"GENETIC DIVERGENCE FOR FRUIT TRAITS IN TOMATO (*Lycopersicon esculentum* Mill)"

M. Sc. (Ag.) THESIS

By

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DEPARTMENT OF HORTICULTURE

COLLEGE OF AGRICULTURE

INDIRA GANDHI KRISHI VISHWAVIDYALAYA

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"GENETIC DIVERGENCE FOR FRUIT TRAITS IN TOMATO (*Lycopersicon esculentum* Mill)"

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CERTIFICATE - I

This is to certify that the thesis entitled **"GENETIC DIVERGENCE FOR FRUIT TRAITS IN TOMATO (*Lycopersicon esculentum* Mill.)"**, submitted in partial fulfilment of the requirements for the degree of **"MASTER OF SCIENCE IN AGRICULTURE"** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **PRAMILA JOGI** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

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

Date: 5-12-07

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CERTIFICATE - II

This is to certify that the thesis entitled **"GENETIC DIVERGENCE FOR FRUIT TRAITS IN TOMATO (*Lycopersicon esculentum* Mill.)''** Submitted by **PRAMILA JOGI** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) in partial fulfilment of the requirements for the degree of "M.SC (Ag)", in the **Department of Horticulture** has been approved by the external examiner and Student's Advisory Committee after oral examination.

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(Pramila Jogi)

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LIST OF ABBREVIATIONS

Abbreviations	Full form
%	Per cent
@	at the rate
°C	Degree Celsius
CD	Critical Difference
cm	Centimeter
CV	Coefficient of variation
DAS	Days after sowing
DAT	Days after transplanting
df	Degree of freedom
et.al.	and co-workers/ and others
Fig.	Figure
FYM	Farm yard manures
g	Gram
GA	Genetic advance
GCV	Genotypic coefficient of variation
ha	hectare
h^2 (b)	Heritability in broad sense
hrs	Hours
i.e.	That is
kg	Kilogram
l	Litre
mm	millimeter
ml	millilitre
m^2	Square meter
MSS	Mean sum of square
No.	Number
NPK	Nitrogen, phosphorus and potassium
NS	Not significant
PCV	Phenotypic coefficient of variation
q	Quintal
q/ha	Quintal per hectare
t	Tonnes
var.	Variety
Via.	Through
Viz.	For example

Introduction

CHAPTER-I

INTRODUCTION

The tomato (*Lycopersicon esculentum* Mill.) is one of the most important solanaceous fruit vegetable crops grown for fresh and processing in the world over, due to its wide adaptability under various agro-climatic conditions. The fruits of omatoes are used for soup, salad, pickles, ketchup, puree, sauces and many other ways. There are various types of flavoring compounds found in the fruits, which enrich the taste. Tomato is very good appetizers and its soup is said to be a good remedy for patients suffering from constipation. The crop is rightly known as an industrial crop because of its outstanding processing quality. It is estimated that only 10 per cent area of vegetable is under the hybrids of which tomato covers 36 per cent. There are several species of tomato but the fruits are edible only of two species namely *L. esculentum* and *L. pimpinellifolium*. All the species of tomato are native of Western South America (Rick, 1976). Tomato is rich source of minerals, vitamins and organic acid and the fruit provides 3-4% total sugar, 4-7% total solids, 15-30 mg/100 g ascorbic acid, 7.5-10 mg/100 ml tritrable acidity and 20-50 mg/100 g fruit weight of lycopene.

Tomato is the largest vegetable crop after potato and sweet potato in the world with an area of 4,550,719 ha, production 125,015,792 mt and productivity 27471 kg/ha. In India tomato occupies an area of 540,000 ha with production of 7,600,00 mt and productivity of 14074 kg/ha. Whereas in Chhattisgarh, tomato

occupies an area of 20,000 ha with production of 3,02000 mt and productivity of 15100 kg/ha which is very low against the world productivity (Anon,2005).

Due to a large number of open- pollinated varieties under cultivation, the area of suitable and high -yielding F_1 hybrids of tomato are very limited for various fruit traits. A very little work has been done to evaluate the high- yielding varieties in this state. The information is also scanty as regards to suitability of new promising varieties under Chhattisgarh plains.

Hence, there is an urgent need of systematic breeding approach to develop suitable and high-yielding hybrids with desirable fruit characters for Chhattisgarh plains. A knowledge of genetic diversity, its nature and degree is very much useful for selecting parents from large number of available varieties/genotypes being released from different research organization for the successful breeding programme.

Tomato being a classical experimental material of plant breeding on account of its highly self- pollinated nature, easy in crossing with varieties and some wild species, large number of seeds per fruit, easily grown under varied climatic conditions, shorter duration, photo- insensitivity and high mutagenic responsiveness. The scope of improvement in tomato is based on the extent of genotypic and phenotypic variability in the material, more is the genetic potential and there will be greater chances of producing a desired type. The study of genetic diversity among the existing genetic stocks provides an opportunity for selecting the diverse parents for hybridization and D^2 statistics has been found to be powerful and is an effective tool in estimating genetic divergence among

biological populations. The clustering pattern obtained could be utilized in choosing parental combinations for a prospective breeding programme to generate the highest possible variability in fruit yield components for available genetic material. Therefore, the present investigation entitled " Genetic divergence for fruit traits in tomato (*Lycopersicon esculentum* Mill.)" was initiated with the following objectives:

1. To asses the genetic diversity among different genotypes of tomato.
2. To estimate the nature and extent of variability in the available open pollinated varieties for fruit characteristics and fruit yield.
3. To estimate the heritability and genetic advance for fruit yield and quality traits.
4. To establish the inter relationship among fruit yield contributing traits and to asses direct and indirect contribution towards fruit yield and quality components.
5. To isolate suitable genotypes for Chhattisgarh plains.

Review of Literature

CHAPTER -II

REVIEW OF LITERATURE

A sincere effort has been made to collect the available literature on the topic "Genetic divergence for fruit traits in tomato (*Lycopersicon esculentum* Mill.)" and has been reviewed in this chapter under the following heads:

2.1 Phenotypic and genotypic coefficient of variation

2.2 Heritability

2.3 Correlation studies

2.4 Path coefficient analysis

2.5 Genetic divergence

2.1 Phenotypic and genotypic coefficient of variation

For improvement of any crop, it is foremost step to study existing variability amongst available germplasm. Partitioning of observed variation is prerequisite to get a clear idea about the variability. So, a knowledge of the genetic variability and genetic advance being useful in designing selection procedure to a segregating and variable population.

Rattan *et al.* (1983) reported that the genotypic coefficient of variation was higher for fruit weight, seed percentage, number of fruits per plant, ascorbic acid content, fruit length, fruit breadth, fruit yield per plant, mesocarp thickness, acidity and lowest for juice percentage in tomato.

Prasad and Rai (1999) conducted an experiment on seventy-five exotic genotypes of tomato at Namkum, Ranchi and found considerably high amount

of phenotypic and genotypic coefficient of variation for plot yield, plant height, fruit firmness, total soluble solids (TSS) and number of locules.

Singh and Gopalkrishnan (2000) reported that genotypic and phenotypic coefficient of variation was maximum for number of fruits per plant and fruit yield per plant in brinjal.

Singh *et al.* (2002) at Ludhiana, conducted an experiment on fifteen heat -tolerant tomato genotypes and reported high phenotypic (PCV) and genotypic (GCV) coefficient of variation for average fruit weight, shelf life of ripe red fruits, total fruit yield and marketable yield, but were moderate for days from fruit setting to mature green stage and shelf life of mature green fruits. In all the traits, GCV was lower than PCV, indicating the role of the environment in the expression of these characters.

Joshi and Kohli (2003) conducted an experiment in seventy-three genotypes at Nauni, Solan, H.P. and recorded maximum value of coefficient of variability for shelf life of fruit, while it was minimum for days to first picking.

Joshi *et al.* (2004) conducted an experiment at Solan, H. P. on thirty-seven tomato genotypes and observed highest coefficient of variation (genotypic and phenotypic) for shelf life.

Kumar *et al.* (2004) conducted an experiment in Uttar Pradesh on thirty tomato genotypes and observed highest genotypic and phenotypic coefficient of variation alongwith high genetic advance which indicated that it was less affected by the environment and these characters may be improved directly through simple selection.

Karasawa *et al.* (2005) studied genetic divergence among seventy-tomato accession at Brazil. A significant variation among the accession was recorded for total number of fruits, total fruit weight, mean number of fruits, mean fruit weight, fruit length, fruit diameter, number days to germination, number of days to fruit set, number of flower per inflorescence, soluble solid content, number of locules and number of days to flowering, indicating significant genetic variation among the accessions.

Ahmed *et al.* (2006) studied genetic variability for fourteen traits in sixty genotypes, including F_1 hybrids of tomato grown in Srinagar, J and K and reported high phenotypic (PCV) and genotypic (GCV) coefficient of variances for fruit yield per plant, plant height, average fruit weight, juice to pulp ratio and number of fruits per plant.

Mahesha *et al.* (2006a) at Dapoli, Ratnagiri conducted an experiment on thirty genotypes of tomato and reported wide range of variation for plant height, number of branches per plant, fruit weight, fruit length, fruit diameter, number of locules per fruit, fruit set percentage, number of fruits per plant, ascorbic acid content and total soluble solids.

Singh *et al.* (2006) at Dholi, Bihar, India evaluated nineteen genotypes of tomato and observed considerable range of genetic variability for fruit yield, quality components alongwith biochemical characters in the materials under study. Maximum genotypic coefficient of variation was recorded for number of leaves per plant followed by number of clusters per plant.

2.2 Heritability

Heritability estimate provides the information regarding the amount of transmissible genetic variation to total variation and determines genetic improvement and response to selection.

The estimate of genetic advance in percentage of mean provides more reliable information regarding the effectiveness of selection in improving a trait. Thus, the estimates of habitability and genetic advance are of great significance to the plant breeders for developing suitable selection strategy

The term heritability in broad sense was defined as the ratio of genetic variance to the total phenotypic variance (Lush, 1940; Jhonson *et al.*, 1955).

Sahu and Mishra (1995) conducted an experiment on sixteen tomato lines at Bhubaneshwar and showed that there were significant differences among the lines for all the characters. Fruit yield per plant, number of fruits per plant, number of flower clusters per plant and fruit weight had high value of heritability.

Prasad and Rai (1999) conducted an experiment on seventy five exotic genotypes of tomato at IIVR, Ranchi and observed very high heritability estimates along with high genetic advance for fruit weight, fruit length, fruit breadth and pulp thickness due to additive gene effect.

Singh *et al.* (2002) evaluated fifteen heat- tolerant tomato cultivars in Ludhiana, Punjab and reported high heritability for days to anthesis, days from fruit setting to mature green stage, average fruit weight, total fruit yield, shelf life of mature green fruits and shelf life of ripe red fruits except days from fruit

setting to red ripe stage. The high genetic advance was predicted for average fruit weight, followed by shelf life of ripe fruits.

Mariame *et al.* (2003) at Ethiopia conducted an experiment on twenty-one fresh market tomato genotypes and recorded high heritability estimates coupled with high genetic advance as per cent of mean for plant height, number of nodes on main stem, number of flowers per cluster, number of fruits per plant and number of seeds per fruit, Which revealed that simple selection may improve these traits.

Joshi *et al.* (2004) evaluated fifteen heat- tolerant tomato cultivars at Ludhiana, Punjab and reported moderate heritability and moderate genetic gain for number of fruits per cluster, fruit length, fruit breadth, number of locules per fruit, whole fruit firmness, ascorbic acid content and plant height indicating additive gene effects. Low heritability and low genetic gain was observed for pericarp thickness.

Kumar *et al.* (2004) conducted an experiment in Uttar Pradesh on thirty tomato genotypes and reported that the average fruit weight showed high heritabilities that ranged from 89.10 to 96.50%.

Singh *et al.* (2005) conducted an experiment on fifteen advance generation breeding lines of tomato including four control cultivars at Lucknow, India and estimated high heritability for total soluble solids (TSS), pericarp thickness, fruit firmness, acidity and dry matter content except lycopene content.

Ahmed *et al.* (2006) at Srinagar, J and K, India studied genetic variability for fourteen traits in sixty genotypes, including F_1 hybrids and recorded high estimates of heritability for all characters except fruit pH. High heritability with high genetic advance as per cent of mean was observed for juice to pulp ratio, fruit yield per plant, average fruit weight, acidity, number of fruits per plant, fruit length and earliness.

Mahesha *et al.* (2006a) conducted an experiment at Dapoli, Ratnagiri, India on thirty genotypes of tomato and observed that fruit weight, number of fruits per plant and plant height exhibited very high heritability values alongwith high genetic gain.

Singh *et al.* (2006) at Dholi, Bihar evaluated nineteen genotypes of tomato and estimated high heritability for ascorbic acid content, average weight of fruits, number of leaves per plant, number of locules per fruit, number of fruits per plant, leaf area and dry matter content. High estimates of heritability with high genetic advance was recorded in case of leaves per plant, average weight of fruits, number of fruits per plant and plant height, whereas high heritability with low genetic advance was recorded for number of locules per fruit, dry matter content, pericarp thickness and fruit yield per plant.

2.3 Correlation studies

The necessity of coefficient of correlation to describe the degree of association between independent and dependent variables was first suggested by Galton in 1888 and its theory was developed by Pearson in 1904. The

mathematical utilization at phenotypic, genotypic and environmental levels was described by Searle (1961).

Bodunde, (2002) at Nigeria reported that the number of leaves at flowering, plant height and fruit diameter directly affected fruit yield. They also reported that the five traits were directly responsible for the determination of fruit yield in tomato.

Singh *et al.* (2002) evaluated fifteen heat-tolerant tomato cultivars in Ludhiana, Punjab and observed that total fruit yield was significantly and positively correlated with marketable yield, average fruit weight and days from fruit setting to ripe red stage. The positive and highly significant correlation of average fruit weight with the shelf life of mature green and ripe red fruits indicated that large fruits had better shelf life than small fruits.

Joshi *et al.* (2004) conducted an experiment at Solan, Himachal Pradesh on thirty-seven tomato genotypes and concluded that the fruit yield per plant was positively and significantly correlated with average fruit weight, fruit length, plant height and harvest duration. The average fruit weight was positively correlated with fruit length, fruit breadth, stem end scar size, pericarp thickness, whole fruit firmness and shelf life of the fruits. However, the fruit weight was negatively correlated with the number of fruits per plant, number of fruits per cluster and ascorbic acid content.

Padma *et al.* (2002) conducted an experiment on correlation analysis for fruit yield components of six tomato cultivars grown in Bapatla, Andhra Pradesh and observed that the association between fruit weight and fruit

volume, skin thickness and fruit length, fruit diameter and fruit volume, fruit yield per plant and fruit weight, plant height and number of branches, plant height and number of fruits per plant, fruit diameter and fruit length, fruit diameter and fruit weight, fruit volume and fruit weight and total soluble solid (TSS) content and number of fruits per plant was positive and highly significant. A negative correlation was observed between fruit weight and fruit number, plant height and fruit weight, fruit weight and TSS content, fruit yield and plant height. However, Fruit weight had the greatest direct effect on fruit yield.

Singh *et al.* (2002) evaluated fifteen heat-tolerant tomato cultivars in Ludhiana, Punjab and concluded that total fruit yield was significantly and positively correlated with marketable fruit yield, average fruit weight and days from fruit setting to red ripe stage. The positive and highly significant correlation of average fruit weight with shelf life of mature green and ripe red fruits indicated that large fruits had better shelf life than small fruits.

Mohanty (2002) conducted an experiment on eighteen indigenous and exotic genotypes of tomato at Hisar, India and reported significant and negative correlation of fruit yield with plant height and average fruit weight. Number of fruits per plant was inversely related with average fruit weight.

Kumar *et al.* (2003) conducted an experiment on thirty diverse tomato genotypes at Solan, Himachal Pradesh and reported that the correlation coefficients at genotypic level generally higher than the corresponding phenotypic ones. Fruit yield per plant was positively and significantly

associated with plant height, fruit number per plant, fruit shape index and pericarp thickness.

Lakshmikant and Mani (2004) conducted an experiment on nineteen genotypes of tomato for estimation of correlation coefficient at Hawalbagh, Uttar Pradesh and reported that the fruit yield had significant and positive correlation with fruits per plant, number of primary branches, plant height and fruit per bunch.

Singh *et al.* (2004) conducted an experiment on ninety-two tomato genotypes at Pantnagar and reported that the number of fruits per plant and number of fruits per cluster showed a highly significant and positive correlation with fruit yield. Similarly, there was a negative correlation between the number of fruits per cluster and average weight per fruit. Plant height was positively correlated with days to 50% flowering, days to first fruit set, number of fruits per plant and total soluble solids.

Singh *et al.* (2006) conducted an experiment at Ludhiana on fifteen advanced breeding lines of tomato alongwith four checks and reported positive and significant correlation with total fruit yield, number of fruits per plant, fruit weight and days from transplanting to first fruit maturity. The pericarp thickness was highly significantly and positively correlated with shelf life of fruits.

2.4 Path coefficient analysis

The concept of path coefficient analysis was originally developed by Wright in 1921, but the technique was first used for plant selection by Dewey

and Lu (1959). Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects. In other hands, it measures the direct and indirect contribution of various independent characters on a dependent character.

Verma and sarnaik (2000) computed path coefficient analysis using thirty genotypes for eighteen characters at Raipur and observed that number of fruits per plant, average weight of fruit, thousand seed weight and number of branches per plant exhibited positive as well high direct effects. Therefore, these traits may be considered, while selecting the genotype for high fruit yield potential.

Bodunde (2002) at Nigeria reported that the number of leaves at flowering, plant height and fruit diameter directly affected fruit yield. They also reported that the number of leaves at flowering, plant height at first harvest, fruit diameter, fruit length and days to maturity were directly responsible for the determination of fruit yield in tomato.

Mohanty (2002) conducted an experiment on eighteen indigenous and exotic genotypes of tomato at Hisar, India and observed that number of branches per plant and average fruit weight exerted high positive direct effect on fruit yield and high positive indirect effect with each other.

Joshi *et al.* (2004)evaluated thirty-seven tomato genotypes at Solan, H.P. and reported that path coefficient analysis showed that the number of fruits per plant is the most important fruit- yield contributing traits followed by fruit length, fruit breadth and plant height.

Lakshmi-Kant and Mani (2004) at Hawalbagh, U. P. studied nineteen genotypes of tomato and indicated the importance of fruits per plant, fruit width, days to 50% flowering and fruits per bunch as these characters showed the highest direct effect on fruit yield.

Padma *et al.* (2002) conducted an experiment at Bapatla, A. P. on correlation and path analysis for fruit yield components of six tomato cultivars and reported that number of branches, dry matter production, fruit weight, fruit length, fruit volume, total soluble solid (TSS), juice percentage and number of fruits per plant exhibited direct effect on fruit yield per plant at the genotypic and phenotypic level.

Singh *et al.* (2004) conducted an experiment at Pant Nagar on path coefficient analysis with ninety-two tomato genotypes and reported positive direct effect of number of fruits per plant on fruit yield followed by fruit diameter, average fruit weight per fruit, fruit length, days to 50% flowering, number of fruits per cluster and days to first harvest.

Singh *et al.* (2006) conducted an experiment at Ludhiana on fifteen advanced breeding lines of tomato alongwith four checks and observed that total fruit yield per plant, number of fruit per plant and fruit weight had exerted positive and direct effect on marketable fruit yield per plant. Days for transplanting to first fruit maturity was involved indirectly in the improvement of marketable yield per plant.

2.5 Genetic divergence

The concept of D^2 statistics was originally developed by P.C. Mahalonobis (1936). Then C.R. Rao (1952) suggested the application of this technique for the arrangement of genetic diversity in plant breeding. Now, this technique is extensively used in vegetable breeding for the study of genetic divergence in the various breeding material including germplasm. This analysis also helps in the selection of diverse parents for the development of hybrids.

Gadenar *et al.* (1992) reported that the D^2 values were ranged from 37.77 to 5145.47. The lowest value was shown by a pair of strains 'NE 275' and 'N 100' while the highest value was recorded by the pair of 'EC-118277' and 'Metabo', which were the least and most divergent strains, respectively.

Bhattacharya *et al.* (1993) observed among the fifty tomato genotypes and reported that the cluster including the pear-shaped cultivars were disposed distinctly apart from the clusters including round-fruited cultivars.

Amaral *et al.* (1997) at Brazil conducted an experiment on genetic divergence and found that the efficiency in predicting the behaviour of tomato hybrids based on parents' genetic divergence which was evaluated via D^2 analysis of data on fifteen characteristics (ten related to morphological and agronomic aspects, and five to fruit quality) in five parents (Clara, Jumbo AG 592, Angela I5100, IPA 05 and Floradade) and their hybrids. Almost all correlations between D^2 and hybrid population means, heterosis and combining abilities were positive, indicating that genetic divergence is a very efficient parameter for hybrids behaviour prediction.

Rai *et al.* (1998) assessed thirty-seven tomato genotypes at Raipur, India and reported that the clustering pattern indicates that there was no association between geographical distribution of genotypes and genetic divergence. The genetic drift and selection in different environments can produce greater diversity than geographical distance. The characters, number of primary branches, longitudinal fruit length, days to flowering, pericarp thickness, plant height and average fruit weight contributed to maximum divergence and played a major role in the improvement of tomato fruit yield.

Dharmatti *et al.* (2001) at Dharwad, Karnataka conducted an experiment on genetic divergence in a four hundred two tomato lines and observed that cluster II was the most divergent consisting of fifty one genotypes/hybrids with potato leaf types and pink fruits, which exhibited field tolerance to TLCV. Cluster III and IV had ninety-nine and thirty-five genotypes, respectively. Considerable diversity within and between the clusters was noted, and it was observed that the characters TLCV resistance, fruit yield per plant and number of whiteflies per plant-contributed maximum to the divergence.

Sharma and verma (2001) at HPKV Bajaura, H.P. studied eighteen genotypes of tomato for genetic divergence and observed fruit yield per plant, pericarp thickness and fruit diameter played an important role in divergence between the populations. Therefore, the selection for divergent parents based on these characters will prove useful for heterosis breeding in tomato.

Joshi and Kohli (2003) conducted an experiment at Solan, H.P. on genetic divergence by cluster analysis in seventy-three tomato genotypes and reported maximum value of coefficient of variability for shelf life of fruits while, it was minimum for days to first picking. The grouping of the genotypes into fifteen clusters indicated the presence of wide range of genetic diversity among the genotypes. Genotypes belonging to cluster V and VI were highly diverse from each other. The mean fruit yield per plant and average fruit weight were highest in cluster V and III, respectively. The plant height and harvest duration were maximum in cluster XV. The highest mean value of fruit firmness, shelf life and lowest number of locules was recorded in cluster IX. However, cluster VI showed the highest ascorbic acid content and number of fruits per cluster. The minimum value for days to first picking and stem end scar size was recorded in cluster IX and VI, respectively.

Mahesha *et al.* (2006 b) conducted an experiment at Dapoli, Ratnagiri , on thirty genetically diverse genotypes of tomato and grouped the genotypes into nine clusters. The maximum number of genotypes indicated that days to 50 per cent flowering, plant height, number of branches per plant, number of clusters per plant, number of fruits per clusters, fruit weight, fruit length, fruit diameter, number of locules per fruit, number of seeds per fruit, fruit set percentage, fruits per plant and fruit yield per plant were important characters towards the maximum genetic divergence. The maximum genetic distance was observed between clusters VI and IX, whereas it was maximum between cluster IV and I.

Materials and Methods

CHAPTER –III

MATERIALS AND METHOD

This chapter deals with a concise description of the materials used and methods adopted in carrying out the present investigation entitled "Genetic divergence for fruit traits in tomato (*Lycopersicon esculentum* Mill.)". The investigation was conducted during *rabi season* during the year 2006 at All India Coordinated Vegetable Improvement Project, Horticultural farm, Department of Horticulture, Indira Gandhi Krishi Vishwa Vidyalaya, Raipur (C.G.).

3.1 Geographical Situation

Raipur is situated in mid eastern part of Chhattisgarh at latitude 21°16'N, longitude 81°36'E and at an altitude of 298 metres above the mean sea level.

3.2 Agro-climatic condition

The general climate prevailing in the district Raipur of Chhattisgarh region is dry sub-humid type with annual rainfall varying from 1200 to 1400 mm. The temperature reaches upto maximum of 45°C and minimum temperature during winter may go down to 8°C in Raipur. May is the hottest and December is the coolest month of the year.

The weather data recorded during the period of investigation from sowing to harvesting are presented in Table 3.1 and graphically depicted in fig 3.1.

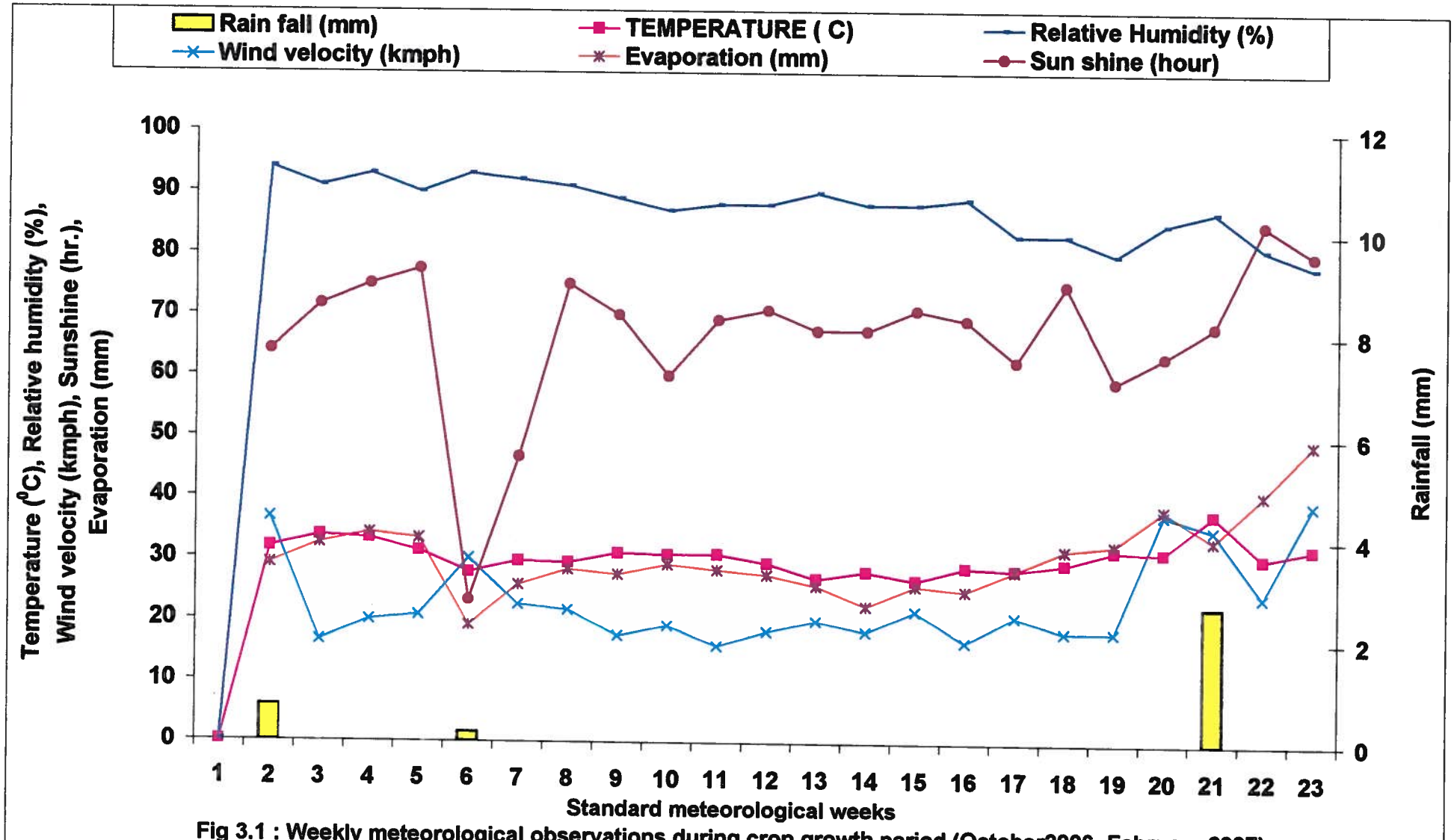


Fig 3.1 : Weekly meteorological observations during crop growth period (October2006- February 2007)

3.3: Field preparation

The preparation of field was done by tractor-drawn cultivator followed by two cross-harrowing to pulverize the soil. To enrich the soil, well-rotten FYM @ 25 t/ha was applied before harrowing and well-mixed with the soil by planking. Finally, the field was levelled with planker and then experiment was laid out.

3.4 Experimental details

The experiment consists of twenty-eight genotypes of tomato, which was laid out in randomized block design with three replications. Details of treatment are given below:

S.No.	Treatments/ Genotypes	Notation	Source
1	SC-3	V1	Sungro Seeds Pvt. Ltd., Delhi
2	Local-2	V2	O.P.V. from local market
3	Uday PGT-II	V3	O.P.V. from local market
4	Sarvodaya	V4	Century seeds Pvt.Ltd., New Delhi
5	S-22	V5	Nunhems India Pvt. Ltd., Hyderabad (A.P.)
6	RK-318	V6	O.P.V. from local market
7	S-22 (U.P.)	V7	O.P.V. from local market
8	S-21	V8	Golden Seeds, Bangalore.
9	Navodaya	V9	O.P.V. from local market
10	Punjab Kesary	V10	Promod Seeds Comp., Faizabad (U.P.)
11	PKM-1	V11	Century seeds Pvt.Ltd., New Delhi
12	C-21	V12	Century seeds Pvt.Ltd., New Delhi
13	Pusa Early Dwarf	V13	IARI, New Delhi
14	Pant-T-7	V14	G.B.P.U.A. and T., Pantnagar

S.No.	Treatments/ Genotypes	Notation	Source
15	RCMT-2	V15	Barapani
16	RCMT-1	V16	Barapani
17	JTP-02-09	V17	Junagarh
18	Pant-T-3	V18	G.B.P.U.A. and T., Pantnagar
19	Pant-T-8	V19	G.B.P.U.A. and T., Pantnagar
20	Improved Shalimar	V20	Shrinagar
21	KS-229	V21	C.S.A.U. and T., Kalyanpur (Kanpur)
22	KS-227	V22	C.S.A.U. and T., Kalyanpur (Kanpur
23	ALT-02-39	V23	G.A.U., S.K. Nagar (Gujarat)
24	VR-20	V24	IIVR, Varanasi (U.P.)
25	JTP-02-07	V2	Junagarh
26	Pusa Ruby	V26	IARI, New Delhi
27	DVRT-2	V27	IIVR, Varanasi (U.P.)
28	CO-3	V28	TNAU, Coimbatore (T.N.)

3.5 Nursery raising

The nursery beds of 10 m x 1m x 0.15 m were prepared on well-ploughed and levelled field at 30 cm distance between two beds. A well-rotten cow dung manure @ 30 kg per 5.0 m long and 1.0 m wide nursery bed was well mixed in the soil with the help of spade. The seeds of each genotype were treated with thiram @ 2.5 g per kg of seeds before sowing and then sown in lines 10 cm apart @ 500 g seeds per ha. A gap of 10 cm was kept in between two genotypes sown in the nursery bed. After sowing, the seeds were covered by sieved well-rotten FYM. The bed was covered with the dry grass and it was irrigated with the help of water can. The grass covered on the nursery bed was

removed immediately after germination. To protect the seedling from damping off disease drenching was done with 2.5 g diathane M-45 per litre of water at ten days interval after germination. The spraying of Nuvacron @2.0 ml per litre of water was done on tenth day for insect protection.

3.6 Transplanting

The healthy seedlings of 30 days were transplanted in the experimental plot on October 28,2006 at the spacing of 60 cm between rows and 40 cm between plant to plant. A plot size of 4.2m x 3.5m was kept for each genotype.

3.7 Fertilizer application

The recommended doses of fertilizer viz., 100 kg N, 90 kg P_2O_5 and 60 kg K_2O per ha was applied through urea, single super phosphate and muriate of potash, respectively. A half dose of nitrogen and full dose of phosphorus and potash were applied in two equal splits at 30 and 60 days after transplanting (DAT).

3.8 Irrigation

The nursery bed was irrigated one day before transplanting (October 27, 2006) to uproot the seedlings conveniently. Later on, one irrigation was applied just after the transplanting of seedlings in the experimental plots. Subsequent six irrigations were applied as per the need of the crop. Frequent irrigation was given at winter season to avoid cold damage.

3.9 Intercultural operations

The weeds were completely removed at the time of field preparation. At later growth stages, two hand weedings at 15 and 45 DAT (days after transplanting) were sufficient to keep the plot free from weeds.

3.10 Staking

The staking of tomato plant was done by 1m long and 3cm wide bamboo stick which was inserted into ground near the plant and bamboo stick was loosely tied with ropes at 3-4 places.

3.11 Plant protection measures

Adequate plant protection measures were adopted to control the major insect pests during crop period. To control the infestation of early blight disease and insects, spraying of 0.25% Dithane M-45 @ 1.25 kg per ha and Nuvacron @ 2 ml per litre was done at 15 days interval till flowering.

3.12 Harvesting

The picking of fruits was done at the turning stage of the fruits. In all, eight pickings were undertaken. Picking of fruits was done at an interval of 10 to 15 days.

Fruits of 10 plants selected randomly were picked up separately for studying the various yield and quality attributes. The weight of fruits recorded from each net plot was converted into quintal per ha.

3.13 Observations:

3.13.1 Growth characters

3.13.1.1 Plant height (cm)

The plant height of five randomly selected plants were recorded with the help of a metre scale from the base of the plant to the shoot tip at the final picking and the average height (cm) per plant was calculated.

3.13.1.2 Number of primary branches per plant

The total number of primary branches of five randomly selected plants were counted and averaged at the time of final picking.

3.13.2 Flowering and physical characters of fruits

3.13.2.1 Days to 50% flowering

Each plot was daily observed to record the date of 50% flowering. The period from the transplanting date to the date of 50% flowering was recorded and expressed in number of days, when 50% plants of the plot bloomed. The average values per genotypes were calculated on plot basis.

3.13.2.2 Fruit weight (g)

The weight (g) of five randomly selected ripened fruits of each genotype in each replication was recorded and then average fruit weight was calculated.

3.13.2.3 Fruit length (cm)

Five randomly selected fruits of each genotype were measured for fruit length (cm) with the help of vernier calipers and the average was calculated.

3.13.2.4 Fruit width (cm)

Five randomly selected fruits of each genotype were measured for fruit width (cm) with the help of vernier calipers and the average was calculated.

3.13.2.5 Number of locules per fruit

Three ripe fruits were randomly selected. The fruits were cut transversely and locules were counted in each fruit, then average number of locules per fruit was calculated.

3.13.2.6 Pericarp thickness (mm)

Three fruits were selected randomly from each genotype and cut transversely. The pericarp thickness (mm) was measured with the help of a vernier calipers and then averaged.

3.13.3 Quality characters of fruits

3.13.3.1 Total soluble solid (T.S.S.)

From each genotypes of each replication, ten fruits were randomly drawn from the harvested lot and thoroughly washed with tap water. The fruits were cut into pieces and squeezed to obtain the juice and determine T.S.S. per cent with the help of Erma hand refractometer.

3.13.3.2 pH

With the help of a pH meter, pH of the fruit juice extracted from five randomly selected fruits from each of the genotype was determined and the average was calculated.

3.13.3.3 Acidity (%)

The acidity was determined by the method described by Ranganna (1997).

3.13.3.4 Reducing sugar (%)

Reducing sugar was determined by the method of Lane and Eynon as described by Ranganna (1986).

3.13.4 Fruit yield

3.13.4.1 Fruit yield per plant (kg)

The weight of fruits of five selected plants was recorded at each picking and the total weight of fruits was calculated in kilograms.

3.13.4.2 Fruit yield (q/ha)

The fruit yield in q/ha was worked out with the help of the following formula

$$\text{Yield (q/ha)} = \frac{\text{Weight of fruit (kg per plot)}}{\text{Net plot area (sq.m.)}} \times \frac{10000}{100}$$

3.14. Statistical and Biometrical analysis

3.14.1 Analysis of variance

The data collected from different characters were processed and analysed by the method of analysis of variance as derived by Panse and Sukhatme (1967).

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F value	
				Calculated	Tabulated at 5% and 1%
Replication	(r-1)	SS_r	MS_r	MSr / MS_e *Significant at 5%	
Treatment	(t-1)	SS_t	MS_t	$M S_t / MS_e$**Significant at 1%	
Error	(r-1)(t-1)	SS_e	MS_e		
Total	(rt-1)				

Where,

r = Replication

t = Treatments

SS_r = Replication sum of squares

SS_t = Treatment sum of squares

SS_e = Error sum of squares

MS_r = Replication mean sum of squares

MS_t = Treatment mean sum of squares

MS_e = Error mean sum of squares

3.14.2 Biometrical parameter of variation

3.14.2.1 Range

The range of distribution was expressed by the limit of the smallest and the largest value of each observation.

3.14.2.2 Mean

This mean was found by summing up all the observations and dividing the sum by the number of observations.

3.14.2.3 Heritability

Heritability in broad sense (h^2) is defined as the properties of the genotypic variance to the total variance (phenotypic variance). This was estimated by using the formula given by Burton and De Vane (1953).

$$h^2 \text{ (bs) } \% = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where, $\sigma^2 g$ Genotypic variance

$\sigma^2 p$ Phenotypic variance

3.14.2.4 Genetic advance

Expected genetic advance (GA) was calculated as per the method suggested by Johnson *et al.* (1955).

$$GA = K. \sigma p h^2$$

Where,

K = Constant (standard selection differential) having value of 2.06 at 5% selection intensity

σp = Phenotypic standard deviation

h^2 (bs) = Heritability estimates in broad sense

3.14.2.5 Genetic advance as percentage of mean

Genetic advance as percentage of mean was calculated by the following formula:

$$\text{Genetic advance as \% of mean} = \frac{\text{G. A.}}{\bar{X}} \times 100$$

Where,

G. A. = Genetic advance

$\bar{X}$ = Mean of the character

3.14.2.6 Genotypic and phenotypic coefficient of variation

The genotypic and phenotypic coefficients of variation were calculated using formula as suggested by Burton (1952).

$$\text{GCV (\%)} = \frac{\sqrt{\text{Genotypic variance}}}{\bar{X}} \times 100$$

$$\text{PCV (\%)} = \frac{\sqrt{\text{Phenotypic variance}}}{\bar{X}} \times 100$$

Where,

GCV = Genotypic coefficient of variation

PCV = Phenotypic coefficient of variation

$\overline{X}$ = Mean of the character

3.14.3 Character association (Correlation coefficient)

Correlation coefficient (r) were calculated for all possible combination of fruit yield and its component parameters by using the standard procedure given by Searle (1961).

$$r_{(x,y)} = \frac{Cov.(x,y)}{\sqrt{Var(x) \cdot Var(y)}}$$

where,

$r_{(x,y)}$ = Correlation coefficient between character x and y

var(x) = Variance of x character

Var(y) = Variance of y character

3.14.4 Test of significance

Phenotypic and genotypic coefficients were tested for their significance 't' test as follows

$$t_c = r\sqrt{\frac{n-2}{1-r^2}}$$

at (n -2) degree of freedom

where, n = Number of genotype

If 't' calculated (t_c) is greater than 't' tabulated (t_t) at (n -2) degree of freedom at given probability level the phenotypic correlation is taken as significant.

The calculated (r) is then compared with table value of 'r' at 5% and 1% level of significance (Snedecor and Cochran, 1967).

3.14.5 Path-coefficient analysis

The genotypic correlation coefficients were further partitioned into direct and indirect effects with the help of path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959). Path coefficient was calculated separately for all important characters considering fruit yield as dependable variable.

Path-coefficient was estimated using simultaneous equations and the equations showed a basic relationship between correlation coefficient and path-coefficient. These equations were solved by presenting them in matrix notations.

$$A = B.C$$

The solution for the vector 'C' may be obtained by multiplying both sides by inverts of 'B' matrix *i.e.* $B^{-1}.A = C$. After calculation of values of path-coefficient *i.e.* 'C' vector, it is possible to obtain path values for residual (R). Residual effect was calculated using formula from Singh and Chaudhary (1985).

$$R = \sqrt{1 - \sum di \times r_{ij}}$$

Where,

di = direct effect of i^{th} character

rij = correlation coefficient of i^{th} character with j^{th} character

Direct and indirect effects of different characters on fruit yield were calculated at genotypic level.

3.14.6 Genetic divergence analysis

The genetic divergence among the genotypes was carried out using Mahalonobis' D^2 statistic (Rao, 1952).

Results and discussion

CHAPTER – IV

RESULTS AND DISCUSSION

The results obtained on various aspects from present investigation are presented through appropriate tables and graphs and are briefly discussed under the following heads:

4.1 Analysis of variance

4.2 Genetic variability

4.3 Phenotypic and genotypic coefficient of correlation

4.4 Path-coefficient analysis

4.5 Divergence analysis

4.1 Analysis of variance

Analysis of variance was worked out for fruit yield and its component characters alongwith quality characters, which indicated that the difference among the genotypes were highly significant for characters *viz*., days to 50 per cent flowering, plant height, number of primary branches per plant, fruit weight, fruit length, fruit width, number of locules per fruit, number of calyx per fruit, number of seeds per fruit, reducing sugars, total soluble solids, acidity and fruit yield per plant as shown in Table 4.1. This indicated that sufficient variation was present in genotypes under study for all the characters. The high magnitudes of variability among the genotypes for fruit yield and attributing characters, it indicated that enough scope is there, for the improvement of various traits in selection.

Table 4.1 : Analysis of variance for fruit yield and its components

Source of Variation	Degree of freedom	Days to 50% flowering	Plant height (cm)	No. of primary branches per plant	Fruit weight (g)	Fruit length (cm)	Fruit Width (cm)	No. of locules/ Fruit	No. of calyx/ fruit	Pericarp thickness (mm)	No. of seed/ fruit	Total soluble solids (%)	Reducing sugar (%)	Acidity (%)	pH	Fruit yield/ plant (g)
	Mean sum of squares															
Replication	3	1.23	0.516	2.37	33.79	0.015	0.099	0.369	0.322	0.008	1.75	0.073	0.059	0.002	2.62	0.228
Genotypes/ Treatment	28	145.56**	1357.26**	10.21**	1256.26**	0.572**	1.42**	2.55**	0.580**	0.014	7036.67	0.898**	2.660**	0.689**	0.118	4.28**
Error	84	0.941	2.63	3.12	28.08	0.381	0.146	1.48	0.297	0.008	1.28	0.065	0.006	21.05	0.012	0.102

* : Significant at 5%, ** : Significant at 1%

4.2 Genetic variability

The genetic variability was estimated and presented in Table- 4.2 and 4.3 for twenty-eight diverse genotypes and discussed under the following heads:

4.2.1 Mean performance

The mean performance of twenty-eight genotypes for fruit yield and its components in tomato are presented in Table 4.2

4.2.1.1 Days to 50 % flowering

S-22 (61.00 days) showed significant earliest days to 50 % flowering followed by CO-3 (62.33 days) and RCMT-1 (63 days).Days to fifty per cent flowering were observed between 61.00 (S-22) to 89.00 (Local-2) with a mean of 70.70.

4.2.1.2 Plant height

Plant height was recorded significantly minimum by genotype Navodaya (43.67 cm) which is followed by Pusa Early Dwarf (44.67 cm). Plant height varied from 43.67 cm (Navoday) to118.60 cm (Improved Shalimar) with a mean of 71.16 cm.

4.2.1.3 Number of primary branches per plant

Number of primary branches per plant was ranged from 9.00 (ALT-02-39) to 17.33 (Improved Shalimar) with a mean of 12.01.

4.2.1.4 Fruit weight

Significantly maximum fruit weight was recorded in genotype Sarvoday (115.44 g), followed by SC-3 (113.06 g) and Uday PGT-II (95.58 g). Fruit weight varied from 33.07g (Pusa Early Dwarf) to115.44g (Sarvoday) with a mean value of 66.27g.

Table 4.2 : Mean performance for fruit yield and its components alongwith quality traits in tomato

Characters	Days to 50% flowering	Plant height (cm)	No of primary branches per plant	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	No. of locules/ Fruit	No. of calyx/ fruit	Pericarp thickness (mm)	No. of seeds/ fruit	Total soluble solids (%)	Reducing sugar (%)	Acidity (%)	pH	Fruit yield/ plant (kg)
SC-3	75	90.33	11.67	113.06	5.91	5.76	2.67	5.67	0.22	112.00	4.20	6.88	0.60	4.42	4.11
Local 2	89	82.67	11.67	81.75	5.41	4.08	4.67	6.33	0.09	113.00	4.10	4.55	0.51	4.28	6.08
Uday PGT II	75	48.33	11.00	95.58	5.83	5.38	4.33	6.00	0.15	121.00	5.20	5.00	0.39	4.43	6.97
Sarvodaya	71	50.00	11.00	115.44	5.80	5.92	4.67	5.67	0.24	232.00	4.20	6.86	0.72	4.32	5.25
S-22	61	54.67	10.00	83.83	6.02	5.12	4.67	5.33	0.07	236.00	4.00	3.73	0.30	4.32	5.19
RK-318	64	63.00	11.33	75.14	5.52	4.94	4.00	5.67	0.11	182.33	3.60	3.50	0.45	4.36	5.18
S-22 UP	67	79.67	11.00	36.47	5.23	3.77	6.00	5.33	0.07	237.33	4.00	6.91	0.63	4.03	2.08
S-21	65	108.67	13.00	44.18	4.60	3.36	4.33	5.67	0.09	172.00	4.20	4.33	0.54	4.40	4.95
Navodaya	73	43.67	10.33	52.58	4.30	4.18	5.67	6.00	0.32	161.00	5.00	4.32	0.63	4.08	3.53
Punjab Keshary	75	62.00	10.33	79.64	4.84	5.33	2.33	5.67	0.09	117.00	5.00	6.86	0.51	4.05	3.57
PKM-1	64	59.67	15.33	52.04	5.20	3.89	3.67	5.00	0.04	146.00	4.00	4.55	0.87	4.70	1.31
C-21	64	62.33	11.67	56.33	5.13	4.06	4.00	6.00	0.03	137.00	4.70	4.27	0.63	4.33	3.69
Pusa Early Dwarf	78	44.67	9.67	33.07	4.28	3.81	3.67	5.67	0.05	102.00	3.50	5.45	0.75	4.23	2.28
Pant T-7	78.33	94.60	11.33	56.60	5.08	4.12	3.00	5.67	0.17	224.00	4.00	3.91	0.60	4.05	4.23
RCMT-2	66.33	70.40	11.67	75.57	5.29	4.56	2.67	5.33	0.13	102.00	3.13	5.09	0.39	3.95	4.18
RCMT-1	63	51.83	11.33	50.00	5.29	5.14	4.00	5.67	0.19	133.00	4.10	5.45	0.39	4.57	4.15
JTP-02-09	69.67	50.83	11.00	60.83	5.32	3.70	2.67	5.67	0.11	263.00	4.20	3.91	0.63	4.33	4.34
Pant T-3	75.67	106.90	10.67	51.32	5.30	4.01	4.33	6.00	0.07	176.00	4.10	5.09	0.33	4.14	4.11
Pant T-8	77	76	14.67	71.93	5.26	4.47	3.33	7.00	0.10	186.00	4.10	5.45	0.33	4.19	3.98
Improved Shalimar	76.67	118.60	17.33	60.77	5.18	4.05	2.67	6.67	0.19	104.00	5.00	4.91	0.63	4.06	5.03
KS-229	80	75.33	12.67	78.11	5.23	5.38	4.00	6.33	0.11	148.00	4.13	5.09	0.39	4.04	4.81
KS-227	78.33	64.40	13.67	54.85	5.08	4.75	3.00	6.00	0.22	176.33	4.00	4.45	0.39	4.22	4.15
ALT-02-39	63.67	65.00	9.00	62.88	5.09	4.84	4.67	5.33	0.13	139.00	4.87	5.54	0.57	3.94	4.70
VR-20	64.67	65.20	13.33	61.71	5.33	4.81	4.00	5.33	0.15	146.33	5.17	5.09	0.57	4.20	4.13
JTP-02-07	70.67	51.80	12.33	66.99	5.16	3.88	2.67	5.67	0.11	221.00	4.53	4.86	0.69	4.33	4.53
Pusa Ruby	68	112.00	14.67	52.20	4.77	3.84	3.33	6.33	0.09	132.00	5.10	4.77	0.75	4.10	6.45
DVRT-2	64.33	77.20	12.00	86.45	6.02	5.22	3.33	6.00	0.18	221.00	3.50	4.55	0.45	3.82	4.59
CO-3	62.33	62.60	12.67	46.31	5.17	4.53	4.00	6.00	0.07	212.00	4.00	4.55	0.33	4.12	4.33
Mean (x)	70.70	71.16	12.01	66.27	5.24	4.53	3.79	5.82	0.13	166.15	4.27	4.99	1.595	4.21	4.35
CV (%)	1.37	2.27	14.7	7.99	11.78	8.43	32.03	9.36	6.81	0.68	1.89	1.56	8.58	2.61	7.35
CD at 5%	1.59	2.65	2.89	8.68	1.01	0.63	1.99	0.89	0.01	1.85	0.13	0.13	0.08	0.18	0.52

4.2.1.5 Fruit length

Genotype DVRT-II (check) showed significantly higher fruit length of 6.02 cm followed by SC-3 (5.91 cm) and Uday PGT-II (5.83 cm). Fruit length showed a mean value of 5.24 cm within the range of 4.28 cm (Pusa Early Dwarf) to 6.02 cm (DVRT-2).

4.2.1.6 Fruit width

Fruit width was significantly maximum in Sarvodaya (5.92 cm) which is followed by SC-3 (5.76 cm) and Uday PGT-II (5.38 cm). However, fruit width were ranged from 5.92 cm (Sarvoday) maximum to 3.36 cm (S-21) minimum with a mean of 4.53 cm.

4.2.1.7 Number of locules per fruit

In case of number of locules, genotype S-22 (UP) was noted significantly higher (6.00) followed by Navodaya (5.67) and S-22 (4.67). Number of locules per fruit showed a mean value 3.79 within the range of 2.33 (Punjab Keshary) to 6.00 (S-22, U.P.).

4.2.1.8 Number of calyx per fruit

Genotype Improved Shalimar was recorded significantly higher number of calyx (6.67) per fruit followed by Pusa Ruby (6.33), KS-229 (6.33) and Local-2 (6.33). Similarly, number of calyx per fruit varied from 5.00 (PKM-1) to 7.00 (Pant-T-8) with a mean of 5.82.

4.2.1.9 Pericarp thickness

A character responsible for transporting point of view, genotype Navodaya measured significantly highest value of pericarp thickness i.e. 0.32

PLATE-1: DIFFERENT GENOTYPES OF TOMATO

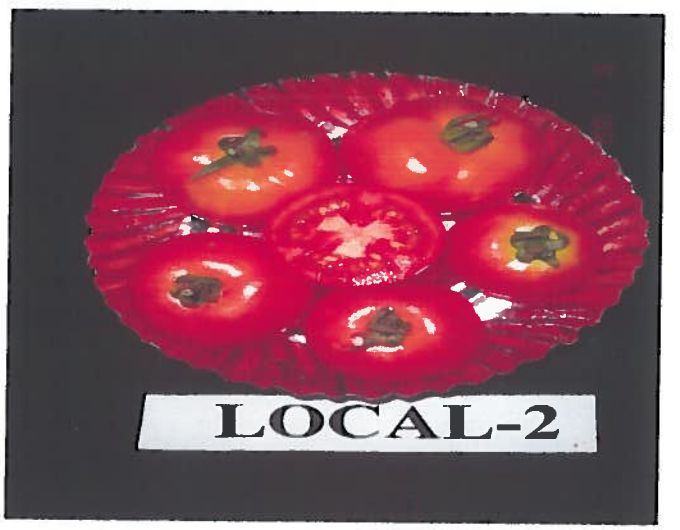
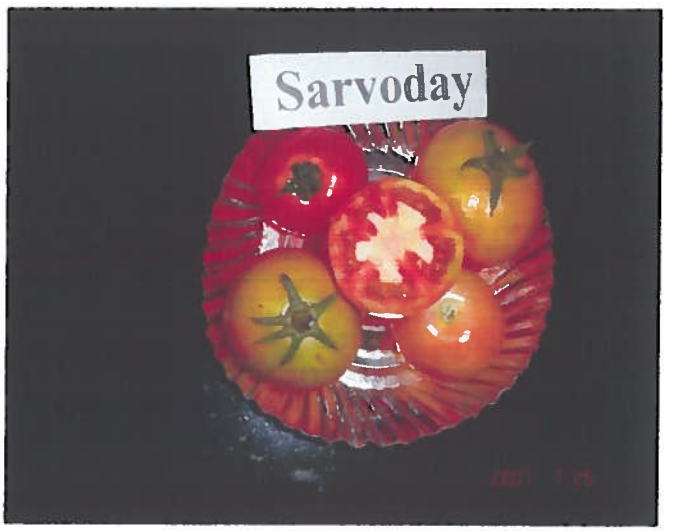


PLATE-2: DIFFERENT GENOTYPES OF TOMATO



mm, followed by Sarvodaya (0.24 mm) and SC-3 (0.22 mm). Pericarp thickness was ranged between 0.03mm (C-21) to 0.32mm (Navoday) with a mean of 0.13mm.

4.2.1.10 Number of seeds per fruit

Genotype JTP-02-09 counted significantly highest number of seeds per fruit i.e. 263 which is followed by S-22 UP (237) and S-22 (236). Number of seeds per fruit was recorded between 102 (Pusa Early Dwarf) to 263 (JTP-02-09) with an overall mean of 166.15.

4.2.1.11 Total soluble solid

A character desirable for processing i.e. total soluble solid, which was highest in genotype Uday PGT-II (5.20) followed by VR-20 (5.17), Navodaya (5.00), Improved Shalimar (5.00) and Punjab Keshary (5.00). Total soluble solid ranged from 3.13 per cent (RCMT-2) 5.20 per cent (Uday PGT-II) with a mean of 4.27 per cent.

4.2.1.12 Reducing sugar

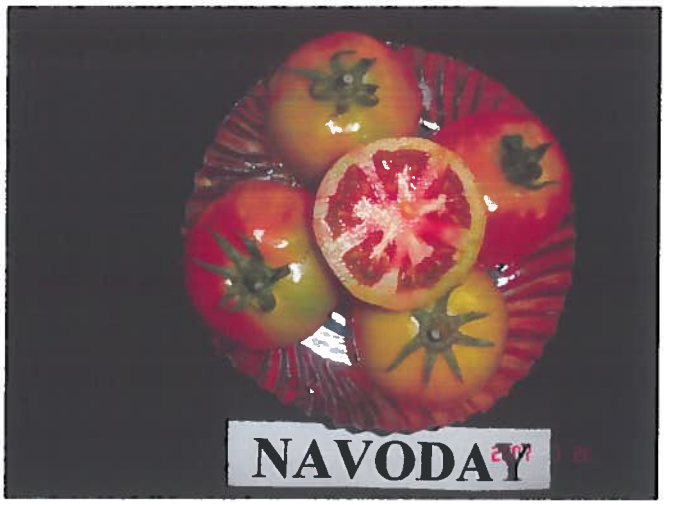
In genotype S-22, UP significantly highest reducing sugar i.e. 6.91 was recorded, followed by SC-3 (6.88) and Sarvodaya (6.86). Reducing sugar ranged between 3.50 per cent (RK-318) to 6.91 per cent (S-22, UP) with a mean of 4.99 per cent.

4.2.1.13 Acidity and pH

The titrable acidity was recorded significantly maximum in genotype PKM-1 (0.87) followed by Pusa Early Dwarf (0.75), Pusa Ruby (0.75) and

PLATE-3: DIFFERENT GENOTYPES OF TOMATO

PLATE – 4 : DIFFERENT GENOTYPES OF TOMATO



Sarvodaya (0.72). Acidity was recorded minimum 0.30 per cent (S-22) and maximum 0.87 per cent (PKM-1) with a mean of 1.595 per cent

In case of pH, genotype PKM-1 recorded maximum pH of (4.70) which is followed by RCMT-1 (4.57) and Uday PGT-II (4.43) with pH mean 4.21 between the range of 3.82 (DVRT-2) to 4.70 (PKM-1).

4.2.1.14 Fruit yield per plant

Maximum fruit yield (6.97 kg) per plant was recorded significantly superior in genotype Uday PGT-II followed by Pusa Ruby (6.45) kg and Local-2 (6.08 kg) check, whereas DVRT-2 check gave 4.59 kg and CO-3 check 4.33 kg per plant. The minimum fruit yield 1.31 kg per plant was recorded in PKM-1.

A wide range of variation was recorded for number of seeds per fruit, plant height, days to 50 per cent flowering and fruit weight, which indicated that there is better scope for selection for the improvement of these characters. These findings are in close proximity with the results of Singh *et al.* (2000), Brar *et al.* (2000), Joshi and Singh (2003), Mariame *et al.* (2003), Ahmed *et al.* (2006) and Mahesha *et al.* (2006 a).

4.2.2 Genotypic and phenotypic coefficient of variation

The information on the nature of extent of genetic variability present in the population for desirable characters in selection for improvement of a crop. The knowledge of genotypic and phenotypic coefficient of variation is being useful in designing selection criteria from variable population.

Genotypic and phenotypic coefficients of variation of different characters are presented in Table 4.3. In general, it was noted that the value of phenotypic coefficient of variation is higher than the genotypic coefficient of variation. The highest value of phenotypic coefficient of variation was recorded by pericarp thickness 53.21 mm, which was followed by number of locules per fruit (35.69), fruit weight (31.56), plant height (29.95), acidity (29.20 per cent), number of seeds per fruit (29.15), fruit yield per plant (28.09), number of primary branches per plant (19.50), reducing sugar (18.89 per cent), fruit width (16.67), total soluble solids (12.90), fruit length (12.73), number of calyx per fruit (10.74) and days to 50 per cent flowering (9.92) whereas, lowest phenotypic coefficient of variation was recorded for pH of fruit (5.18).

In case of genotypic coefficient of variation highest value was recorded by pericarp thickness (52.77) followed by fruit weight (30.53), plant height (29.86), number of seeds per fruit (29.15), acidity (27.91), fruit yield per plant (27.11), reducing sugar (18.82), number of locules per fruit (15.74), fruit width (14.38), number of primary branches per plant (12.80), total soluble solids (12.76), days to 50 per cent flowering (9.82), number of calyx per fruit (5.28) and fruit length (4.82) whereas, lowest genotypic coefficient of variation was recorded for pH of fruit (4.47).

The magnitude of phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for most of the characters. This might be due to the interaction of the genotypes with the environment to some degree or environmental factors influencing the expression of these characters.

Table 4.3 : Genetic parameters of variation

Characters	Mean	Range		Coefficient of variation		Heritability (h^2 %)	Genetic advance as % of mean
		Minimum	Maximum	Phenotypic	Genotypic		
Days to 50% flowering	70.70	61.00	89.00	9.92	9.82	98.10	20.81
Plant height (cm)	71.16	43.67	118.60	29.95	29.86	99.40	61.34
Number of primary branches per plant	12.01	9.00	17.33	19.50	12.80	43.10	17.32
Fruit weight (g)	66.27	33.07	115.44	31.56	30.53	93.60	60.84
Fruit length (cm)	5.24	4.28	6.02	12.73	4.82	14.40	3.82
Fruit width (cm)	4.53	3.36	5.92	16.67	14.38	74.40	25.61
Number of locules per fruit	3.79	2.33	6.00	35.69	15.74	19.40	14.25
Number of calyx per fruit	5.82	5.00	7.00	10.74	5.28	24.10	5.33
Pericarp thickness (mm)	0.13	0.03	0.32	53.21	52.77	98.40	107.69
Number of seeds per fruit	166.15	102	263	29.15	29.15	99.90	60.02
Total soluble solid (%)	4.27	3.13	5.20	12.90	12.76	97.90	25.99
Reducing sugar (%)	4.99	3.50	6.91	18.89	18.82	99.30	38.68
Acidity (%)	0.54	0.30	0.87	29.20	27.91	91.40	53.70
pH	4.21	3.82	4.70	5.18	4.47	74.50	7.82
Fruit yield per plant (kg)	4.35	1.31	6.97	28.09	27.11	93.20	54.02

Close correspondence between phenotypic and genotypic coefficient of variation were observed for following characters *viz*., days to 50 per cent flowering (9.92 & 9.82), plant height (29.95 & 29.86), number of primary branches per plant (19.50 & 12.80), fruit weight (31.56 & 30.53), fruit width (16.67 & 14.38), pericarp thickness (53.21 & 52.77), number of seeds per fruit (29.15 & 29.15), total soluble solids (12.90 & 12.76), reducing sugar (18.89 & 18.82), acidity (29.20 & 27.91), pH (5.18 & 4.47) and fruit yield per plant (28.09 & 27.11). These characters implied their relative resistance to environmental variation. These findings are in consonance with Rattan *et al.* (1983) for fruit weight, seed percentage, fruit length, fruit width, fruit yield per plant and acidity. Similar findings were also observed by Prasad and Rai (1999) and Mahesha *et al.* (2006a) for plant height and total soluble solids (TSS) and Ahmed *et al.* (2006) for plant height, total fruit yield per plant and fruit weight.

4.2.3 Heritability and genetic advance

Heritability estimate provides the information regarding the amount of transmissible genetic variation to total variation and determines genetic improvement and response to selection. The term heritability in broad sense was defined as the ratio of genetic variance to the total phenotypic variance (Lush, 1940; Jonson *et al.*, 1955).

The estimates of genetic advance as per cent of mean provide more reliable information regarding the effectiveness of selection in improving a trait. Genetic advance denotes the improvement in the genotypic value of the new population

compared to the original population. Thus, the estimates of heritability and genetic advance are of great significance to the vegetable breeders for developing suitable selection strategy.

In present investigation, heritability estimates in broad sense has been depicted in Table 4.3. High estimates for heritability was exhibited by number of seeds per fruit (99.9) followed by plant height (99.4), reducing sugar (99.3) and days to 50% flowering (98.1), total soluble solids (97.9), fruit weight (93.6), fruit yield per plant (93.2), acidity (91.4), pH (74.5) and fruit width (74.4) whereas, moderate estimates of heritability were recorded for number of primary branches per plant (43.1) and number of calyx per fruit (24.1). Similarly, lower estimates of heritability were observed for number of locules per fruit (19.4) and fruit length (14.4).

High value of heritability for characters *viz.*, number of seeds per fruit followed by plant height, reducing sugar and days to 50 per cent flowering, total soluble solids, fruit weight, fruit yield per plant, acidity, pH and fruit width. These characters demonstrated that they were least influenced by environmental changes and selection based on phenotypic performance would be reliable.

High heritability have also been reported by Sahu and Mishra (1995) for fruit yield per plant and fruit weight; Singh *et al.* (2000) for fruit weight and total fruit yield; Singh *et al.* (2005) for total soluble solids (TSS), pericarp thickness and acidity and Ahmed *et al.* (2006) for fruit yield per plant, fruit weight, acidity and fruit length. Similar results were also given by Kumar *et al.*

(2004) for fruit weight. High value of heritability alongwith moderate to high genetic coefficient of variation and genetic gain were manifested by characters pericarp thickness, fruit weight, number of seeds per fruit, plant height, acidity and fruit yield per plant. This might be assigned to additive gene action controlling the expression of these traits and can be brought about phenotypic selection for their amelioration. Thus, improvement of fruit yield components can be achieved by simple selection methods like pure lines selection or by mass selection, following hybridization and selection in early generation. These results are conformity with the findings of Singh et *al.* (2000) for fruit weight, number of locules per fruit and plant height, whereas, high heritability with low genetic advance was recorded for pericarp thickness, number of locules per fruit and fruit yield per plant, Mariame *et al.* (2003) also found similar result for plant height and number of seeds per fruit, Joshi *et al.* (2004), who reported moderate heritability coupled with moderate genetic advance for fruit length, fruit width, number of locules per fruit and plant height and Mahesha *et al.* (2006a) reported high heritability coupled with high genetic advance for fruit weight and plant height.

On the other hand, high estimates of heritability coupled with low genetic advance as per cent of mean were observed for days to 50% flowering (98.1 & 20.81 respectively), total soluble solids (TSS) (97.9 & 25.99 respectively), reducing sugars (99.3 & 38.68 respectively), pH (74.5 & 7.82 respectively) and fruit width (74.4 & 25.61 respectively). It may be inferred that these characters were governed by non-additive gene action. In this

situation simple selection will not be rewarding. It can be improved by development of hybrid varieties. These results are in accordance with the findings of Brar *et al.* (2000) for number of fruit per plant and total yield per plant and Joshi *et al.* (2004) for fruit width and pericarp thickness.

4.3 Phenotypic and genotypic coefficient of correlation

Association analysis is an important approach in a breeding programme. It gives an idea about relationship among the various characters and determines the component characters, on which selection can be used for genetic improvement in the fruit yield. The degree of association also affects the effectiveness of selection process. The degree of association between independent and dependent variables was first suggested by Galton in 1888, its theory was developed by Pearson 1904 and their mathematical utilization at phenotypic, genotypic and environmental levels was described by Searle (1961).

The major causes underlying association are either due to pleiotropic gene action or linkage or both. The phenotypic correlation includes a genotypic and environmental effect, which provides information about total association between the observable characters. The phenotypic correlations were normally of genetic and environmental interaction which provided information about the association between the two characters. Genotypic correlation provided a measure of genetic association between the characters and normally used in selection, while environmental as well as genetic architecture of a genotype plays a great role in achieving higher yield combined with better quality.

Table 4.4 : Phenotypic correlation coefficient between fruit yield and its components alongwith quality traits in tomato

Characters	Days to 50% flowering	Plant height (cm)	No of primary branches per plant	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	No. of locules /fruit	No. of calyx/ fruit	Pericarp thickness (mm)	No. of seeds/ fruit	Total soluble solids (%)	Reducing sugar (%)	Acidity (%)	pH	Fruit yield/ plant (kg)
Days to 50% flowering	1.000	0.206	0.034	0.170	-0.112	-0.031	-0.111	0.385	0.177	-0.280	0.054	0.159	-0.013	-0.102	0.148
Plant height (cm)		1.000	0.394*	-0.117	-0.026	-0.280	-0.128	0.259	-0.092	-0.161	0.064	0.000	-0.011	-0.256	0.217
No of primary branches/ plant			1.000	-0.112	-0.026	-0.153	-0.162	0.184	0.000	-0.127	0.104	-0.129	0.109	0.083	0.046
Fruit weight (g)				1.000	0.465*	0.685**	-0.078	0.071	0.344	-0.017	0.034	0.282	-0.166	0.065	0.455*
Fruit length (cm)					1.000	0.473*	0.013	-0.130	0.043	0.187	-0.131	0.046	-0.207	0.094	0.228
Fruit width (cm)						1.000	-0.023	-0.061	0.375*	-0.072	0.015	0.357	-0.318	-0.096	0.273
No. of locules/fruit							1.000	-0.051	0.025	0.122	0.050	0.028	-0.037	0.054	-0.016
No. of calyx/fruit								1.000	0.082	-0.106	0.144	-0.054	-0.221	-0.132	0.277
Pericarp thickness (mm)									1.000	0.002	0.181	0.132	0.003	0.120	0.189
No. of seeds/fruit										1.000	-0.246	-0.215	-0.074	-0.052	-0.047
Total soluble solids (%)											1.000	0.131	0.227	0.017	0.285
Reducing sugar (%)												1.000	0.157	-0.099	-0.228
Acidity (%)													1.000	0.166	-0.323
pH														1.000	-0.080
Fruit yield/ plant															1.000

* : significant at 5%, ** : Significant at 1%

The genotypic and phenotypic correlation for fruit yield and its component in tomato (in Table 4.4 and 4.5) only significant correlations are discussed here.

The findings clearly indicated that genotypic correlations were of higher magnitude to the corresponding phenotypic ones, thereby establishing strong inherent relationship among the characters studied. The low phenotypic value might be due to appreciable interaction of the genotypes with the environments.

Days to 50 per cent flowering had positive and significant correlation with number of calyx per fruit at genotypic level only. Plant height exhibited significant positive correlation with number of primary branches per plant at phenotypic and genotypic levels and a negative correlation with fruit length at genotypic level. Number of primary branches per plant showed positive and significant correlation with number of calyx per fruit whereas, significant negative correlation with number of locules per fruit at genotypic level.

Fruit weight showed significant and positive correlation with fruit length followed by fruit width and fruit yield per plant at phenotypic and genotypic levels, respectively. Fruit length had significant positive correlation with fruit width at phenotypic and genotypic levels whereas, number of seeds per fruit and fruit yield per plant at genotypic level only. Fruit length showed negative and significant correlation with acidity at genotypic level. Fruit width had significant positive correlation with pericarp thickness and reducing sugar but had significant negative correlation with acidity at genotypic level only. Number of calyx showed significant positive correlation with fruit yield per plant, whereas pH exhibited

Table 4.5 : Genotypic correlation coefficient between fruit yield and its components alongwith quality traits in tomato

Characters	Days to 50% flowering	Plant height (cm)	No of primary branches per plant	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	No. of locules/ Fruit	No. of calyx/ fruit	Pericarp thickness (mm)	No. of seeds/ fruit	Total soluble solids (%)	Reducing sugar (%)	Acidity (%)	pH	Fruit yield/ plant (kg)
Days to 50% flowering	1.000	0.209	0.106	0.177	-0.252	-0.017	-0.252	0.775**	0.181	-0.283	0.059	0.161	-0.011	-0.138	0.156
Plant height (cm)		1.000	0.590**	-0.119	-0.790**	-0.318	-0.255	0.547**	-0.093	-0.162	0.066	0.002	-0.015	-0.300	0.228
No of primary branches per plant			1.000	-0.146	-0.065	-0.330	-0.737**	0.847**	-0.019	-0.189	0.193	-0.167	0.199	0.139	0.016
Fruit weight (g)				1.000	1.284	0.840**	-0.307	0.079	0.360	-0.018	0.024	0.285	-0.174	0.061	0.493**
Fruit length (cm)					1.000	0.970**	-0.213	0.066	0.164	0.484**	-0.322	0.112	-0.661**	0.220	0.634**
Fruit width(cm)						1.000	-0.093	-0.023	0.452*	-0.085	0.017	0.409*	-0.410*	0.034	0.300
No. of locules/fruit							1.000	-0.357	0.006	0.273	0.131	0.042	-0.056	-0.013	-0.052
No. of calyx /fruit								1.000	0.176	-0.224	0.279	-0.127	-0.366	-0.393*	0.605**
Pericarp thickness (mm)									1.000	0.002	0.186	0.136	0.002	-0.145	0.196
No. of seeds/fruit										1.000	-0.249	-0.216	-0.078	-0.600**	-0.049
Total soluble solids (%)											1.000	0.133	0.245	0.020	0.311
Reducing sugar (%)												1.000	0.164	-0.112	-0.234
Acidity (%)													1.000	0.228	-0.353
pH														1.000	-0.066
Fruit yield/ plant															1.000

* : significant at 5%, ** : Significant at 1%

significant negative correlation. Number of seeds per fruit showed significantly negative association with plt at genotypic level.

Similar association were also confirmed by Padma *et al.* (2002) who studied positive and highly significant correlation between fruit yield per plant and fruit weight; plant height and number of primary branches per plant; fruit length and fruit width; fruit weight and fruit width. Whereas, negative correlation was observed between plant height and fruit weight.

The present findings are in conformity with Singh *et al.* (2002), Joshi *et al.* (2004), Kumar *et al.* (2003) and Singh *et al.* (2005).

4.4 Path coefficient analysis

Path coefficient analysis is an important tool for partitioning the correlation coefficients into the direct and indirect effects of independent variables on a dependent variable. With the inclusion of more variables in correlation study, their indirect association becomes more complex. Two characters may show correlation, just because they are correlated with a common third one. In such circumstances, path coefficient analysis provides an effective means of a critical examination of specific forces action to produce a given correlation and measure the relative importance of each factor. In this analysis, fruit yield per plant was taken as dependent variable and the rest of the characters were considered as independable variables.

The path coefficient analysis which splits total correlation coefficient of different characters into direct and indirect effects on fruit yield per plant in such a manner that the sum of direct and indirect effects is equal to total genotypic

correlation as presented in Table 4.6. The data revealed that fruit weight showed the highest positive direct effect (0.897) on fruit yield per plant followed by number of locules per fruit (0.474), number of primary branches per plant (0.319), total soluble solids (0.318), fruit length (0.162) and days to 50 per cent flowering (0.125).

Fruit width (-0.474), reducing sugars (-0.373), acidity (-0.353), number of seeds per fruit (-0.238), pH (-0.163) and number of calyx per fruit (-0.101) showed negative direct effects on fruit yield per plant. Whereas, the sum of direct and indirect effects of number of calyx per fruit (0.605) showed positive effect on fruit yield per plant.

Days to 50 % flowering showed positive indirect effect on fruit yield per plant through fruit weight (0.159), number of seeds per fruit (0.067), number of primary branches per plant (0.034), pH (0.022) and total soluble solids (0.019).

Plant height exhibited positive indirect effect on fruit yield per plant *via*., number of primary branches per plant (0.188), fruit width (0.151), pH (0.049), number of seeds per fruit (0.038), days to 50% flowering (0.026) and total soluble solids (0.021). Plant height showed positive and indirect effect on fruit yield per plant through number of primary branches per plant (0.188), fruit width (0.151), and pH (0.049).

Number of primary branches per plant exhibited positive indirect effect on fruit yield per plant through fruit width (0.157), reducing sugar (0.062), total soluble solids (0.061) and number of seeds per fruit (0.045). Fruit weight showed positive indirect effect on fruit yield per plant *via*, fruit length (0.208), whereas

Table 4.6 : Direct and indirect effect of component character on fruit yield per plant in tomato

Characters	Days to 50% flowering	Plant height (cm)	No of primary branches per plant	Fruit weight (gm)	Fruit length (cm.)	Fruit width (cm.)	No. of locules/ Fruit	No. of calyx/ fruit	Pericarp thickness (mm.)	No. of seeds/ fruit	Total soluble solids (%)	Reducing sugar (%)	Acidity (%)	pH	Fruit yield/ plant (kg)
Days to 50% flowering	**0.125**	0.010	0.034	0.159	-0.041	0.008	-0.119	-0.079	0.006	0.067	0.019	-0.060	0.004	0.022	0.156
Plant height (cm)	0.026	**0.050**	0.188	-0.107	-0.013	0.151	-0.121	-0.055	-0.003	0.038	0.021	-0.001	0.005	0.049	0.228
No of primary branches /plant	0.013	0.029	**0.319**	-0.131	-0.011	0.157	-0.350	-0.086	-0.001	0.045	0.061	0.062	-0.070	-0.023	0.016
Fruit weight (g)	0.022	-0.006	-0.046	**0.897**	0.208	-0.398	-0.146	-0.008	0.012	0.004	0.008	-0.106	0.062	-0.010	0.493
Fruit length (cm)	-0.031	-0.004	-0.021	1.152	**0.162**	-0.460	-0.101	-0.007	0.005	-0.115	-0.103	-0.042	0.234	-0.036	0.634
Fruit width (cm)	-0.002	-0.016	-0.105	0.754	0.158	**-0.474**	-0.044	0.002	0.015	0.020	0.006	-0.152	0.145	-0.006	0.300
No. of locules/ fruit	-0.031	-0.013	-0.235	-0.276	-0.035	0.044	**0.474**	0.036	0.000	-0.065	0.042	-0.016	0.020	0.002	-0.052
No. of calyx/ fruit	0.097	0.027	0.270	0.071	0.011	0.011	-0.169	**-0.101**	0.006	0.053	0.089	0.047	0.129	0.064	0.605
Pericarp thickness (mm)	0.023	-0.005	-0.006	0.323	0.027	-0.215	0.003	-0.018	**0.033**	-0.001	0.059	-0.051	-0.001	0.024	0.196
No. of seeds/ fruit	-0.035	-0.008	-0.060	-0.016	0.079	0.040	0.129	0.023	0.000	**-0.238**	-0.079	0.081	0.027	0.010	-0.049
Total soluble solids (%)	0.007	0.003	0.061	0.021	-0.052	-0.008	0.062	-0.028	0.006	0.059	**0.318**	-0.050	-0.087	-0.003	0.311
Reducing sugar (%)	0.020	0.000	-0.053	0.256	0.018	-0.194	0.020	0.013	0.004	0.052	0.042	**-0.373**	-0.058	0.018	-0.234
Acidity (%)	-0.001	-0.001	0.064	-0.157	-0.107	0.195	-0.027	0.037	0.000	0.019	0.078	-0.061	**-0.353**	-0.037	-0.353
pH	-0.017	-0.015	0.044	0.054	0.036	-0.016	-0.006	0.040	-0.005	0.014	0.006	0.042	-0.081	**-0.163**	-0.066

Residual value : 0.3073

fruit length showed positive indirect effect on fruit yield per plant *via*, fruit weight (1.152) and acidity (0.234). However, fruit width showed positive indirect effect on fruit yield per plant through fruit weight (0.754), fruit length (0.158) and acidity (0.145).

Number of locules had positive indirect effect on fruit yield per plant through fruit width (0.044), total soluble solids (0.042) and number of calyx per fruit (0.036). However, number of calyx per fruit showed positive indirect effect on fruit yield per plant *via*, number of primary branches per plant (0.270), acidity (0.129), days to 50% flowering (0.097), total soluble solids (0.089), fruit weight (0.071), pH (0.064) and number of seeds per fruit (0.053).

Pericarp thickness showed positive indirect effect on fruit yield per plant *via*., fruit weight (0.323) and total soluble solids (0.059). Number of seeds per fruit showed positive indirect effect on fruit yield per plant *via*, number of locules per fruit (0.129), reducing sugar (0.081), fruit length (0.079) and fruit width (0.040).

Total soluble solids showed positive indirect effect on fruit yield per plant through number of locules per fruit (0.062), number of primary branches per plant (0.061) and number of seeds per fruit (0.059). Whereas, reducing sugar showed positive indirect effect on fruit yield per plant through fruit weight (0.256), number of seeds per fruit (0.052) and total soluble solids (0.042).

Acidity showed positive and indirect effect on fruit yield per plant through fruit width (0.195), total soluble solids (0.078), number of primary branches per plant (0.064) and number of calyx per fruit (0.037). Whereas, pH showed positive

and indirect effect on fruit yield per plant *via*, fruit weight (0.054), number of primary branches per plant (0.044) and reducing sugar (0.042).

The effect of residual factor (0.307) on fruit yield per plant was negligible, thereby, suggested that no other major yield component is left over.

In present investigation, fruit weight showed high positive and direct effect had significant positive correlation with fruit yield per plant. Therefore, the fruits with higher weight should be considered in selection criteria for increasing fruit yield per plant. The present study suggested that more emphasis should be given to selecting genotypes with high fruit weight. Directly or indirectly all characters showed positive effect on fruit yield per plant, which is in confirmation to the finding of Verma and Sarnaik (2000) who also reported that number of fruit per plant, average fruit weight and number of primary branches per plant exhibited positive as well as high direct effect.. Bodende (2002) also reported that plant height, fruit diameter and fruit length were directly responsible for the determination of fruit yield in tomato.

Mohanty (2002) also observed that fruit weight exerted high positive and direct effect on fruit yield per plant. Similar results were obtained by Padma *et al.* (2002), Singh *et al.* (2004) and Singh *et al.* (2006).

Overall the path analysis confined that direct effect of fruit weight, number of locules per fruit and number of primary branches per plant whereas, indirect effect of plant height, fruit length, fruit width, number of calyx per fruit, pericarp thickness, number of seeds per fruit, total

soluble solids, reducing sugar, acidity, pH and fruit yield per plant should be considered simultaneously for amenability in fruit yield of tomato.

The unexplained variations in genotypic and phenotypic path were 0.307 and 0.413, respectively. It predicted that 69.3 and 58.7 per cent variation at phenotypic or genotypic level, respectively had been determined and further indicated that some more factors not considered in this study contributed to fruit yield per plant. Therefore, some more traits may be considered while selecting the genotypes for high fruit yield in tomato for Chhattisgarh plains.

4.5 Divergence analysis

The concept of D^2 statistics was originally developed by P.C. Mahalonobis (1936). Then C.R. Rao (1952) suggested the application of this technique for the arrangement of genetic diversity in plant breeding. Now, this technique is being extensively used in vegetable breeding to study the selection of different parents. Genetic variability and selection of parants from diverse breeding material including germplasm and there diverse parents can be used for the development of hybrids in tomato.

On the basis of D^2 analysis, 28 genotypes were grouped into five clusters (Table 4.7). Maximum number of genotypes were grouped into cluster V (*viz.*, S-21, S-22 (U.P.), Navoday, PKM-1, C-21, Pusa Early Dwarf, JTP-02-09 and JTP-02-07) followed by cluster IV (SC-3, Uday-PGT-II, Sarvoday, Punjab Keshary, RCMT-1, ALT-02-39 and VR-20), cluster III (Local-2, Pant-T-7, Pant-T-3, Pant -T-8, KS-229 and KS-227) and cluster I (S-22, RK-318, RCMT-2, DVRT-2, CO-3), whereas only two genotypes in cluster II (Improved Shalimar, Pusa Ruby)

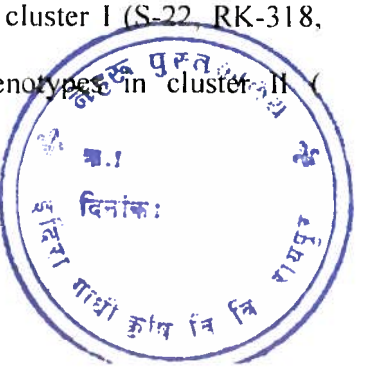


Table 4.7 : Composition of clusters

Cluster Number	Number of genotypes included	Name of genotypes
I	05	S-22, RK-318, RCMT-2, DVRT-2, CO-3.
II	02	Improved Shalimar, Pusa Ruby
III	06	Local-2, Pant T-7, PantT-3, Pant T-8, KS-229, KS-227
IV	07	SC-3, Uday PGT-II, Sarvoday, Punjab Keshary, RCMT-1, ALT-02-39, VR-20.
V	08	S-21, S-22 (U.P.), Navoday, PKM-1, C-21, Pusa Early Dwarf, JTP-02-09, JTP-02-07.

Table 4.8 : Intra (bold) and Inter cluster distance values in tomato

Cluster Number	I	II	III	IV	V
I	**2.498**				
II	5.990	**1.629**			
III	3.213	4.219	**2.459**		
IV	3.402	5.484	3.524	**3.156**	
V	3.791	5.135	3.465	3.805	**3.495**

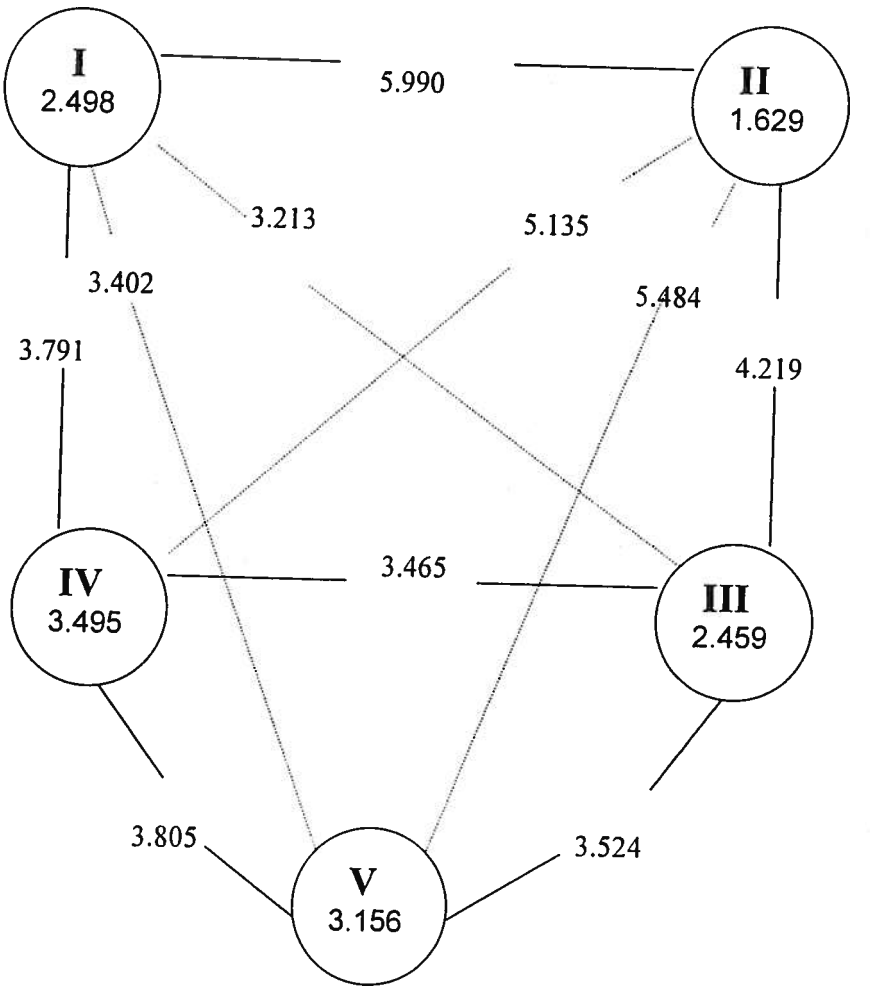


Fig. 4.8 : D^2 diagram showing intra and inter cluster distance of fruit yield and its attributing characters

PLATE-5: DIFFERENT GENOTYPES OF TOMATO

PLATE-6: DIFFERENT GENOTYPES OF TOMATO

It is vivid from the Table 4.8 that maximum inter cluster distance was observed between cluster I and II (5.990) followed by cluster II and IV (5.484), cluster II and V (5.135), cluster II and III (4.219), cluster IV and V (3.805) and cluster I and V (3.791).

4.5.1 Mean performance of clusters

The mean performance for different clusters of genotypes for fruit yield and its components are presented in Table 4.9. The data of cluster means for all the characters showed appreciable differences.

The cluster mean performance for days to 50 % flowering was highest in cluster III (79.72), which was followed by cluster II (72.33), cluster IV (69.62), cluster V (68.92) and lowest for cluster I (63.60). As regards to plant height, the highest average performance (115.30 cm) was recorded in cluster II, which was followed by cluster III (83.32 cm), cluster I (65.57 cm), cluster V (62.66 cm) and cluster IV (61.81cm). Number of primary branches per plant showed maximum cluster mean performance in cluster II (16.00), which was followed by cluster III (12.44), cluster V (11.79), cluster I (11.53) and cluster IV (11.10).

The highest cluster mean value for fruit weight was recorded by cluster IV (82.62 g) followed by cluster I (73.46 g), cluster III (65.76 g), cluster II (56.49 g) and cluster V (50.31 g), While fruit length recorded the highest cluster mean performance in cluster I (5.60 cm) which was followed by cluster IV (5.44 cm), cluster III (5.23 cm), cluster II (4.98 cm) and cluster V (4.90 cm).

The highest cluster mean was recorded for fruit width by cluster IV (5.31 cm), which was followed by cluster I (4.87 cm), cluster III (4.47 cm),

Table 4.9 : Mean performance of different clusters for fruit yield and its component traits alongwith quality characters

Clusters	Days to 50% flowering	Plant height (cm)	No of primary branches per plant	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	No. of locules/fruit	No. of calyx/ fruit	Pericarp thickness (mm)	No. of seeds/ fruit	Total soluble solids (%)	Reducing sugar (%)	Acidity (%)	pH	Fruit yield/ plant (kg)
I	63.60	65.57	11.53	73.46	5.60	4.87	3.73	5.67	0.11	190.67	3.65	4.28	0.38	4.11	4.69
II	72.33	115.30	16.00	56.49	4.98	3.95	3.00	6.50	0.14	118.00	5.05	4.84	0.69	4.08	5.74
III	79.72	83.32	12.44	65.76	5.23	4.47	3.72	6.22	0.13	170.56	4.07	4.76	0.43	4.15	4.56
IV	69.62	61.81	11.10	82.62	5.44	5.31	3.91	5.62	0.17	142.90	4.68	5.96	0.54	4.28	4.70
V	68.92	62.66	11.79	50.31	4.90	3.83	4.08	5.63	0.10	179.92	4.27	4.82	0.67	4.30	3.34

cluster II (3.95 cm) and cluster V (3.83 cm). The highest number of locules per fruit was found in cluster V (4.08) followed by cluster IV (3.91), cluster I (3.73), cluster III (3.72) and cluster II (3.00). The maximum number of calyx per fruit was recorded in cluster II (6.50) followed by cluster III (6.22), cluster I (5.67), cluster V (5.63) and cluster IV (5.62).

Pericarp thickness showed the highest mean performance for cluster IV (0.17 mm), which was followed by cluster II (0.14 mm), cluster III (0.13 mm), cluster I (0.11 mm) and cluster V (0.10 mm). Number of seeds per fruit exhibited the highest mean performance for cluster I (190.67) followed by cluster V (179.92), cluster III (170.56), cluster IV (142.90) and cluster II (118.00). The maximum mean for total soluble solids was recorded in cluster II (5.05%), followed by cluster IV (4.68%), cluster V (4.27%), cluster III (4.07%) and cluster I (3.65%). The reducing sugar was recorded highest in cluster IV (5.96%) followed by cluster II (4.84%), cluster V (4.82%), cluster III (4.76%) and cluster I (4.28%). The maximum (0.69%) and minimum (0.38%) acidity was recorded in cluster II and I, respectively. The highest (4.30) and lowest (4.08) pH was observed in cluster V and II, respectively. As regards fruit yield per plant, the highest mean performance was recorded in cluster II (5.74 kg per plant), which was followed by cluster IV (4.70 kg per plant), cluster I (4.69 kg per plant), cluster III (4.56 kg per plant) and cluster V (3.34 kg per plant).

Thus, while planning hybridization programme for the development of heterotic hybrids and better transgressive segregants one should select

PLATE-7: DIFFERENT GENOTYPES OF TOMATO

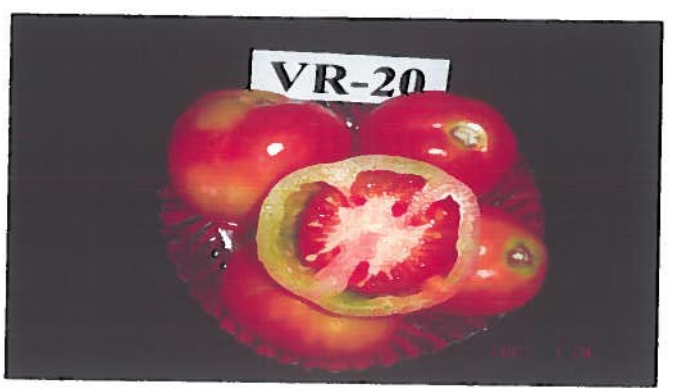
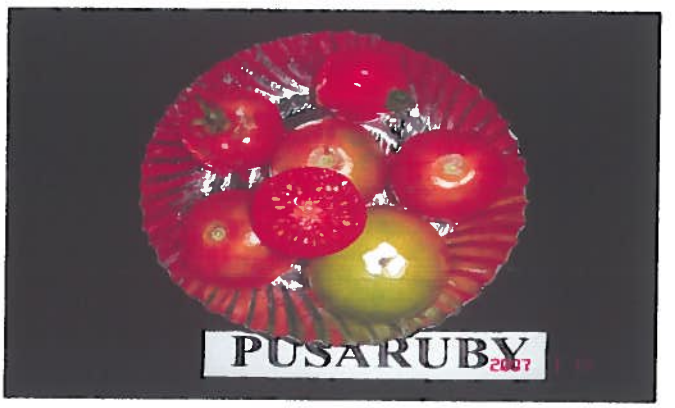


PLATE-8: DIFFERENT GENOTYPES OF TOMATO



genotypes S-22, RK-318, RCMT-2, DVRT-2, CO-3 from cluster I for early flowering. Similarly genotypes Improved Shalimar and Pusa Ruby more number of primary branches, less number of seeds per fruit, higher fruit yield alongwith more total soluble solids and acidity from cluster II. Whereas, genotypes SC-3, Uday-PGT-II, Sarvoday, Punjab Keshary, RCMT-1, ALT-02-39 and VR-20 to be selected from cluster IV for determinant plant type, higher fruit weight, thick pericarp and higher reducing sugar.

The clustering pattern revealed that geographical diversity could not be related to genetic diversity in the material investigated. Similar conclusions were drawn by Rai *et al.* (1998) for number of primary branches per plant, days to 50 per cent flowering, fruit length, plant height and average fruit weight; Sharma and Verma (2001) for fruit yield per plant, pericarp thickness and fruit diameter; Joshi and Kohli (2003) for fruit yield per plant and average fruit weight and Mahesha *et al.* (2006) for days to 50 per cent flowering, plant height, number of branches per plant, fruit weight, fruit length, fruit width, number of locules per fruit, number of seeds per fruit and fruit yield per plant.

This implied that their was no parallelism between genetic divergence and geographical divergence. This has been observed that diverse the parents within its overall limits of fitness, the greater are the chances of heterotic expression in F_1's and a broad spectrum of variability in segregating generations. In this study, group constellation showed that Uday PGT-II, Navoday, Sarvoday, S-22 and Improved Shalimar were highly divergent from all other genotypes and may be used as parents in hybrid breeding programme, which exploits heterotic expression for fruit yield and quality characters in tomato for Chhattisgarh plains.

Summary, Conclusions and Suggestion for future research work

CHAPTER - V

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH WORK

The present investigation entitled " **Genetic divergence for fruit traits in tomato (*Lycopersicon esculentum* Mill.)**" was conducted at Department of Horticulture, Horticultural Research Farm, under All India Coordinated Vegetable Improvement Project, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Rabi* 2006-07. The experiment was comprised of 28 genotypes of tomato (*Lycopersicon esculentum* Mill.) and laid out in Randomized Block Design (RBD) with three replications to estimate the genetic variability, heritability, genetic advance, correlation coefficient, path analysis and genetic divergence.

Five randomly selected plants were considered for observations of different characters *viz.*, days to 50 % flowering, plant height (cm), number of primary branches per plant, fruit weight (g), fruit length (cm), fruit width (cm), number of locules per fruit, number of calyx per fruit, pericarp thickness (mm), number of seeds per fruit, total soluble solids (%), reducing sugar (%), acidity (%), pH and fruit yield per plant (kg).

The analysis of variance indicated that the mean sum of square due to genotypes were significantly influenced for days to 50 % flowering, plant height (cm), number of primary branches per plant, fruit weight (g), fruit length (cm), fruit width (cm), number of locules per fruit, number of calyx per fruit, number of

seeds per fruit, total soluble solids, reducing sugar, acidity and fruit yield per plant (kg).

The highest yield was recorded in genotype Uday PGT-II, which was followed by Pusa Ruby and Local-2. The earliest flowering was recorded at 61 (S-22) days, followed by 62.33 (CO-3) days. The Maximum plant height was recorded by Improved Shalimar, followed by Pusa Ruby, S-21, Pant-T-3 and Pant-T-7.

The highest genotypic and phenotypic coefficient of variation was recorded for pericarp thickness, number of locules per fruit, fruit weight and plant height. The phenotypic coefficients of variation were higher than the genotypic coefficient of variation. The highest heritability was noted in characters like number of seeds per fruit, plant height, reducing sugars, days to 50% flowering, total soluble solids, fruit weight and fruit yield per plant. Whereas, highest heritability coupled with highest genetic advance were observed for characters *viz.*, pericarp thickness, fruit weight, number of seeds per fruit, plant height, acidity and fruit yield per plant. Hence, these characters might be improved by simple selection.

Fruit yield per plant exhibited significant positive correlation with fruit weight at phenotypic and genotypic levels but with fruit length and number of calyx per fruit only at genotypic level. It indicated that major emphasis should be given on these components for increasing the fruit yield per plant.

Similarly significant negative correlations were recorded for plant height with fruit length, acidity, number of calyx per fruit and number of seeds per fruit. Hence, these characters may improved from indirect selection.

Path coefficient analysis revealed that fruit weight, number of locules per fruit, number of primary branches per plant, total soluble solids, fruit length, days to 50% flowering, plant height and pericarp thickness had positive direct effect on fruit yield per plant. On the other hand, the positive and indirect effect of days to 50 per cent flowering, number of primary branches per plant, fruit weight, fruit length, number of locules per fruit, plant height and pericarp thickness was recorded with fruit yield per plant.

D^2 values recorded on fruit yield and its components for twenty eight genotypes, indicated the presence of appreciable amount of genetic diversity among the genotypes, which were grouped into five clusters based on relative magnitude of D^2 values.

In this study, group constellation showed that Uday PGT-II, Navoday, Sarvoday, S-22 and Improved Shalimar were highly divergent from all other genotypes. This indicated that hybrid breeding programme with Uday PGT-II and Sarvoday will be used as parents, may be effective to exploit heterotic expression for fruit yield and quality characters in tomato for Chhattisgarh plains.

Thus, while planning hybridization programme for the development of heterotic hybrids and better transgressive segregants one should select genotypes S-22, RK-318, RCMT-2, DVRT-2, CO-3 from cluster I for early flowering. Similarly genotypes Improved Shalimar and Pusa Ruby more number of primary branches, less number of seeds per fruit, higher fruit yield alongwith more total soluble solids and acidity from cluster II. Whereas, genotypes SC-3, Uday-PGT-II, Sarvoday, Punjab Keshary, RCMT-1, ALT-02-39 and VR-20 to be selected from

cluster IV for determinant plant type, higher fruit weight, thick pericarp and higher reducing sugar.

SUGGESTIONS FOR FUTURE RESEARCH WORK

Since the results of present investigation belong to only one year of experiment, for reaching to any definite conclusion and recommendation, it needs further conduction of the same for at least two successive years in different environment. However, following studies are also suggested to be undertaken in future

1 The experiment may be conducted during different seasons.

2 There is need of in depth study on qualitative aspect and post harvest preservation technology of the tomato which has not been adequately covered under the present study.

3 More number of genotypes may be collected from different untouched places of India.

4 In order to improve the fruit yield per plant and other important attributes genotypes falling in distant characters may be utilized in future breeding programme.

5 There is need to screen the genotypes against biotic stresses (disease and insect) particularly bacterial wilt and viral diseases complex.

6 Characterization of *Lycopersicon esculentum* genotypes may be included for DUS (distinctness, uniformity and stability) testing and PVP (plant variety protection) legislation. Thus, this will enable to use in future crop improvement programme.

7 The present study raised the possibility of selection and breeding strategies on the basis of genetic diversity for flavour and colour components of fruit. This would lead to significant success for development in *Lycopersicon esculentum* and its varieties for commercial exploitation for Chhattisgarh plains.

Abstract

"GENETIC DIVERGENCE FOR FRUIT TRAITS IN TOMATO (*Lycopersicon esculentum* Mill.)"

by

PRAMILA JOGI

ABSTRACT

The present investigation was conducted at Department of Horticulture, Horticultural Research Farm, under All India Coordinated Vegetable Improvement Project, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Rabi* 2006-07. The experimental material comprised of twenty-eight genotypes of tomato and the experiment was laid out in Randomised Block Design with three replications. Data were analysed to work out the variability, heritability, genetic advance, path analysis, correlation coefficients and genetic divergence for the characters viz., days to 50 per cent flowering, plant height, number of primary branches per plant, fruit weight, fruit length, fruit width, number of locules per fruit, number of calyx per fruit, pericarp thickness, number of seeds per fruit, total soluble solids, reducing sugar, acidity, pH and fruit yield per plant.

The analysis of variance revealed that the high genotypic and phenotypic coefficient of variation were recorded for days to 50 per cent flowering, plant height (cm), number of primary branches per plant, fruit weight (g), fruit length (cm), fruit width (cm), number of locules per fruit, number of calyx per fruit, number of seeds per fruit, total soluble solids, reducing sugar, acidity and fruit yield per plant (kg).

Correlation and path analysis revealed that fruit weight influenced the fruit yield per plant with high direct effect and significant positive correlation therefore, fruit weight as an important character which may be included in selection criterion for improvement in fruit yield per plant.

The divergence analysis revealed the presence of appreciable amount of genetic diversity in the tested genotypes. Twenty-eight genotypes were grouped into five clusters. Thus, while planning hybridization programme for the development of heterotic hybrids and better transgressive segregants one should

select genotypes S-22, RK-318, RCMT-2, DVRT-2, CO-3 from cluster I for early flowering. Similarly genotypes Improved Shalimar and Pusa Ruby more number of primary branches, less number of seeds per fruit, higher fruit yield alongwith more total soluble solids and acidity from cluster II. Whereas, genotypes SC-3, Uday-PGT-II, Sarvoday, Punjab Keshary, RCMT-1, ALT-02-39 and VR-20 to be selected from cluster IV for determinant plant type, higher fruit weight, thick pericarp and higher reducing sugar.

Inter crossing of genotypes from diversed clusters, showing superior mean performance may help in obtaining higher fruit yield per plant with growth and fruit characters of lead components in tomato for Chhattisgarh plains.

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* *Originals not seen.*

Appendices

APPENDIX-1

Weekly meteorological observations during crop growth period (October 2006 – February 2007)

Week no.		TEMPERATURE (°C)		Rain fall (mm)	Relative Humidity (%)		Wind velocity (kmph)	Evaporation (mm)	Sunshine (hour)
		Maximum	Minimum		morning (I)	evening (II)			
Oct., 2006	40	31.8	23.7	5.9	94	63	4.4	3.5	7.7
	41	33.7	23	0	91	43	2	3.9	8.6
	42	33.3	20.8	0	93	46	2.4	4.1	9
	43	31.3	18.8	0	90	47	2.5	4	9.3
	44	27.8	20.8	1.6	93	65	3.6	2.3	2.8
Nov., 2006	45	29.6	18.3	0	92	43	2.7	3.1	5.6
	46	29.4	14.6	0	91	35	2.6	3.4	9
	47	31	15.2	0	89	31	2.1	3.3	8.4
	48	30.7	18	0	87	41	2.3	3.5	7.2
Dec., 2006	49	30.8	15	0	88	32	1.9	3.4	8.3
	50	29.4	12.2	0	88	29	2.2	3.3	8.5
	51	26.9	10.6	0	90	35	2.4	3.1	8.1
	52	28.1	11.9	0	88	36	2.2	2.7	8.1
Jan., 2007	1	26.7	9.6	0	88	30	2.6	3.1	8.5
	2	28.8	10.6	0	89	32	2	3	8.3
	3	28.4	11.5	0	83	30	2.5	3.4	7.5
	4	29.4	10.4	0	83	22	2.2	3.8	9
	5	31.6	15.6	0	80	32	2.2	3.9	7.1
Feb., 2007	6	31.3	16.4	0	85	37	4.5	4.6	7.6
	7	37.6	15	22.4	87	43	4.2	4	8.2
	8	30.4	13	0	81	21	2.9	4.9	10.2
	9	32	16.6	0	78	27	4.7	5.9	9.6