged from Laila (6.95 kg plant^{-1}) to Youvraj 1003 (13.03 kg plant^{-1})

Significantly superior fruit yield kg plant^{-1} was recorded in Youvraj 1003 (13.03 kg) followed by Nowara (9.01 kg). Sheeja (9.27 kg) followed by Laila (6.95 kg) had recorded minimum individual fruit yield.

This variation in fruit yield kg plant^{-1} might be due to inverse relationship existing between average fruit weight, and number of fruits cluster^{-1}. This was conformity with the findings of Prema *et al*. (2011), Islam *et al*. (2012). Vooren *et al*. (1986) who opined higher or lower fruit weight may also be ascribed to the varietal characteristics.

4.2.11 Fruit yield (t ha^{-1})

The fruit yield differences among the varieties with respect to fruit yield tone hectare^{-1} were highly significant (Table 4.10 and fig. 10)

The highest fruit yield t ha^{-1} was recorded in the variety Youvraj 1003 (58.54 t ha^{-1}) followed by Sheeja (50.73 t ha^{-1}) but statistically both are at par with each other. The variety, Laila (42.19 t ha^{-1}) has recorded significantly lowest fruit yield hectare^{-1} which is attributed mainly due to the less number of fruiting clusters plant^{-1}, poor fruit set and poor response of these varieties to polyhouse conditions.

The highest fruit yield t ha^{-1} in Youvraj 1003 is attributed to better vegetative growth, early flowering, more number of fruits cluster^{-1}, highest average fruit weight, higher fruit set percentage and taller plants over the other variety. This may be due to the inherent ability of the hybrids and their better response to polyhouse conditions.

Similar reports of better performance of hybrids due to genetic makeup have been reported by Munshi and Kumar (2000), Singh *et al*. (2001), Pandey *et al.* (2006), Arora *et al*. (2007) and Razzak *et al.* (2013) in tomato.

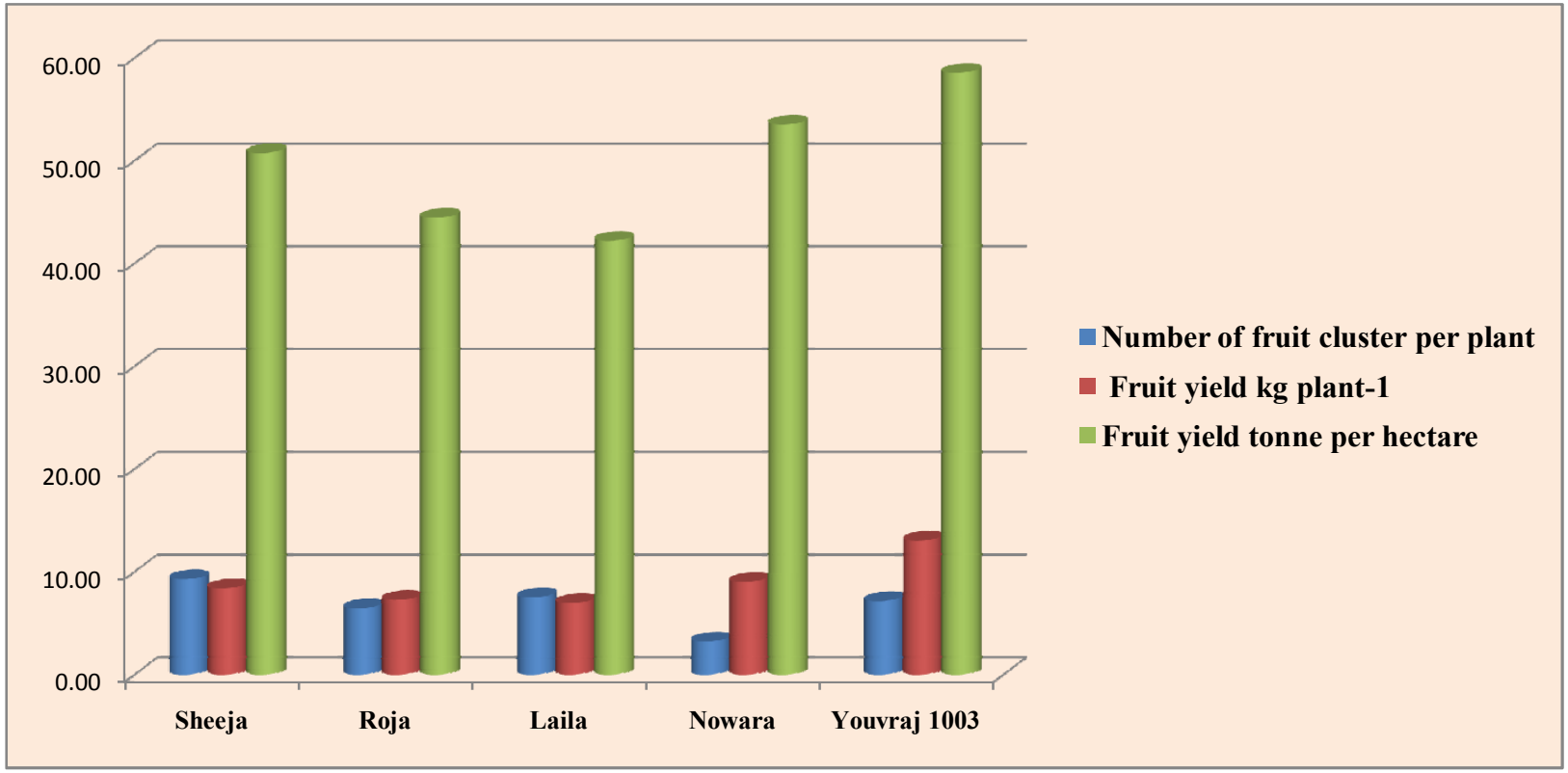

Fig.10: Number of fruit cluster plant^{-1}, Average fruit yield kg plant^{-1} and Fruit yield tone ha^{-1} tomatoes grown in under polyhouse conditions.

Table 4.1.10: Number of fruit cluster plant^{-1}, fruit yield kg plant^{-1} and fruit yield tones ha^{-1}.

Treatment	Varieties	Number of fruit cluster plant^{-1}	Fruit yield plant^{-1}(kg)	Fruit yield tones ha^{-1}
1	Sheeja	9.27	8.39	50.73
2	Roja	6.43	7.25	44.45
3	Laila	7.50	6.95	42.19
4	Nowara	3.21	9.01	53.51
5	Youvraj 1003	7.15	13.03	58.54
	SEm±	**0.29**	**0.23**	**0.35**
	CD at 0.01	**0.87**	**0.67**	**1.03**

*Significant at 1% level of significance

4.3 Correlation analysis

Correlation coefficient is a statistical measure used to know the degree and direction of relationship between two or more variables. The degree of association also affects an effectiveness of the selection process. Thus, correlation indicates the degree of relationship existing among various attributing characters.

Association between fruit yield and its component characters were estimated in all possible combination at different levels.

The phenological and yield correlation coefficients for 17 characters in tomato varieties were presented in (Table 4.11)

4.3.1 Correlation among yield and its components

At varietical level only fruit yield plant^{-1} had significant positive correlation with % (0.917), while it was significantly negative correlated with days to fruit initiation both at level indicating that it was strongly affected the fruit yield plant^{-1}. Leaf area (-0.889) were significantly negative correlated with fruit yield plant^{-1} at genotypic level.

The important findings of the correlation studies are summarized below:

Total fruit yield per plant showed significant positive correlation with leaf area (0.712) similar results were also reported by Abdelmageed *et al*. (2007), Firon *et al*. (2006), Dhanakar *et al*. (2002), Ansary, Hannna *et al*. (1980). Plant height showed highly significant and positive correlation with number of leaves plant^{-1} (0.232), node to first inflorescence (0.215), days to first fruit set (0.372), fruit diameter (0.352), lycopene content (0.865) and total sugar and reducing sugar (0.852, 0.805) while, significantly negative correlation with fruit yield (-0.187) both at phenotypic level. (In indeterminate tomato varieties plant height was negative correlated with yield and other yield increasing characters).

Leaf area showed highly significant positive correlation with number of flower plant $^{-1}$ (0.097), node to first inflorescence (0.300), fruit diameter (0.297), number of fruit cluster plant^{-1}(0.307), starch content (0.395), chlorophyll content (0.626), TSS (0.716), acidity (0.065),ascorbic acid (0.300), reducing sugar (0.021), total sugar (0.110), average fruit yield kg plant^{-1} (0.788) and fruit yield (0.712) while significantly negative correlation with days to first flowering (-0.949),days to first fruit set (-0.951), lycopene content (-0.325) and TSS (-0.485), at different level, Mohamed *et al.* (1997).

Number of flowers plant^{-1} exhibited highly significant positive correlation with node to first inflorescence (0.563), days to first fruit set (0.004), number of fruit cluster plant^{-1} (0.769), starch content (0.578), chlorophyll content (0.774), TSS (0.818) and (0.986) and while high significantly negative correlation with fruit diameter (-0.921) , lycopene content (-0.049), ascorbic acid (-0.682), total sugar (-0.822), reducing sugar (-0.820) average fruit yield kg plant^{-1} (-0.489) and fruit yield (0.553) both at different level. Fenny Dane *et al.* (1991) suggested abundantly flowering and small fruited genotypes were less affected by heat stress. Silva *et al.* (2000), Nainar *et al.* (2004), Ahmadi *et al.* (1979), Goncharova *et al.* (1983) and Sam *et al*. (1993).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Plant height (m)	1																		
Number of leaves plant^{-1}	0.232	1.00																	
Leaf area (cm)^2	-0.334	-0.524	1.00																
Days to first flowering	0.430	0.723	-0.949	1.000															
Number of flowers plant^{-1}	-0.522	0.543	0.097	-0.024	1.00														
Node to first infloresence	0.215	0.340	0.300	-0.196	0.563	1.00													
Days to first fruit set	0.372	0.724	-0.951	0.998	0.004	-0.227	1.00												
Fruit diameter (cm)^2	0.352	-0.730	0.297	-0.348	-0.921	-0.444	-0.374	1.00											
Number of fruit cluster plant-1	-0.616	0.442	0.307	-0.133	0.769	0.175	-0.093	-0.607	1.000										
Starch content (%)	-0.970	-0.104	0.395	-0.415	0.578	-0.171	-0.357	-0.381	0.775	1.00									
Lycopene content %	0.865	0.495	-0.325	0.435	-0.049	0.618	0.380	-0.103	-0.379	-0.835	1.000								
Chlorophyll content %	-0.731	0.103	0.626	-0.527	0.774	0.347	-0.492	-0.491	0.891	0.833	-0.450	1.000							
TSS ^{0}B	-0.307	0.716	-0.485	0.490	0.818	0.310	0.518	-0.973	0.460	0.299	0.108	0.311	1.000						
Acidity%	-0.587	0.563	0.065	0.019	0.986	0.433	0.055	-0.917	0.842	0.658	-0.154	0.796	0.819	1.000					
Ascorbic acid (mg/100 g)	-0.231	-0.763	0.300	-0.395	-0.682	-0.789	-0.379	0.788	-0.218	0.200	-0.677	-0.153	-0.752	-0.599	1.000				
Reducing sugar%	0.852	-0.249	0.021	0.032	-0.820	-0.040	-0.023	0.782	-0.697	-0.834	0.527	-0.692	-0.759	-0.866	0.264	1.000			
Total sugar %	0.805	-0.308	0.110	-0.055	-0.822	-0.044	-0.108	0.820	-0.665	-0.782	0.470	-0.635	-0.812	-0.866	0.318	0.996	1.000		
Average fruit yield kg plant^{-1}	0.010	-0.657	0.788	-0.730	-0.489	-0.152	-0.743	0.780	-0.046	0.060	-0.294	0.141	-0.895	-0.478	0.695	0.487	0.567	1.000	
fruit yield tonne per acare	-0.187	-0.889	0.712	-0.778	-0.553	-0.350	-0.780	0.815	-0.192	0.168	-0.517	0.063	-0.872	-0.538	0.851	0.352	0.430	0.917	1.000

Table 4.1.11: Correlation coefficient analysis among fruit yield and its component trades in tomato varieties under polyhouse conditions

Days to first flowering were highly significant positive correlation with days to first fruit set (0.988) and lycopene content (0.435), TSS (0.490) and acidity (0.019) at genotypic level. while it showed highly negative correlation with number of flower plant^{-1} (- 0.024), node to first inflorescence (-0.196), fruit diameter (-0.348), number of fruit cluster plant^{-1} (-0.133), starch content (-0.415), chlorophyll content (-0.527), ascorbic acid (-0.395), total sugar (-0.055), average fruit yield kg plant^{-1} (-0.730) and total fruit yield (-0.778) while, it showed highly significant negative correlation with different level. Nainar *et al*. (2004).

Node to first inflorescence highly significant positive correlation with number of fruit cluster plant^{-1} (0.175), lycopene content (0.618), chlorophyll content (0.347), TSS (0.818) and acidity (0.433), while it showed significant negative correlation with fruit yield plant^{-1} (-0.350) at environment level, it indicates strong interaction between total sugar and reducing sugar with fruit yield plant^{-1}. While significant negative correlation with fruit yield plant^{-1} (-0.350) at genotypic level. Aida Ali *et al.* (2011).

Days to first fruit set was significant positive correlation with lycopene content (0.380), TSS (0.518) and acidity (0.055) at genotypic level, while it showed negative correlation with number of fruits cluster plant^{-1} (-0.093), starch content (-0.381), chlorophyll content (-0.492), reducing sugar (-0.023), total sugar (-0.044) both at genotypic level. Aida Ali *et al.* (2011).

Starch content show significant negative correlation with lycopene content (-0.835) and reducing sugar (-0.834) at maturity stage. Chlorophyll content was significant positive correlation with average fruit weight (0.060) at genotypic level. Chlorophyll content significant positive correlation with fruit yield plant^{-1}. Lycopene content (mg/100g) didn't significantly correlation with any other characters both at phenotypic and genotypic level. It's a quality parameter, doesn't affect fruit yield plant^{-1}. Heylis *et al.* (2006) and Brandt *et al*. (2006) suggested temperature above 32^{0}C inhibit the synthesis of lycopene content in tomato fruits. Average fruit weight highly significant negative correlation with number of fruits plant-1(-0.517) both at genotypic level, Goncharova *et al.* (1983) reported that fruit thinning increased the

mean weight of remaining fruits. fruit weight was negatively correlated with number of fruits plant^{-1} in tomato.

Number of fruits plant^{-1} showed the highly significant positive correlation with acidity (0.842) both at different level. Abdelmageed *et al.* (2007), Firon *et al* (2006), Silva *et al.* (2000), Nainar *et al.* (2004), Dhanakar *et al*. (2002), Fenne Dane *et al.* (1991), Giordano *et al.* (2005), Ahmed *et al.* (1979), Mohamed *et al.* (1997), Goncharova *et al.* (1983), Sam *et al.* (1993).

CHAPTER – V

SUMMARY AND CONCLUSIONS

5.1 SUMMARY

The investigation entitled "Growth and yield component of tomato (*Solanum lycopersicon* L.) under protected condition" had been conducted at the Research Farm of Center of Excellence on Protected Cultivation and Precision farming, IGKV, Raipur (C.G.) during *kharif* 2016-17. The experiment was laid out in completely randomized design with four replications and five treatments consisting of Sheeja, Roja, Laila, Nowara and Youvraj 1003. The salient findings of the present study summarized below

1. Among the tomato varieties studied, the maximum plant height was recorded at 120 DAT in Laila (312.37cm) followed by Roja (313.30cm).The variety Youvraj 1003 produced significantly highest leaf area 38.59 (cm^2) followed by Sheeja 29.78 (cm^2) but these found are statistically at par with each other.Significantly highest number of leaves was noted in laila (336.75) followed by Roja (284.10).The variety Youvraj 1003 has least Node to first inflorescence (2.80) days and said to be an early varieties followed by Roja (4.45). The earliest fruit set was registered in Youvraj 1003 (41.59 days) and least fruit set laila in (55.12 days). Earliest fruit picking was recorded in the variety Youvraj 1003 (70.05 days) followed by Laila (73.11) and Sheeja (71.03). Fruit diameter (cm) was found maximum in the variety Youvraj 1003 (13.66 cm) and Roja (6.81 cm) due to oval shape of these fruits. The number of cluster $plant^{-1}$ was registered highest in the variety Sheeja (9.27) which is superior over other varieties like Laila, Youvraj 1003, Roja and Nowara. least

number of fruit cluster $^{-1}$ was recorded in Roja (6.43) followed by Nowara (3.21).

2. Significantly highest TSS was recorded in Roja (5.25^{0}B) followed by Sheeja (5.24 ^{0}B), while the lowest TSS was recorded in Youvraj 1003 (4.39 ^{0}B). Significantly high acidity was found maximum in the fruit variety Sheeja (0.81%) followed by Roja (0.77%) and
3. Lowest acidity registered in the variety Nowara (0.62%). Highest lycopene content was exhibssed by Roja (8.33 mg 100 g^{-1}) and lowest lycopene content noted in the variety Sheeja (0.19 mg 100 g^{-1}), it has yellow coloured fruit. Maximum starch content was recorded in Laila (0.24 %) and minimum starch content was recorded in Nowara (0.14 %). The variety Youvraj 1003 (3.83 %) has maximum reducing sugars content and lowest was obtained from Sheeja (2.48 %). Total sugars was highest in the variety Youvraj 1003 (3.83%) and the lowest total sugars was recorded in Sheeja (2.48%). Highest chlorophyll content was recorded in Laila (43.50 %). While least content was in Nowara (35.78%).
4. Significantly highest fruit yield plant^{-1} was recorded in the varietiy Youvraj1003 (13.03 kg) and lowest fruit yield plant^{-1}was noted in Laila (6.95 kg). Superior mean fruit yield (t ha^{-1}) was recorded from Youvraj 1003 (58.54 t ha^{-1}) and significantly lowest fruit yield t ha^{-1} was recorded Laila (42.19 t ha^{-1}).

CONCLUSION

- The results clear indicated that among the varieties of tomato tested Youvraj 1003, performed better as Sheeja, Roja, Laila and Nowara.
- Days to first fruit set, days to first flowering, fruit diameter, yield contributing traits were found relatively better with was found clearly associated with the physiological markers days to first flowering, days to first fruit set and number of fruit per plant.

SUGGESTIONS FOR FUTURE RESEARCH WORK

1. The experimental conclusions are indicative of better findings hence it is suggested that this experiment should be repeated at least for another one year.
2. The varieties should be tested under polyhouse condition to finally verify the varitically stability of varieties.
3. The variety should be screened for their response to different doses of nutrients applied through fertigation amount of nutrients. So that their nutrient uptake ability and utilization can be assessed in a better way.
4. Experiment should be conducted to study the effect of control environment on biochemical aspect TSS, acidity, ascorbic acid, lycopene content, starch content, reducing sugar, total sugar and chlorophyll content.
5. Environmental factor play an important role in plant growth and development. The genotypic traits should be repeated under polyhouse condition of light and photoperiod and their effect on different physiological characters along with yield should be examined.

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Appendix-I

Fortnight meteorological data recorded during the experimental period from September -2016 to April -2017 outside the naturally ventilated polyhouse.

Month/Fortnight	Temperature		Relative humidity (%)		Rain-fall (mm)	Wind speed (km/h)	Evaporation (mm)	Sunshine (hr)
	Max. (^{0}C)	Min. (^{0}C)	I	II				
17-Aug-31	30.88	25.22	90.00	70.73	2.53	5.12	3.49	5.00
01-Sep-15	30.96	24.90	90.80	73.40	13.40	4.40	3.37	1.91
16-Sep-30	31.13	24.75	95.33	78.00	15.10	2.77	4.00	5.10
01-Oct-15	31.16	23.59	94.00	58.40	3.83	1.96	3.38	5.27
16-Oct-30	31.37	18.73	88.53	38.07	0.00	1.43	3.83	9.53
31-Oct-14	30.03	16.79	87.93	38.13	0.00	1.82	3.33	8.29
15-Nov-29	30.12	12.52	87.80	25.87	0.37	1.19	3.16	8.47
30-Nov-14	29.11	13.37	87.09	34.61	0.00	1.62	4.96	7.69
15-Dec-29	27.81	9.37	86.40	25.20	0.00	1.46	4.72	8.01
30-Dec-13	28.22	12.13	81.77	33.33	0.00	1.65	2.88	6.09
14-Jan-28	29.14	12.71	83.80	27.87	0.00	1.55	3.35	7.93
29-Jan-12	31.36	13.42	74.96	27.80	0.00	1.93	4.14	9.18
13-Feb-27	32.55	15.24	74.53	20.67	0.00	2.33	5.34	8.86
28-Feb-14	33.31	17.71	67.60	25.40	0.37	3.07	5.53	8.05
15-Mar-29	34.49	19.87	61.60	15.87	0.00	2.80	7.09	9.01
30-Mar-13	41.09	24.32	43.33	12.73	0.00	4.11	9.51	8.71
14-Apr-28	42.43	25.51	38.27	9.40	0.00	4.95	11.38	9.95

Appendix-II

Fortnight metrological data recorded during the experimental period from September -2016 to April -2017 inside the naturally ventilated polyhouse.

Month/fortnight	Temperature (^{0}C)	Humidity (%)
16-Aug-30	27.45	58.20
31-Aug-14	26.48	55.27
15-Sep-29	27.92	57.00
30-Sep-14	29.33	51.07
15-Oct-29	27.83	56.53
30-Oct-13	29.95	59.53
14-Nov-28	26.71	60.60
29-Nov-13	26.69	62.73
14-Dec-28	28.05	60.33
29-Dec-12	27.48	60.80
13-Jan-27	27.20	59.33
28-Jan-11	30.63	56.33
12-Feb-26	31.41	58.67
27-Feb-13	32.85	59.93
14-Mar-28	34.87	56.67
29-Mar-12	41.50	55.60
13-Apr-27	46.33	20.33

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