

**Studies on Genetic Variability, Heritability, Genetic Advance, Correlation Coefficient and Path Analysis in Tomato (*Solanum lycopersicum* L.)**

**THESIS**

Submitted To  
Babasaheb Bhimrao Ambedkar University  
(A Central University)  
Lucknow

BABASAHEB  
BHIMRAO  
AMBEDKAR  
UNIVERSITY



प्रजा शील करुणा  
ESTABLISHED 1996

FOR THE AWARD OF THE DEGREE OF  
**Doctor of Philosophy**  
In  
**HORTICULTURE**

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**Prof. R. B. Ram**

*Submitted By:*  
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Enrollment No.-1326/16

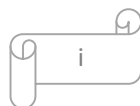
DEPARTMENT OF APPLIED PLANT SCIENCE (HORTICULTURE)  
SCHOOL FOR BIO-SCIENCES AND BIOTECHNOLOGY  
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INDIA  
**2021**

*Dedicated To*

*My*

*Loving Parents*

*Rajeev Kumar*



# DECLARATION

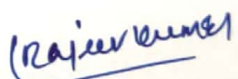
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I, **Rajeev Kumar**, Enrollment No. **1326/16**, hereby declare that, I am a candidate for the degree of **Doctor of Philosophy in Horticulture**, Department of Applied Plant Science (Horticulture), School for Bio-sciences and Biotechnology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Raebareli Road, Lucknow-226025 (U.P.), India and have carried out my research work entitled "**Studies on Genetic Variability, Heritability, Genetic Advance, Correlation Coefficient and Path Analysis in Tomato (*Solanum lycopersicum* L.)**". This thesis has been submitted for the award of the degree of Doctor of Philosophy in Horticulture is my original research work.

I do also hereby undertake that the thesis is essentially free from any kinds of plagiarism.

Date: 10.09.2021

Place: BBAU, Lucknow

  
(Rajeev Kumar)

## CERTIFICATE

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This is to certify that the thesis entitled “**Studies on Genetic Variability, Heritability, Genetic Advance, Correlation Coefficient and Path Analysis in Tomato (*Solanum lycopersicum* L.)**”. Submitted by **Mr. Rajeev Kumar**, Enrollment No. **1326/16** is an original research work and has not been previously submitted in part or full for the award of any other degree or diploma to this or any other university.

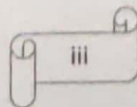
The thesis submitted to Babasaheb Bhimrao Ambedker University, Lucknow satisfies all the requirements as stipulated in the Doctor of Philosophy (Ph.D.) regulations- 1999 as amended in 2008/2010/2013 and it is fit for submission and evaluation for the award of the degree of Doctor of Philosophy of the University.

Date: 10.09.2021

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Supervisor

  
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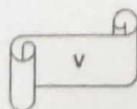
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*Date: 10.09.2021*

*Place: BBAU, Lucknow*

*(Rajeev Kumar)*  
(Rajeev Kumar)



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## List of Abbreviations

Symbol	Abbreviation	Stands for
%	-	Percentage
&	-	And
/	-	Per
@	-	At the rate of
-	0C	Degree Celsius
-	ANOVA	Analysis of variance
-	CD	Critical difference
-	cm	Centimeter
-	CV	Coefficient of variation
-	cm <sup>2</sup>	Centimeter square
-	m	Meter
-	cv.	Cultivar
-	Df	Degree of freedom
-	<i>et al.</i>	et alli (others)
-	etc.	Et cetera
-	Fig.	Figure
-	RBD	Randomized Block Design
-	ha	Hectare
-	Kg/plot	Kilogram per plot
-	q/ha	Quintal per hectare
-	<i>i.e.</i>	id est. (that is)
-	Kg	Kilogram
-	U.P.	Uttar Pradesh
-	MSS	Mean sum of squares

-	Max.	Maximum
-	Min.	Minimum
-	mg	Milligram
-	g	Gram
-	No.	Number
-	NS	Non significant
-	ml	Milliliter
-	mm	Millimetre
-	R.H.	Relative humidity
-	S.Em $\pm$	Standard error of mean
-	PCV	Phenotypic coefficient of variation
-	GCV	Genotypic coefficient of variation
-	$h^2$	Heritability square
-	GA	Genetic advance
-	e.g.	exempli gratia (for example)
-	viz.,	videlicet (namely)
-	N	Normal solution
-	ug	Microgram
-	nm	Nanometer
-	rpm	Rotation per minute
-	Conc.	Concentrated
-	hr.	Hour
-	IU	International unit
-	$^{\circ}\text{B}$	Degree brix
-	fig	Figure
-	Vit- C	Ascorbic acid
-	Vs.	Against
-	Per se	As such with mean
-	VRS	Vegetable Research Station



## ***CHAPTER-1***

### ***INTRODUCTION***

## *INTRODUCTION*

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Vegetable contains an important element of the balance diet for human beings. They supply essential nutrients and minerals that the human body for a healthy and active life. India is currently, the second largest producer of vegetables next to China in the world with an all out production of 175.01 (MT) from 10.29 million hectares area and grown in 2.8% of all out developed land which share 13.38% of world production with a productivity of 17.01(MT/ha) (NHB, 2017). Tomato (*Solanum lycopersicum* L.) belongs to the family Solanaceae with chromosome number  $2n = 24$  and originated from South America. Tomatoes are one of the most frequently farmed and consumed vegetables on the planet, coming in second only to potatoes in terms of importance in many nations and first in terms of preserved and processed vegetables. Tomatoes are a commonly used vegetable crop in both the fresh fruit and processed food industries around the world. Tomato is extra nutritious food and used in preserved products like ketchup, sauce, chutney, soup, paste, puree etc.

The genus *Solanum* contains of annual or short-lived perennial, nutritious plants is a typical day neutral crop and belongs to warm season crop reasonably resistant to hot and drought. The current demand for tomatoes is based on the industrial requirement and ultimately the consumer's preferences. So there is an immediate need for continuous improvement of this crop through development of superior varieties and hybrids in order to the present day requirement.

According to **Aykroyd (1963)** tomato fruit contain 93.1 g water, protein 19 g, fat 0.1 g, carbohydrate 3.6 g, mineral 0.6 g, calcium 20 mg, phosphorus 36 mg, iron 0.8 mg, carotene (as vitamin A) 320 IU, thiamine 2.27 mg, nicotinic acid 0.4 mg , riboflavin 0.01mg, and ascorbic acid 3.1mg per 100 g of pulp of fruit. It also contains folic acid, pantothenic acid, biotin, vitamin K and vitamin related inhibitors E.

Conventional breeding methods such as bulk and back cross breeding with some variation have been principle procedures followed in the improvement of self pollinated plants. Such procedure although significant and productive in their own right impose restriction on the change of better reconfiguration because of larger

linkage blocks associated with the weakness of causing rapid homozygosity and low genetic variation (Clegg *et al.*, 1972). Further, negative correlation among yield constituents and high genotype environmental interaction prevents the full exploitation of genetic variability in characters like yield. If this proposal is to be accepted, to boost the genetic yield potential, we must re-evaluate our breeding procedure. Maximizing the desirable quality for synthesizing any optimal genotype is critical. Fruit yield is a quantitative character which influenced by a number of yield contributing characters. Selection for higher yield the complex inter relationship the yield contributing characters usually shows a complex chain of interacting relationship. The tomato yield is the result of numerous different component characters each contributing to the overall output.

Throughout evolution, domestication and dispersion to extraordinary components of the world, the genetic base of tomato became strongly narrowed, ensuing within side the lack of resulting in the loss of alleles of hobby for breeding necessitating the significance of growing excessive yielding varieties. The basic tool to bring genetic development in a crop is to make use of the genetic variability. If the variety with the populace is basically because of the genetic cause with least surroundings effect, the opportunity of acquiring advance genotype is so visible. Yield development in tomato is a polygenic individuals and it is associated with agronomic, morphologic and physiologic tendencies. Hence direct selection is regularly misleading. The development of breeding in this type of populace is by and large contributed via way of means of magnitude, nature of interplay of genotype, and environmental variant emphasizing the significance to partition the discovered variability into heritable and non-heritable tendencies with appropriate genetic parameters which include heritability, genetic advance etc. The genotypic and phenotypic coefficient of variation are useful for detecting the amount of variability in genotypes, whereas heritability and genetic advance are useful for determining the influence of environment on character expression and the extent to which development is viable after selection Patel *et al.*, (2013). Hence the purpose of this study was to identify the qualities that are extremely important for tomato yield calculating variability, heritability, genetic advance and also to discover advance hybrids, and potential genotypes for breeding programs.

The systematic study and evaluation of germplasm is critical for the crops current and

future agronomic and genetic development of the crop Reddy *et al.*, (2013). Correlation coefficient facilitates a breeder to choose an efficient trait in breeding programmed and to allocate appropriate for obtaining optimal results. Path analysis allows for the division of correlation coefficients into direct and indirect impacts of numerous features on yield or any other attributes, as well as the investigation of specific components that provide a given correlation. As yield is a complicated character, its direct development is difficult. The knowledge of the relationship among yield and other plant characters and their relative contribution to yield is very useful, while formulating the choice scheme with the target to enhance yield. Therefore, if you want to formulate a legitimate breeding plan for its development, through path coefficient analysis the existing test was carried out to determine the correlation and direct and indirect effect of various features on tomato fruit yield.

The breeding objectives of tomato are to broaden excessive yielding cultivars and hybrids, to broaden sort's resistance to pest and diseases, to breed varieties with better keeping quality in the field fruit formation and to broaden hybrid seed production. **Burton (1952)** recommended that genotypic coefficient of variation mixed with heritability is a correct measure to know the heritable variation as well as to gain a better idea of the amount of advance that may be expected from the selection. The heritability of characters decide how tons the phenotype of a plant is a tent to the genotype and thus, assist the breeder to base his choice at the phenotypic overall performance of the plant. The genetic advance fulfils more clear selection by taking into the account of scope and effectiveness of choice for enhancing a character conditions by genetic variability and transmissibility respectively.

Keeping in view of the above facts in mind, the present investigation, entitled “**Studies on Genetic Variability, Heritability, Genetic Advance, Correlation Coefficient and Path Analysis in Tomato (*Solanum lycopersicum* L.)**” has been taken to generate information about general and specific combining ability effect, standard variety and better parent, inbreeding depression, variability, heritability, genetic advance, correlation coefficient and path analysis through different line analysis. The finding of this study would be helpful in the selection of promising F<sub>1</sub> hybrids for yield and different characters and to formulate suitable breeding programme for attaining the favored genetic development in tomato.

**OBJECTIVES OF THE STUDY**

The present research entitled ‘Genetic Variability, Heritability, Genetic Advance, Correlation Coefficient and Path analysis in tomato (*Solanum lycopersicum* L.)’ was planned and carried out with the following objectives:

1. To find out genetic variability, heritability and genetic advance for growth, flowering and yield components in tomato.
2. To investigate the nature of association of yield with its component traits.
3. To determine the correlation coefficient and path analysis among different traits.



*CHAPTER-2*

*REVIEW*

*OF*

*LITERATURE*

*REVIEW OF LITERATURE*

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Differentiation of elite genotypes, based on trustworthy features would not only aid in the preservation of identity but will also reflect genetic variance, which is useful in study of genetic diversity. Intoning and encourage effective genetic assets conservation and germplasm utilization. The amount genetic variability that may be exploited determines the effectiveness of any breeding operation. The fulfilment on die type of variety in available genetic material, as well as the factors that only affect those features, is critical for crops long term viability. Parameters like genetic variability. Heritability and genetic benefit have direct or indirect influence on the fate of the breeding programme of a crop. To make choice of genotypes more efficient knowledge of association of character is very much impotent. Several researchers have obtained green tomato genotypes from various resources. Which revealed a wide range of variation in morphological and physiological characteristics that influence the performance. The literature related to the existing research has been compiled and is being reviewed under the headings below.

2.1 Genetic Variability studies

2.2 Heritability and genetic advances

2.3 Correlation coefficient studies

2.4 Path analysis

**2.1 Genetic Variability Studies:**

Genetic variability denotes the part of phenotypic variance that's as a result of variation in the genetic constitution of individual population. As beforehand of time table as 1889. Galion discovered a box with a constant variety of contents due to genetics. The investigation of heritable and non-heritable sections of inconstancy began with **Johnson's** discovery (1909). Hereditary inconstancy means the part of phenotypic difference which is brought about by variety in the hereditary charter of

person populace. How much the in fidelity of quantitative individual is resolved to the offspring is alluded as heritability.

**Nadar *et al.* (1980)** determined that the maximum accelerated hereditary changeability for yield consistent with plant and referenced that for all characters viz; plant stature, natural product weight and natural product yield per plant. The genotypic coefficient of range changed into now no longer precisely the phenotypic coefficient of range in tomato.

**Bhutani *et al.* (1983)** taken into consideration the hereditary changeability of eighty four genotypes of tomato and observed that Sel. No. 23, Grow hens Globe, Punjab Chhuhara, VS 11-2, Pusa Red Plum and H.S.I 00 displayed the maximum noteworthy characteristics for juice/mash proportion, range of locules according to organic product, pericarp thickness, number of seeds per organic product, number of organic products per plant and yield per plant.

**Dudi *et al.* (1983)** observed that the excessive genotypic and phenotypic coefficient of range for organic product weight, number of natural product per plant and natural product yield in line with plant in tomato. **Abani and AZO (1984)** detailed high hereditary variety for all out dissolvable robust in tomato. **Cobani and Merja (1986)** recorded low variety for organic product shape (share of period to breadths) mash thickness and titrable acidity in tomato.

**Sonone *et al.* (1986)** introduced the maximum improved genotypic and phenotypic fluctuation of tomato for plant stature, number of natural product in keeping with plant and organic product weight.

**Kumar and Lal (1988)** recorded the number of natural products per plant. Level of natural product set, seed content (gm) indicated excessive degree of PCV and GCV in tomato.

**Padmalata and Reddy (1990)** investigated that the excessive genotypic and phenotypic coefficient of variety in tomato for plant tallness, quantity of natural products per plant and organic product yield in line with plant and occasional GCV and PCV for natural product weight.

**Reddy and Reddy (1992)** tested 139 genotypes of tomato and precised that the most extreme scope of variety for number of organic products per plant, yield per plant and average natural product weight, while least variety for a considerable length of time to half blossoming.

**Bhangu and Singh (1993)** claimed a wide range (24.66 to 66.69g) of inconstancy for normal natural product weight in 7 tomato assortments. **Jasmine and Ramdas (1993)** recorded the best return per plant (1.06) in cross breed ARTH-4 and most reduced yield per plant (0.40) in FM-2 in tomato. **Matiar et al., (1994)** discovered greatest (2.67kg) and least (1.32kg) yield per plant in Manik and TMO 290 separately among the 12 lines thought about for yield chance in tomato.

**Bharadwaj and Thakur (1994)** observed that natural product yield of tomato relied on factors like number of organic products per plant and size of organic products. Both these traits were legitimately impacted by high temperature during summer which caused decrease in natural product yield of certain genotypes. **Kumari and Subramanian (1994)** exhibited wide scope of changeability (1.94-5.68) for wide variety of locules according to organic product in 87 cultivar of tomato.

**Nair and Thamburaj (1995a)** evaluated excessive inconstancy at genotypic and phenotypic degrees as showed by most noteworthy value determinations of GCV and PCV for number of organic products per plant (40.79% and 41.93%) in tomato, which is a significant yield part.

**Pujari et al. (1995)** introduced maximum noteworthy genotypic and phenotypic coefficient of range for number of organic products per plant and natural product weight in tomato.

**Lupascu et al. (1996)** observed that the excessive inconstancy in tomato for wide variety of natural products per plant and foulness yield per plant and low phenotypic range for plant tallness.

**Mittal et al. (1996)** led the changeability thinks approximately in tomato below sub-damp state of Himachal Pradesh and demonstrated exceptionally critical distinction among the cultivars, showing significant measure of hereditary inconstancy for attractive organic product yield per plant, normal natural product weight, plant stature and number of natural products per plant. These characters are

below the have an effect on of brought substance features which holds a decent possibility of progress through determination.

**Sreenivasula and Rao (1996)** confirmed excessive hereditary fluctuation in tomato for the characters of number of branch per plant, number of natural products per plant, organic product weight and natural product yield per plant.

**Padmini and Vadivel (1997)** recorded the little difference amongst genotypic and phenotypic distinction in tomato for number of organic products per group, number of natural products per plant, organic product length and natural product width, number of days taken from transplanting to first blooming, organic product weight, mash thickness and organic product yield according to plant.

**Singh et al. (1997)** determined excessive phenotypic but exceedingly low genotypic change in tomato for plant stature, number of organic products per plant, natural product weight and organic product yield according to plant.

**Ambarus (1998)** located that the low fluctuation in tomato for plant stature, organic product duration and natural product distance throughout but excessive alternate for organic product weight.

**Ambras and Tanasescu (1998)** found that the low distinction in tomato for plant tallness, organic product length and natural product width and mild fluctuation for range of organic products per plant and organic product weight.

**Brar et al. (1998)** observed that the high difference in tomato for the characters of organic product weight and TSS in tomato.

**Das et al. (1998)** recorded excessive genotypic coefficient of variety in tomato for organic product length, number of natural products per plant, natural product measurement, organic product weight and natural product yield in step with plant.

**Phookan et al. (1998)** opined maximum noteworthy genotypic and phenotypic coefficient of variety in tomato for organic product weight and natural product yield in keeping with plant.

**Batra et al. (1999)** observed excessive distinction in tomato for mash thickness and TSS content (3.5% - 7.0%).

**Kumar and Tewari (1999)** opined that yield proven the maximum improved phenotypic and genotypic coefficient of changes, trailed by juke consistency, causticity and ascorbic corrosive in tomato.

**Prasad *et al.* (1999)** determined that the maximum noteworthy genotypic and phenotypic coefficient of variety for plant stature and TSS content material in tomato.

**Pradeep kumar *et al.* (2001)** pointed out that the extensive scope of variety for plant stature, quantity of natural products per plant, single organic product weight and natural product yield per plant in tomato and moreover noticed that the tremendous majority of the characters to show high phenotypic coefficient of variety and genotypic coefficient of variety esteems.

**Bharti *et al.* (2002)** located that yield in step with plant had excessive genotypic coefficient of variety (GCV) and phenotypic coefficient of variety (PCV) in tomato.

**Mohanty (2002)** noticed that the high GCV in tomato for number of natural product per plant (27.87%) and number of locules which will be improved through sincere choice. **Singh *et al.*, (2002)** noticed that excessive PCV and GCV of tomato for normal natural product weight. Number of organic products per plant has likewise been accounted for to have excessive GCV **Marine *et al.*, (2003); Aradhana and Singh (2003).**

**Joshi *et al.* (2004)** found the highest coefficient of variant for phenotypic and genotypic for number of that in keeping with plant and fruit shelf life.

**Ahmed *et al.* (2006)** observed that the high phenotypic and genotypic coefficient of variation for yield per plant, plant height, common fruit weight, juice to pulp ratio and number of per plant. Further Hide range of variation was observed by **Mahesha *et al.* (2006)** for plant height, number of branches according to plant, fruit weight, fruit length, fruit diameter, avenge fruit weight, number of locules according to fruits, fruit set percent and fruit yield according to plant.

**Singh *et al.* (2006)** determined high GCV for number of natural products according to plant, normal organic product weight, number of locules according to organic product, length of foods grown from the ground yield according plant in tomato.

**Golani *et al.* (2007)** observed that the high GCV and PCV in tomato for regular natural product weight and yield per hectare. **Kumari *et al.*, (2007)** noticed that maximum noteworthy GCV in tomato to be available for plant tallness pursued by yield and lycopene content material on this way. Thus, these characters might be improved through choice.

**Haydar *et al.* (2007)** determine that the GCV and PCV in tomato to be maximum noteworthy for organic product weight and number of leaves at blooming. They also saw higher GCV and PCV for natural product weight according to plant in tomato.

**Mehta and Asati (2008)** Ascertained that the high GCV and PCV for natural product yield according to plant, normal organic product weight and number of groups according to plant in tomato.

**Ara *et al.* (2009)** examine that the number of essential branches per plant and number of organic products according to plant had high GCV and PCV, while normal natural product weight and TSS showed moderate GCV and PCV in tomato.

**Singh (2009)** determined the characters of genotypes like number of fruits according to plant, fruit yield, plant height, average fruit weight and fruit length and found high genotypic and phenotypic coefficient of variation among these characters and moderate genotypic and phenotypic of variation in character like fruit width, fruit diameter and number of branches according to plant.

**Ghosh *et al.* (2010)** observed that for features like days to first flowering, fruits length, fruit diameter and fruit yield per plant, there was very little difference between phenotypic and genotypic coefficient of variation.

**Shashikanth *et al.* (2010)** and **Mohamed *et al.* (2012)** assessed the natural product weight indicated the maximum elevated genotypic and phenotypic fluctuation (1642.9 and 1779.1), though organic product yield according plant demonstrated the least ones (0.17 and 0.39). High genotypic fluctuation was watched for a large portion of the characters demonstrating more commitment of hereditary segment for the complete variety. Genotypic coefficients of varieties (GCV) and phenotypic coefficient of variety (PCV) were maximum noteworthy for organic product weight (0.4885 and 0.4905). The vast majority of the characters had higher GCV and PVC

indicating a greater span of inconstancy for these characters. Plant stature (97%) had the highest heritability, whereas organic product output per plant had the lowest (43%). High heritability (expansive faculties) measure was watched on for all the tried characters showing that these characters are constrained by added substance qualities activity which is valuable in choice.

**Tasisa et al. (2011)** and **Singh et al. (2006)** reported regarding hereditary development as percent of mean was maximum noteworthy for normal organic product weight (45.12%) and number of locules (33.64%) indicating significant job of hereditary factor towards articulation of these characters as hereditary development was evaluated based on heritability. In this manner for these characters, there is most extreme probability of productive phenotypic choice. Heritability assesses alongside hereditary development is more valuable than the heritability alone. Maximum elevated appraisals of heritability went with high hereditary development were found in normal organic product weight, natural product yield according plant, number of gathering, TSS and number of locules.

**Dar and Sharma (2011)** reported that investigation of coefficient of variety uncovered that size of phenotypic coefficient of variety was higher than genotypic coefficient of variety for every one of the characters under examination. The higher estimations of Phenotypic Coefficient of Variation (PCV) were recorded for yield q/h, normal natural product weight, and number of organic products per plant though high Genotypic Coefficient of Variation (GCV) was recorded with 0-carotene in tomato.

**Kaushik et al. (2011)** carried out research on ten varieties of tomato and reported that maximum variation was found for fruit yield and minimum was found for fruit width. Number of leaves, fruit length, and fruit yield had the greatest magnitude of genotypic and phenotypic coefficient of variation. High standards of heritability attached with high genetic advance were practical for number of leaves at sixty days after transplanting and fruit yield.

**Vyas et al. (2011)** reported high phenotypic and genotypic coefficient of variation for fruit yield, average fruit weight, number of locules per fruit, number of fruits per plant, number of seeds per fruits and storability.

**Taisa *et al.* (2011)** examined the high estimations of GCV and PCV in tomato were available for organic product per plant and plant stature demonstrating the presence of higher greatness of inconstancy.

**Mohamed *et al.* (2012)** assessed the natural product weight demonstrated the most noteworthy genotypic and phenotypic fluctuation (1642.9 and 1779.1) while, organic product yield per plant indicated the least ones (0.17 and 0.39). For the vast majority of the features high genotypic fluctuation was discovered, indicating a greater commitment of hereditary portion for the overall variation. For organic product weight (0.4885 and 0.4905), phenotypic coefficients of variety (PCV) and genotypic coefficients of variety (GCV) were the most notable, albeit the least ones were for a long time to half flowering (0.0552 and 0.0665). Higher GCV and PVC were recorded for the vast majority of the characters demonstrating higher greatness of changeability for these characters in tomato.

**Ayush *et al.* (2012)** found substantial differences in yield and yield contributing features across several tomato genotypes. Number of fruits per plant had the largest phenotypic coefficient of variation and genotypic coefficient of variation, whereas the harvest index, on the other hand was the lowest. The number of primary branches per plant, the number of fruits per plant, the number of fruits per cluster, the average fruit weight, and the fruit yield per plant demonstrated strong heritability and advancement as a percentage the mean.

**Buckseth *et al.* (2012)** reported for number of fruits per plant, average fruit weight, yield per plant, pericarp thickness and thousand seed weight were originate high phenotypic and genotypic coefficients of variation as well as elevated heritability with high genetic gain.

**Rahaman *et al.* (2012)** evaluated thirty-four genotypes of tomato during Rabi season to determine genetic factors such as variability, heritability and genetic advance. Fruit weight, followed by fruit length, had the highest phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) estimates, while number of flowers per cluster and total acid had the lowest (percent).

**Kumar *et al.* (2013)** studied on the yield and yield contributing characters of twenty-six tomato genotypes. For the characteristics, the analysis of variance

indicated highly significant differences among all genotypes. Plant height, number of fruits per plant, yield per plant, and fruit weight all had high phenotypic coefficients of variability (PCV), genotypic coefficient of variability (GCV) and heritability estimations, as well as high genetic sails.

**Patel *et al.* (2013)** reported that the highest GCV and PCV were found for natural product yield per plant, organic product yield per plant and number of locules per natural product respectively, while the lowest GCV was observed for a long time to harvest, days to half blooming and pericarp thickness, they also discovered high PCV for a long time to harvest and day to half blooming.

**Reddy *et al.* (2013)** observed that PCV was found to be superior than the (GCV), and the characters plant height, number of clusters per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, fruit length, fruit weight, fruit yield had high heritability united with high genetic progress suggest that additive gene action governs these traits, and that these features can be increased through simple selection.

**Shankar *et al.* (2013)** found that plant tallness, number of organic products per group, normal natural product weight, yield per plant, ascorbic corrosive, and lycopene had high of PCV and GCV values, indicating a good deal of changeability in those characters, implying the viability of determining of attractive sorts for development.

**Meitei *et al.* (2014)** investigated the hereditary variation in yield and yield ascribes as well as genotypes for protection against early tomato plague infection (*Solanum lycopersicum* L.). With the exception of the vital branches plant, the genotypes read for each of the traits revealed a wide range of variation. The genotype H-24 was chosen as the finest of the genotypes in terms of yield (1309.50g plant ) and natural product bunch plant (37.33), resulting in the best return/ha (401.64q). for single organic product weight, the genotype 2012/TOLCVRES-3 was practically the most notable (71.33g). NDT-3, another genotype, was the best for naturopathic medicine. It was the best for natural product width (6.47cm). More edibles were grown from the ground bunches plant in Sel 35. Organic product bunches and plants, single organic product weight, natural product yield plant and organic product yield/ha all had high GCV.

**Khapte and Jansirani (2014)** studied on the plant height, number of flowers per clusters, number of flower clusters per plant, fruit length, fruit diameter, fruit shape index, pericarp thickness, total soluble solids, average fruit weight fruit firmness, number of fruits per plant and yield per plant all revealed higher phenotypic coefficient of variation than genotypic coefficients of variation.

**Osekita and Ademiluyi (2014)** claimed that the PCV and GCV showed significant differences in the amount of natural products per plant (PCV = 52.40) and (GCV=19.11), as well as the number of locules per plant (PCV = 27.27) and (GCV = 9.64).

**Paul *et al.* (2014)** carried out experiment with the motivation behind the investigation was to discover the hereditary variation among the yield contributing qualities as well as their immediate and backhanded commitment of these parameters to yield and to identify better mixes as selection criteria for growing high yielding tomato genotypes. Aside from the height of the first leaf at seedling stage, other characters showed significant differences across genotypes for a long time to germination, organic products per pack, gather record, and yield per plant, the genotypic coefficient and phenotypic coefficients of variety (GCV) and PCV) were both quite high (g).

**Henerah (2015)** found that a study of variation revealed a significant difference between genotypes for all of the tested features.

## **2.2 Heritability and genetic advances:**

Heritability refers to the proportion of quantitative features that are passed down from generation to generation. The proportion of genotypic and phenotypic change is used to communicate this. It aids the reproducer in determining the degree of similarity between the parent and off-jumps on a specific attribute. As a result, this information is an important part in planning a reasonable yield.

**Vallejo and Lobo (1978)** opined that in the tomato high level of heritability in terms of yield, natural product weight and number of organic products per plant.

**Bhutani *et al.* (1983)** observed some features like number of seeds and number of the amount of organic products have high heritability. Appear to have shown a high

heritability for natural product weight, early yield per plant, and number of natural products per plant in tomato recorded by **Dudi *et al.*, (1983)**.

**Sonone *et al.* (1986)** found in tomato high heritability for natural product weight, number of days from transplanting to first blooming, TSS and sharpness, but poor heritability for number of branches per plant.

**Reddy and Lal (1987)** obtained that the features number of organic products per plant, natural product weight, and plant stature had strong heredity (expansive sense), and heritability was indicated by level of organic product - set and number of organic products per plant.

**Reddy and Reddy (1992)** recorded the quantity of organic products per plant, natural product weight, and organic product yield per plant are all highly heritable. In tomato, **Kumari and Subramanian (1994)** ascertained that plant stature, organic product width, and natural product weight have strong heritability in tomato.

**Barman *et al.* (1995)** observed highest heritability for plant tallness, number of organic products per plant, and number of seeds per natural product, number of organic products per plant, and number of seeds per organic product in tomato.

**Pujari *et al.* (1995)** noticed that the high heritability for plant height, quantity of organic products per plant and natural product weight in tomato.

**Singh *et al.* (1997)** recorded for organic product weight and number of natural products per plant and he found the high heritability indicators paired with high hereditary development. **Phookan *et al.* (1998)** and **Vikram & Kohli (1988)** obtained comparable results in a changeability study that observed high heritability combined with high hereditary development for normal organic product weight and yield per plant.

**Das *et al.* (1998)** assessed the number of organic products per plant, natural product length, and natural product distance across, organic product weight, and natural product yield per plant have high heredity.

**Phookan *et al.* (1998)** confirmed that plant stature, organic product weight and natural product yield per plant have high heredity, but number of branches per plant has low inheritance in tomato.

**Prasad *et al.* (1999)** reported that the organic product length, natural product width, mash thickness and organic product weight in tomatoes were found to have substantial heritability in tomato.

**Brar *et al.* (2000)** assessed the heritability gauges for number of attractive organic products per plant (83.50%), number of natural products per group (81.57%) and number of natural products per plant (77.34%) were all high, while all out organic product yield (58.59%) and attractive organic product yield per plant (63.53%) indicated moderate.

**Singh (2001)** claimed that if a character's heritability is high, such as 80% or more, determining such characters could be genuinely straightforward. This is because there would be a close relationship between the genotype and the phenotype due to the earth's relative lack commitment to the phenotype.

**Pradeep kumar *et al.* (2001)** estimated high heritability values for all characters studied, including number of organic products per group, number of blooms per bunch, natural product set rate with yield per plant being the most notable in tomato.

**Aradhana and Singh (2003)** determined that the plant stature had high heritability in tomato. **Kumari *et al.*, (2007)** discovered that both added substance and non added substance quality activity is represented by the characters, all out number of natural product bearing branches, weight per foods grown from the ground to development having high heritability in tomato and low hereditary development. As a result, these traits, along with several other reproducing techniques, could be improved by choice.

**Joshi *et al.* (2004)** studied tomato genetic variability and found that number fruits per cluster, fruit length, fruit breath, stem end scar size, number of locules per fruit, total fruit firmness, ascorbic acid substance and plant height all confirmed modest heritability and genetic gain. On the other side, pericap thickness had low heritability and genetic gain, while harvest time had intermediate heritability and low genetic gain, but shelf life had high heritability and high genetic gain.

**Ahmed *et al.* (2006)** found advancement as a percentage of mean with high heritability with high genetic increase for juice to pulp ratio, yield per plant, average

fruit weight, acidity, fruit length, pericarp thickness, plant height, earliness and number of fruits per plant in tomato crop.

**Mahesha et al. (2006)** studied genetic variability and predicted genetic progress in thirty genotypes, findings substantial differences for all of the parameters studied, has very high heritability values and robust emetic development, including fruit weight, fruits per plant and plant height.

**Haydar et al. (2007)** and **Mohamed et al. (2012)** expressed high heritability indicators for plant height, organic product weight, and number of natural product per plant in various genotypes of tomato. For various traits, genetic gain (communicated as a population mean) ranged from reserved to high in nature. Plant height, number of natural products per plant, yield per plant, organic product weight, organic product length, stem end scar size, and seed per natural product were all above average. The quantity of natural products per group, organic product width, pericarp thickness, and number of locules per organic product were all monitored under moderate hereditary addition. For gather span, hundred seed weight, and all out solvent solids, hereditary addition was minimal. The findings support those of **Mohamed et al., (2012)** who observed noteworthy heredity for plant height and organic product weight and modest heritability for the amount of natural product per bunch in diverse genotypes.

**Hidayatullah et al. (2008)** found the plant stature, number of natural products per plant, organic product weight per plant, organic product length, organic product distance across, single organic product weight, number of locules, pericarp thickness, TSS and seeds per natural product all have high heritability in tomato.

**Mehta and Asati (2008)** assessed plant stature, number of organic product per group, weight of natural goods per plant, all-out natural product yield per hectare, number of regions and TSS all have high heritability in board sense according to them in tomato.

**Ara et al. (2009)** noticed that all of the traits had high heritability and high genetic gain, with the exclusion of days to first picking, harvesting duration, and lycopene content, which had tall heritability and modest genetic gain. moreover, the number of flower per cluster had enough estimation for both heritability and genetic gain in their tomato research.

**Suarma et al. (2009)** carried out an experiment and found that fruit output, number of fruits per plant, average fruit weight, plant height and number of branches per plant had high heritability paired with strong genetic process. **Ghosh et al., (2010)** found strong heritability for all yield contributing characters except number of flowers per cluster, and strong heritability correlated with tall genetic advance for number of fruit clusters per plant, number of fruits per plant, number of fruit per clusters, individual fruit weight and fruit yield per plant.

**Kaushik et al. (2011)** observed for the number of leaves at sixty days after transplanting and fruit yield, there was a strong heritability and genetic progress.

**Dar and Sharma (2011)** claimed that the characteristics carotene, ascorbic corrosive and lycopene content in tomatoes have a high heredity, allowing for easy determination and enhancement of these characters in tomato rearing lines.

**Bukseth et al. (2012)** stated that the heritability (expansive sense) assessments for the majority of the tomato features were high, indicating that the genotypes under research have a tremendous scope for the determining these characters.

**Mane and Paul (2012)** found that the number of locules/organic product, natural product weight, organic product length, number of natural products/plant, pericarp thickness, nutrient 'C' and complete corrosive in tomato had a high to direct heritability combined with a high to direct hereditary increase in number of locules/organic product, natural product weight, organic product length, number of natural products/plant, nutrient C progressively solid for compelling determination.

**Mohamed et al. (2012)** reported that plant stature has the highest heredity (97%), whereas organic product output per plant has the lowest (43%). All of the tested characteristics had high heritability (broad faculties) gauges, indicating that these character are constrained by other substance qualities activity which is quite beneficial in choice.

**Cherent et al. (2013)** recorded that the most notable heredity indicators were the quantity of created organic products per plant (98.34%) and the the number of important branches (best 47.36%). Number of developed organic products per plant (97.07%), TSS (97.07%), natural product set rate (96.31%), days to development

(95.58%), days to half fruiting (93.73%), number of insects per organic product (94.62%), plant tallness (90.20%) all had extremely high heritability gauges (>80%).

**Kumari and Sharma (2013)** recorded high heritability and high genetic gain for number of fruits per plant, average fruit weight, fruit production per plant, number of seeds per fruit and plant height.

**Saleem *et al.* (2013)** opined that the organic product width, natural product length, plant tallness, organic product weight, organic product yield per plant and number of natural products per plant demonstrated high heredity in tomato.

**Reddy *et al.* (2013)** found that high heritability combined with high heritability combined with high development was found for the character plant stature, number of groups per plant, number of blossoms per bunch, number of natural products per bunch, number of organic products per plant, organic product length, organic product weight, organic product yield per plant and TSS in tomato.

**Khapte and Jansirani (2014)** ascertained that plant height, number of flowers per clusters, number of flower clusters per plant, fruit length, fruit diameter, fruit from index, pericarp thickness, total soluble solids, average fruit weight, fruit firmness, number of fruits per plant and yield per plant were all found to have high heritability.

**Osekita and Ademiluyi (2014)** found that the gauge of heritability among the genotypes spans from low to high with number of bunch per plant having the lowest heredity rate (2.60%) and days to half blooming having the highest heritability rate (99.68%) in tomato.

**Meitei *et al.* (2014)** reported that high heritability with moderate to low hereditary development was observed for a long period in tomato half blossoming and fruiting, first and final picking, plant stature and natural product distance across in tomato.

**Paul *et al.* (2014)** opined that all of the tomato traits studied was highly heritable in a broad sense. **Nwosu *et al.*, (2014)** discovered that leaf length, leaf breadth, days to bloom, days to half flowering, number of natural products per plant, natural product length, organic product distance across, natural product weight and 1000 seed weight have extremely high heritability.

**Henareh (2015)** found that the highest and lowest levels of heritability were measured independently for the quantity of seeds per food generated from the ground of blooms per inflorescence.

**Genetic Advance:**

The normal hereditary development is defined as the differences between the mean of chosen people's offspring and the general population.

**Johnson et al. (1955)** claimed that heritability gauges when evaluated in the context of hereditary development, provide more accurate data than hereditary research alone. Hereditary development is a product of heritability and brings together the potential for determination force. Hereditary development is combined with heritability a reasonable assessment of the consequences of population parenting choices can be made.

**Nandpuri et al. (1977)** stated that the number of natural products per plant has a high hereditary development in tomato. **Nadar et al., (1980)** noticed high hereditary development markers for plant height, organic product number and natural product yield per plant in tomato.

**Dudi et al. (1983)** described the most notable hereditary development for natural product weight, organic product yield per plant and number of organic products per plant. **Sonone et al., (1986)** noticed the most elevated hereditary development in terms of natural product weight, plant stature and organic product output per plant, as well as the most lost hereditary development in terms of the number of days from transplanting to first flowering and acidity.

**Reddy and Lal (1987)** noticed that the number of organic products per plant has a high hereditary development, organic product weight, plant stature and natural product yield per plant. **Kumar and Lal (1988)** claimed that high hereditary development was demonstrated by the degree of natural product - set and organic product per plant.

**Barman et al. (1995)** observed that high hereditary development for plant stature, number of natural goods per plant and number of seeds per organic product. **Pujari et al. (1995)** revealed high hereditary development for plant stature, number of

natural products per plant and organic product weight. **Mittal *et al.*, (1996)** found high hereditary development for plant height, number of organic product per plant and organic product weight.

**Padmini and Vadivel (1997)** noticed that the organic product length and natural product distance across had high hereditary development, as did the number of days taken from transplanting to first flowering and natural product yield per plant. **Singh *et al.*, (1997)** described how organic product distance across has the highest hereditary development for plant tallness has the lowest.

**Phookan *et al.* (1998)** found that organic product weight and natural product yield per plant have strong hereditary development. High hereditary development for tomato juice content was observed by **Kumar and Tewari (1999)** in tomato. **Prasad *et al.*, (1999)** discovered that natural product length, organic product width and natural product weight have high hereditary development.

**Brar *et al.* (2000)** studied that the number of attractive natural products per plant and absolute number of organic products per plant are high indicators of hereditary development, whereas, all out yield per plant and attractive natural product yield per plant and number of organic products per bunch indicated low hereditary development.

**Pradeep kumar *et al.* (2001)** observed that plant tallness, number of natural products per plant, organic product weight, organic product yield per plant, number of locules/organic product, pericarp thickness, plant stature and number of collect have high hereditary development as percent of mean.

**Singh *et al.* (2002)** recorded the most notable hereditary development was normal natural product weight, which was followed by timeframe of realistic usability of red ready organic products.

**Mohanty (2002)** evaluated 18 tomato genotypes and observed high heritability with moderate to high genotypic coefficient of variety and hereditary development for normal natural product with (93.0, 34.94, 68.59 percent, separately) number of branches per plant 992.2, 32.52, 64.40 percent, individually) and organic products per plant (87.4, 27.87, 53.69percent, individually) plant stature (78.1, 22.35,

43.46percent, separately) and days to initially gather (91.4, 15.29, 28.53percent, individually) plant stature with could be improved by straight forward determination.

**Golani et al. (2007)** found substantial hereditary development as percent of mean for the parameters normal organic product weight and natural product yield per hectare.

**Shashikanth et al. (2010)** advocated for the amount of organic products per plant and natural product yield per plant. Ghosh et al. (2010) looked at the number of natural products per plant, organic product yield per plant and number of natural products per bunch, all of which have a strong genetic component.

**Taisa et al. (2011)** pointed out that the greater projected hereditary development as a percent of mean was recorded for organic products per plant, plant tallness, yield per plant and natural product distance across, indicating that choice would be increasingly advantages to increase these attributes.

**Mohamed et al. (2012)** found that the highest heritability was noticed in plant tallness (97%) with a normal hereditary development over level of mean of 69.6%, followed by organic product weight (92%) with a normal hereditary development over level of mean of 92.9 percent, number of branches per plant (70%) with a normal hereditary development over level of mean of 35.07 percent, days to half blooming (69%) with a normal hereditary development over level of mean of 9.4 percent, number of natural products per bunch (68%) with a normal hereditary development over level of mean of 30.8 percent and number of blossoms per inflorescence (63%) with a normal hereditary development over level of mean of 22.3 percent, while the least heritability was that of natural product yield per plant (43%) with a normal hereditary development over level of mean of 33.9 percent.

**Ahirwar et al. (2013)** reported that hereditary development at 5% was high for plant tallness after 120 DAT, number of natural products per plant, ascorbic corrosive and organic product yield per plant, while hereditary development of 5% was high for all other characteristics except days to bloom inception and days to initially reap.

**Saleem et al. (2013)** discovered that high hereditary development for plant stature, natural product weight, number of organic products per plant, natural product yield per plant, natural product breath and organic product length, **Shankar et al.,**

(2013) discovered that plant stature, number of essential branches per plant, organic product length, natural product width, and normal organic product weight, number of areas per organic product, pericarp thickness, ascorbic corrosive lycopene, and realistic usability timeframe all showed high heritability development as percent of mean.

**Patel *et al.* (2013)** recorded high heritability with high hereditary development when percent of mean was monitored for natural product yield per plant and average organic product weight, both of which might be increased by basic determination.

**Meitei *et al.* (2014)** found that half blooming and fruiting, first and last picking, plant tallness, and natural product distance across were all observed for a long period in the high heritability with moderate to low hereditary development. Natural product yield per plant was found to be strongly linked to organic product breadth, single organic product weight and yield per plant implying that genotyping based on these characteristics will result in better genotypes with higher return.

**Nwosu *et al.* (2014)** reported that high hereditary development predicts leaf length, leaf breath, days to blossom, days to half blooming, number of organic products per plant, natural product length, organic product measurement, organic product weight and 1000 seed weight.

### **2.3 Correlation studies:**

Phenotypic, Genotypic and Environmental connections are the three types of direct connections. The phenotypic connection which assesses natural variation and non-added substance quality activity is a recognized relationship between two components. Genotypic relationship, on the other hand, is the intrinsic link between two elements that may be examined using measured data. Link study is important because it quantifies the shared connection between different plant characters and determines which segment characters can be used to make decisions for increase production. It is especially important for a plant raiser to have knowledge on the link between traits for ease of assessment. Connection coefficients are used to determine the magnitude and significant of a characters link.

**Singh *et al.* (1990)** proved a significant positive association between the number of branches and organic product production in two tomato genotypes grown

back to back over a lengthy period of time. In tomato, **Dudi and Madalagiri (1991)** found that the temporal span of usability was strongly linked to pericarp thickness and free shape but not to the quantity of locules per organic product in tomato.

**Kadam et al. (1992)** reported that yield was definitely correlated with complete dry issue, number of products of the soil of natural product in assortment Pusa Ruby of tomato.

**Patil and Bojappa (1993)** observed that the number of branches per plant has notable and positive link with the amount of organic products per group. They also discovered a favourable and significant relationship between normal natural product weight, number of seeds per organic product, and pericarp thickness and days to 50% flowering. Plant stature, number of branches per plant and number of leaves per plant have a strong relationship with number of organic products per plant, normal natural product weight, number of natural products per group, number of locules per organic product, number of seeds per foods grown from the ground thickness in tomato.

**Soorinatha et al. (1994)** carried out a trial on study of 18 different breeds of tomato and found that number of blooms per bunch was the most important yield contributing attribute. When all was said and done, the number of flowers per group had a significant impact on yield. They also discovered a positive connection between the yield of organic products and the number of natural products per plant.

**Nair and Thamburaj (1995b)** investigated the link between several tomato plant characteristics and discovered that organic product output was positively and critically related to the number of natural products per plant in tomato.

**Maheshwary et al. (1997)** carried out work with 40 F<sub>1</sub> cross breeds revealed those days to blooming were negatively related to organic product production in tomato. **Prasad and Rai (1999)** described a strikingly favourable relationship between natural product yield and organic product weight. In tomatoes, natural product length, and organic product broadness, number of locules and mash thickness are all factors to consider.

**Kumar and Tiwari (1999)** recorded the district number was shown to be unrelated to the thickness of the pericarp and the consistency of organic product in tomatoes.

**De et al. (2002)** observed a strong positive correlation between tomato yield and usability time span of tomato. **Mohanty and Prusty (2002)** observed that superior return of half and half tomatoes was due to a greater extent to the higher number of soil products per plant and to a lesser extent to the expanded measurement of the organic product.

**Harer et al. (2002)** studied on the connection coefficients among features were resolved at the phenotypic and genotypic levels. By and large, genotypic connection coefficients were on average, more significant than phenotypic relationship coefficients. This can be translated as a strong natural genotypic connection between the traits studied, despite the fact that their phenotypic articulation was hampered by environmental factors.

**Mohanty (2003)** conducted a field investigation of 18 genotypes of tomato during rabi season and discovered that yield was fundamentally but adversely related to plant stature, number of branches per plant and average organic product weight, and that yield was essentially and empathically related to number of natural product per plant and number of days to collect. In contrast, the weight of normal natural product was associated with the organic products per plant.

**Joshi et al. (2004)** found the fruit length, fruit width, stem end scar, pericarp thickness, whole fruit firmness, and shelf life were all positively connected, while normal fruit weight was completely correlated with fruit length, fruit width, stem end scar, pericarp thickness, total fruit firmness, and shelf life .

**Singh et al. (2004)** worked on 92 tomato genotypes, discovered that number of natural products per plant and the number of organic products per group had an incredibly strong positive relationship with yield. Similarly, the quantity of organic products per bunch and the average natural product weight had a negative connection. Days to half blooming, days to initial organic product set, amount of natural products per plant and all out solvent solids were all strongly linked to plant height. The number of essential branches per plant was negatively and fundamentally related to the number of days it took for an organic product to set, the number of natural products per bunch, the number of natural products per plant, normal natural product weight, the length of organic product, and the distance across the organic product. The amount of natural products per bunch and the length of organic products had a

profoundly large and negative link with days to half blooming. The quantity of organic products per bunch showed an extremely important and favorable relationship with number of natural products per plant and the length of natural products.

**Prassana *et al.* (2005)** observed yield per plant has a positive relationship with average fruit weight and number of fruits per plant, whereas number of fruits per plant has a negative relationship with average fruit weight, number of locules and flesh thickness.

**Makesh *et al.* (2006)** found a positive and substantial link between yield per plant and number of fruits per plant, plant height, number of lateral per plant and fruits per cluster, but a negative correlation between number of locules per fruits and flesh thickness in tomato.

**Jagdish *et al.* (2007)** reported that tomato production is strongly connected to the number of organic products per plant, normal natural product weight, natural product distance across, and number of locules. There was also a significant link between plant stature and the number of branches. On the other hand **Golani *et al.*, (2007)** announced that plant tallness has huge and negative relationship with organic product weight, natural product circumference, TSS and number of locules per organic product while conducting an investigation on 10 tomato genotypes.

**Sriharsa and Raju (2008)** discovered that the amount of organic product per plant of tomato was predictable and directly related to natural product productions in tomato. Then again **Meheta and Asati (2008)** reported that natural product yield was strongly linked to days to 50% flowering (0.683) in tomato.

**Anjum *et al.* (2009)** investigated 35 tomato genotypes, finding that financially important parameters such as natural product yield per plant had a strong positive relationship with organic product size, plant stature and the quantity of organic products per plant.

**Ara *et al.* (2009)** worked on tomato and reported that the fruit production per plant had a high positive significant relationship with fruit size, plant height, number of fruits per plant and number of primary branches per plant at both phenotypic and genotypic level.

**Rana and Singh (2010)** carried out a trial on 33 tomato genotypes to see if there was a link between their features. They discovered that the number important branches, leaf region, and number of natural products per plant were all strongly linked to organic product yield per plant.

**Dar et al. (2011)** reported that phenotypic and genotypic connection coefficients among distinct features were accounted for the yield per plant was fundamentally and emphatically linked to the amount of natural product per plant at both the phenotypic and genotypic levels. Just at the genotypic level, yield per plant was significantly and definitively linked to the amount of organic products per group. The number of organic products per plant was inextricably linked to the number of natural products each. At the phenotypic and genotypic levels, natural product weight was fundamentally and negatively correlated with organic product length, natural product distance across, pericarp thickness, and stems end scar size, and fundamentally and negatively connected with number of natural product per plant. These variables should be used to make decisions on tomato; there are strong positive relationships between yield per plant and other agriculture characteristics.

**Sharma and Singh (2012)** investigated that fruit yield was shown to be extensively and completely connected to fruit weight per plant, days to 50% flowering and non-significantly but completely correlated with average healthy weight and seed yield per plant.

**Ahirwar and Prashad (2013)** recorded data on plant height after 120 days, days to 50% flowering, leaf curl incidence and intensity showed negative phenotypic and genotypic correlations, whereas number of branches, number of fruits per plant, average fruit weight, number of cluster per plant, fruit set percent, radial and polar diameter, ascorbic acid, and total solid soluble showed positive phenotypic and genotypic correlations.

**Meitei et al. (2014)** examined that natural product yield per plant was found to be strongly linked to organic product breadth. Single organic product weight and yield per ha, implying that genotypes with greater returns would be determined based on the traits. **Paul et al. (2014)** observed that the germination (percentage), natural products per bundle, and collect list were all related to yield per plant.

**Nwosu et al. (2014)** assessed that organic product per plant of tomato is inextricably linked to plant stature, number of branches per plant and leaf length.

**Henareh et al. (2015)** found that genotypes with high return possessed large organic product, firm natural product, high bloom end decay and sun singe, small plant size, scanty foliage thickness, small seed sum/natural product size in tomato.

**Meena and Bahadur (2015)** reported that at the genotypic and phenotypic levels, respectively, organic product yield was basically and positively connected with number of blossom per plant (0.2894 and 0.2891), followed by number of natural product per plant (0.4480 and 0.4486) and natural product weight (0.6223 and 0.6230). the strong connection between these characteristics exposed that determining based on these characteristics would eventually improve the organic product yield, and it is also recommended that hybridization of genotypes with a combination of above characters is usually valuable for obtaining attractive high yielding isolations.

**Rashwan (2015)** discovered that the connection coefficient in M3 populations was extremely significant positive among yield natural product/plant (kg) character and every one of number of group/plant ( $r=0.951$ ), number of blossoms/plant (0-0.941), number of organic products/plant (0.994), weight of natural product (g) (0-1.964) and Marketable of yield/plant (kg) ( $r=0.957$ ) in tomato. The findings show that increasing some yield segments, such as natural product weight (g), number of organic products/plant, number of groups/plant, and numeric yield/plant, will increase total yield/plant in tomato plants.

#### **2.4 Path analysis:**

According to **Wright (1921)** way coefficient research is a standard relapse coefficient that allows the split of relationship coefficient into proportions of immediate and aberrant impact.

**Srivastav and Sachan (1973)** reported that organic product weight of tomato had negative direct impact on output, however the number of natural products per plant had the most severe beneficial outcome on yield, as measured by natural product measurement.

**Singh and Mittal (1976)** observed that the number of branches and organic product weight had a significant positive impact on tomato yield.

**Dudi and Kalloo (1982)** noticed that characteristics such as the number of natural products per plant and the weight of organic products had a strong direct positive effect. According to **Reddy and Lal (1987)**, the quantity of natural products per plant, as well as a single load of organic product, had a direct positive effect on natural product production.

**Singh et al. (1989)** expressed that the quantity of organic products per plant in tomato, natural product length and organic product weight were the immediate factors influencing natural product output in tomato.

**Ingale and Patil (1995)** investigated that days taken from transplanting to first blossoming had the greatest direct and backhanded impact on natural product yield. In any event, it was clear that the backhanded commitment of number of organic products per plant, natural product length, organic product weight and natural product distance across had an impact on brinjal natural product yield.

**Kalda et al. (1996)** determined that the quantity of natural products per plant and the weight of organic product yield per plant had a significant direct positive impact on organic product output per plant. The number of organic products per plant and the weight of natural products are two reliable yield contributing features. Nonetheless, in the tomato, there was a negative association between the weight of organic product and the amount of natural products per plant.

**Bhutani and Kalloo (1998)** found that the number of natural products per plant has the largest positive direct impact on tomato yield, and **Prasad and Rai (1999)** concluded from their research that qualities such as plant stature and natural product length are important. The major yield segments in tomato were natural product expansiveness, organic product immovability, and number of locules.

**Kumar et al. (2001)** reported that the high heritability gauges obtained, may be due to the dissimilar genotype locule in the examination characters, such as number of natural product per plant. Bacterial shrinkage as measured by mean, heritability and GCV suggested that direct selection could improve this germplasm line, and **Kamruzzaman et al. (2002)** reported that the weight was followed by quantity of

blossom three bunches/plant, number of organic product in three groups/plant and number of natural product three/bunch plant. While the equivalent was least for number of leaf at blooming. GCV and PCV was greatest for number of leaf at blossoming and **Mohanty et al. (2003)** also found that the plant tallness had a notable and negative relationship with organic product yield, with a negative immediate impact, but a large and positive abnormal impact on natural product bigness. In this way, the weight of the natural product and number of locules/organic product were important contributors to the organic product yield in tomatoes.

**Kumar et al. (2003)** obtained that the number of organic products per plant, natural product weight and mash thickness in tomatoes had the most extreme favourable direct impact.

**Kumar et al. (2003)** used a method coefficient analysis to look at 30 different tomato genotypes and discovered that the natural product number per plant found the highest significant positive direct impact on yield per plant, followed by normal organic product weight.

**Mohanty (2003)** worked on 18 genotypes of tomato and data revealed that the amount of natural products per plant and average organic product weight had a positive direct contact on yield and negative direct contact through each other.

**Joshi et al. (2004)** examined that the amount of organic products per plant is the most important yield contributing factor, followed by natural product length, natural product breadth, and plant height, using 37 tomato genotypes.

**Kumar et al. (2004)** observed the number of fruits per plant had the highest direct effect on fruit yield in a path analysis experiment, followed by fruit width, number of seeds per fruits and total soluble solids content in tomato.

**Kant and Mani (2004)** noticed that fruit weight has the biggest and direct beneficial effect on tomato fruit yield per plant, followed by total number of fruit clusters per plant, number of branches per plant, titrable acidity, plant height and number of days to 50% flowering.

**Singh et al. (2004)** carried out an investigation on 92 genotypes of tomato and found that the quantity of natural products per plant has positive direct impact on

yield followed by organic product breadth, normal weight per organic product, organic product length, days to 50% blossoming, number of organic products per group and days to first harvest of organic product. In any event, the number of vital branches per plant, plant stature, the number of natural product groups per plant and total solvent solids all had negative direct impact on yield.

**Bharadwaj et al. (2005)** reported that the most elevated positive direct impact was found for natural product shape record followed by size of stem and scar, and **Golari et al. (2007)** observed the heritability with high genetic coefficient variation and hereditary put on for ten fruit weight, number of locules per organic product yield, which could be enhanced by single determination. The phenotypic and genotypic connection of organic product yield was notable and positive with 10 natural product weights, organic product size, T.S.S. only at genotypic level and number of locules per natural product but notable and negative with plant stature. Way investigation affirm that 10 natural product weight had most noteworthy positive direct impact pursued by number of locules while, **Hyder et al. (2007)** discovered that the genotypes had a broad range of variation for every one of the qualities investigated, way of investigations confirms that 10 natural product weight had the most notable beneficial direct impact, followed by number of locules. The characteristics were also thought to be highly heritable. The organic product weight per plant had the highest hereditary development, followed by the number of natural products in three groups/plant and the number of blossom in three bunches for each plant. The positive yield of natural products yield is very high.

**Sharma et al. (2006)** found a direct relationship between marketable yield per plant and the number of profitable fruits per plant, fruit form index, gross yield, plant height, number of flower clusters per plant, number of locules per fruit, and TSS content (plays direct and indirect effect).

**Golani et al. (2007)** investigated that plant tallness had a large and negative correlation with natural product yield, and its immediate influence was negative, while its roundabout impact via means of organic product bigness was high and favorable in tomato. **Prashanth et al. (2007)** investigated 67 genotypes of tomato and announced to facilitate early yield and standard organic product weight had noteworthy direct positive effects on total yield.

**Singh et al. (2007)** observed that the hereditary inconstancy heritability hereditary development, link and manner inquiry were finished in 14 genotype of tomato. The high GCV and PCV were watched for plant stature, organic product biomass, natural product yield, and normal organic product weight. T.S.S number of natural product/plant, number number of locules/organic product vegetative biomass pericarp thickness and **Ruskhsar et al. (2011)** discovered that the width of the phenotypic coefficient of variety was superior than genotypic coefficient of variety for all tomato characters, while **Kumar et al. (2012)** found that number of branches per plant had the most elevated positive direct impact on organic product yield.

**Mehta and Asati (2008)** reported that plant height had the greatest positive direct impact on natural product yield at genotypic level, followed by weight of organic product per plant, days to first fruiting, days to 50% fruiting. Whereas number of branches per plant had the greatest negative direct impact on natural product yield, followed by absolute solvent solids. In the tomato, the days to initial blooming, the number of groups per plant, and the number of locules per natural product are all important.

**Prashanth et al. (2008)** noticed that early fruit set and average fruit weight were found to have a direct positive effect on total yield.

**Ara et al. (2009)** recorded that days awaiting first picking had the most positive direct effect on fruit yield in tomato, the harvest period, number of fruits per plant, average fruit weight plant height, and number of blooms per cluster in tomato is the next factors to consider.

**Rani et al. (2010)** assessed to facilitate fruit has highest positive direct effect on yield per plant, though fruit weight has positive indirect effect on yield per plant.

**Kumar (2010)** claimed that marketable fruits per plant had maximum direct effect on profitable yield per plant followed by average fruit weight and pericarp thickness.

**Dar et al. (2011)** investigated the biggest positive direct effect on yield per hectare was fruit yield per plant, followed by average fruit weight, number of locules per fruit, lycopene content per fruit and ascorbic acid which had negative indirect effect on yield per hectare.

**Buckseth et al. (2012)** reported that shelf life had the greatest direct effect, followed by average fruit weight and number of fruits per plant, showing that these are the true independent features and have the greatest impact on fruit yield. pericarp thickness had the greatest negative effect on yield per plant, followed by fruit form index, whereas (TSS) total soluble solids had the minimum harmful direct effect on yield per plant.

**Manna and Paul (2012)** opined that number of locules per plant, TSS, fruit length, number of fruits plant, fruit weight, vitamin C content and pelican thickness were all positive, and fruit yield was directly influenced by fruit width and total acid content, whereas fruit yield was strongly influenced by fruit width and total acid content.

**Kumar et al. (2013)** stated that to facilitate the fruit weight had highest useful direct effect on yield per plant followed by number of fruits per plant, fruit diameter and number of fruits per cluster. Direct collection based on fruit weight, number of fruits per plant, fruit diameter and number of fruits per cluster is trustworthy.

**Reddy et al. (2013)** noticed that plant height, number of fruits per plant, fruit width and ascorbic acid all showed substantial positive direct effects on fruit production per plant. As a result, direct selection for these features is carried out in order to increase fruit yield per plant.

**Meitei et al. (2014)** tried to investigate the direct that the beneficial direct impact for natural product distance across, single organic product weight. Leafy foods bunch plant on yield plot and choice based on these 11 characters would be progressively solid for yield improvement. **Paul et al. (2014)** observed that the grain production was shown to be directly influenced by germination percent (0.26), length of first leaf appearance (0.19), days to first flowering (0.20) and reap file (0.42) all had a direct impact on grain yield.

**Meena and Bahadur (2015)** determined that natural product weight showed a substantial positive direct genotypic and phenotypic impact on organic product output per plant as measured by the number of flowers per plant with values of 0.9566 and 0.9442 respectively, organic product set percent, number of natural products per plant, TSS °Brix, plot stature, spiral measurement of natural product, leaf twist frequency

percent and days to half blooming in tomato. The characters with a strong direct impact on production per plant indicated that direct resolution for these bottlenecks is possible, and that character selection can improve output per plant. The residual influence was very low (0.0611 and 0.0751) indicating that the characters remembered for this investigation clarified almost all produce changeability.



***CHAPTER-3***

***MATERIALS***

***AND***

***METHODS***

## *MATERIALS AND METHODS*

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The present investigation entitled “**Studies on Genetic Variability, Heritability, Genetic Advance, Correlation Coefficient and Path Analysis in Tomato (*Solanum lycopersicum* L.)**” was conducted at Horticulture Research Farm I, Department of Horticulture, School for Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Rae Bareli Road, Lucknow (U.P.), India during the winter season of 2017-18 and 2018-19. The following are the details of materials used and methods employed to conduct the investigation have been explained in the chapter.

### **3.1 LOCATION AND SITE OF EXPERIMENT:**

The Horticulture Research Farm I, Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Rae Bareli Road, Lucknow is situated at an elevation of 111 meter above mean sea level in the sub tropical tracts of central U.P. at 26°-56° North latitude. The climate of Lucknow is characterized by sub-tropical with hot, dry summer and cool winters. This region received an average annual rainfall of 750 mm, which is distributed over a period of more than 100 days with peak period during July-August. It also received scattered showers during winter months. In general, the temperature ranges from 5.5<sup>o</sup> to 25<sup>o</sup>. The coldest month is January, while the maximum temperature observed during May-June. The Horticulture Research Farm is located approximately 10 km away from the Charbagh Railway Station Lucknow towards South-East off Rae Bareli Road Lucknow, which is surrounded by Bijnaur Road (West), Shaheed Path (south-east), South city (east) and Ratan khand & Rajnikhand (North-East) respectively. However, the exact location of research farm is in front of Gautam Budha Central Library, BBAU.

### **3.2- TOPOGRAPHY, CLIMATE AND WEATHER CONDITIONS:**

The regions climate is sub tropical with maximum temperatures ranging from 29.3<sup>0</sup>C to 45<sup>0</sup>C in summer and lowest temperatures ranging from 3.5 to 15<sup>0</sup>C in winter and relative humidity (RH) of 60-80% throughout the year. The climate of Lucknow is sub tropical climate with hot summer and cool winters. The annual rainfall is around 750mm, with the majority falling between June and September with some sporadic showers in the winters from the North – East monsoon.

### **3.3 Experimental Materials**

The experimental materials of the present investigations were comprised twenty tomato genotypes of tropical and subtropical origin. The list of the genotypes has been given in Table 3.3 which were received from ICAR-Indian Institute of Vegetable Research (IIVR), Varanasi, (U.P.) and evaluated at the Horticulture Research Farm-I of the Department of Horticulture, SAST Babasaheb Bhimrao Ambedkar University, Vidya-Vihar, Rae Bareli Road, Lucknow (U.P.) India. Experimental field was laid out in randomized block design with twenty genotypes and replicated thrice, each block into 20 unit plots. The twenty genotypes were allotted to the 20 unit plots of each block. Thus there were total 60 plots having to size of each plot 2.40m X 1.80m, The spacing between plant to row and row to row 45cm X 60cm, respectively. The plots were raised by 15cm from the ground level to avoid water-logging, if occurred. The each plot divide into four row and each row contained four plants thus, each plot accommodates 16 plants and total plants maintained in cultivated area 960 plants. Farmyard manure ( FYM ) 200 q/ha and nitrogen, phosphorus and potash were applied @ 100 kg, 60 kg and 60 kg per hectare, respectively. Nitrogen was applied in three split doses *i.e.* 40 percent as basal, 30 percent at third week after transplanting and remaining 30 percent at flowering stage of the crop. All necessary cultural operations were done as and when required during the experimentation.

**3.3: The experimental material in form of seeds of 20 genotypes/varieties was obtained from the ICAR- Indian Institute of Vegetables Research Varanasi.**

S. No.	Name of the genotypes/varieties	Source
1	LA-3957	IIVR, Varanasi
2	Rio-Grande	IIVR, Varanasi
3	Punjab Barkha Bahar-2	IIVR, Varanasi
4	Kashi Aman	IIVR, Varanasi
5	Solan Vojr	IIVR, Varanasi
6	IIHR-2202	IIVR, Varanasi
7	VRT-103-6-1	IIVR, Varanasi
8	Kalyanpur typ-1	IIVR, Varanasi
9	Switizar Land	IIVR, Varanasi
10	Pusa Sadabahar	IIVR, Varanasi
11	VRT-02 (Pe)	IIVR, Varanasi
12	TLCV-16	IIVR, Varanasi
13	VRT-50	IIVR, Varanasi
14	Selection-7	IIVR, Varanasi
15	Toleu-32	IIVR, Varanasi
16	VRT-01	IIVR, Varanasi
17	H-86	IIVR, Varanasi
18	KT-8	IIVR, Varanasi
19	TLCV-28	IIVR, Varanasi
20	VRT-51	IIVR, Varanasi

### **3.4 Cultural operations**

#### **3.4.1 Soil and field preparation**

Following the selection of the experimental field, the field was irrigated to achieve the ideal moisture level. Deep ploughing was done first with a disc plough then light ploughing with a cultivator followed by planking. Then according to the layout plan the required area was marked and 60 plots were prepared.

#### **3.4.2 Fertilizer application**

At the time of trial preparation of plots/beds fertilizers were added to the soil at the rate of 100 kg/ha nitrogen, 60 kg/ha phosphorus, and 60 kg/ha potassium. Before planting a full dose of phosphorus and potassium fertilizers, as well as one-third of a dose of nitrogenous fertilizer was broadcast in each beds in an equal amount as basal dose before planting. The leftover nitrogenous fertilizer dose was split into two parts.

#### **3.4.3 Selection of seed and sowing time**

ICAR-IIVR, Varanasi provided pure and healthy seeds for each genotype. To ensure good germination the seeds were soaked in water for 24 hours to before sowing in nursery beds. The sowing of seeds was done on the 05<sup>th</sup> of October, 2017.

#### **3.4.4 Intercultural operations**

During the cropping period the experimental plot were watered based on rain and field moisture. Weedings were done four times to ensure good crop without interruption.

#### **3.4.5 Selection of plants for observations**

A detailed analysis of the entire population in a field experiment is tough. Because all of the plants are exposed to same conditions, some plants from the population were selected at random for further examination. Three plants were selected at random in each plot and tagged for identification.

### **3.5 Experimental design and layout**

#### **(A) Experimental design**

The experiment had three replications and was set up in a Randomized block design. The experiment was conducted at Horticulture Research Farm-I, Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University Vidya-Vihar, Rae Bareli Road, Lucknow (U.P.), India.

**Table -3.6: Details of experiment Layout:**

Location	:	Horticulture Research Farm- I Infront of Gautam Budha Central Library
Name of crop	:	Tomato ( <i>Solanum lycopersicum</i> L.)
Season	:	(Winter Season 2017-18 and 2018-19)
Number of genotypes	:	20
Number of treatments	:	20
Number of replication	:	3
Net plot size	:	2.40m x 1.80m
Gross plot size	:	3.0m x 2.40m
Plant to plant distance	:	45cm
Row to row distance	:	60cm
Number of plants per row	:	4
Number of row per plot	:	4
Number of plants per plot	:	16
Total plots	:	60
Total plants	:	960
Design	:	Randomized Block Design



### **3.6 OBSERVATIONS WERE RECORDED:**

The observations were made on five plants chosen at random from each genotype in each repetition. Before the primary remark of plant height, the chosen plant life had been tagged and correctly classed. The following characters have had there were information recorded:

**3.6.1 Plant height (cm):** With the use of a meter scale, the height of five tagged plants was measured in centimetres from the ground level to the tip of the main stem at final plucking and the average plant height was calculated.

**3.6.2 Number of branches per plant:** The average number of branches per plant counted during final harvest for five tagged plants was calculated.

**3.6.3 Days to 50% flowering:** The number of days between when the plants were transplanted and when 50% of the plants in a plot flowered was recorded.

**3.6.4 Number of clusters per plant:** Just before fourth picking and at the end of the harvest, the total number of clusters in each of tagged plants was counted. The number of clusters per plant was calculated using the final count of clusters per plant recorded in the second observation.

**3.6.5 Number of flowers per cluster:** At the time of peak flowering stage five inflorescences were randomly picked in each treatment and the total number of flowers in each inflorescence was counted followed by the average number of flowers per cluster.

**3.6.6 Number of fruits per cluster:** The average number of fruits per cluster in each entry was calculated by counting the number of fruits in each cluster of five plants.

**3.6.7 Number of fruits per plant:** At each harvest, the marketable fruits picked up from randomly selected plants were counted, totalled and averaged to determine the quantity of fruits per plant.

**3.6.8 Average fruit weight (g):** The mean fruit weight in grams was calculated by dividing the total weight of fruits from five randomly selected plants at each harvest by the total number of fruits from all the harvests.

**3.6.9 Number of locules per fruit:** The number of locules in each fruit was counted using a horizontal axis cut.

**3.6.10 Pericarp thickness (mm):** after cutting the fruits transversely, the pericarp thickness of five randomly selected second harvest fruits in each entry was measured. The measurement was done in millimeters with a Digital Vernier Callipers and mean value was calculated.

**3.6.11 Fruit length (cm):** Fruit length was measured using Vernier Callipers from the stalk end to the blossom end of the fruit at third harvest and an average of 10 fruits was computed and expressed in centimeters.

**3.6.12 Fruit width (cm):** At third harvest, the width of the fruit at the most bulged region was measured using Vernier Callipers and the average of 10 fruits was calculated and given in centimetres.

**3.6.13 Number of ridges on fruit:** The total number of fruit ridges was counted.

**3.6.14 Fruit yield per plant (kg):** The total yield per plant was calculated by averaging the fruit weights from all the pickings.

**3.6.16 Fruit yield (q/ha):** Marketable fruits were picked when they were half-ripe stage. The total yield per plant by the number of pickings. The yield per hectare was determined based on the fruit production per plot.

**3.6.17 TSS (<sup>o</sup>Brix):** Five fruits were chosen at random from each plant. Each fruits TSS (%) was measured with a Hand Refractometer and the average was calculated in %.

**3.6.18 Vitamin C (mg/100g):** The vitamin C concentration was evaluated using the 2, 6-dichlorophenol indophenol visual titration method as described by Ranganna (1994). Aliquotes made by macerating fully ripe tomato fruits in the presence of 3% metaphosphoric acid and titrating against 2, 6-dichlorophenol indophenols dye to pink end point that lost at least 15 seconds.



**Plate-1: A general view of preparing the nursery beds and sowing of seeds.**



**Plate-2: View of packets of 20 genotypes of tomato.**



**Plate-3: View of seedlings of tomato ready to transplant in the field**



**Plate-4: View of tomato crop at the time of transplanting in the trial field.**



**Plate-5: View of tomato genotypes crop being irrigated.**



**Plate-6 : View of cultural practices in tomato genotypes crop.**



**Plate-7: A general view of tomato genotypes crop at growth stage.**



**Plate-8: A general view of tomato genotypes crop at fruit ripening stage.**

### 3.7 STATISTICAL AND GENETICAL ANALYSIS:

#### 1. Analysis of variance for design of experiment:

The analysis of variance for the design of experiment was done for partitioning the variance into treatments and replications, which was carried out according to the procedure outlined by Panse and Sukhatme (1967). The significance of difference among treatment means was tested by “F” test. The analysis of variance for Randomized Block Design is given below:

$$Y_{ij} = \mu + t_i + b_j + e_{ij}$$

Where,

$Y_{ij}$  = Yield of  $i^{\text{th}}$  entry in the  $j^{\text{th}}$  replications

$\mu$  = General mean

$t_i$  = Effect of the  $i^{\text{th}}$  entry ( $i = 1, 2, \dots, v.$ )

$b_j$  = Effect of the  $j^{\text{th}}$  replicate ( $j = 1, 2, \dots, r.$ )

$e_{ij}$  = Environmental effect

#### Analysis of variance

Source of Variation	D.F.	S.S.	M.S.S.	F-calculated values
Replications	(r-1)	SSr.	MSr	MSr/MSe
Genotypes	(g-1)	SSg	MSg	MSg/MSe
Error	(r-1)(g-1)	SSe	MSe	
Total	(rg-1)	TSS		

Whereas,

- r = number of replications
- g = number of genotypes
- MSr = mean squares due to replications
- MSg = mean squares due to genotypes
- MSe = mean squares due to error
- TSS = total sum of squares

The mean squares due to replication and genotype were divided by corresponding error mean squares and the calculated F value was compared with table value of F at P= 0.05 and P= 0.01, respectively.

$$\text{Grand mean} = \frac{\text{Grand total}}{N}$$

Where,

$$N = \text{Total number of Treatments} \times \text{Replications}$$

$$\text{Correction factor} = \frac{(\text{Grand total})^2}{N}$$

$$\text{Total sum of squares} = \text{Sum squares of each treatment} - \text{C.F.}$$

$$\text{Treatment sum of squares} = \frac{\text{Sum of treatment squares}}{\text{Replication number}} - \text{C.F.}$$

$$\text{Replication S.S.} = \frac{\text{Sum of replications squares}}{\text{Treatment number (t)}} - \text{C.F.}$$

$$\text{Error S.S.} = \text{Total S.S.} - (\text{Treatment S.S.} + \text{replication S.S.})$$

Mean sum of squares were obtained by dividing the sum of squares with the respective degrees of freedom.

$$F. \text{ Variation ratio} = \frac{\text{Treatment MS}}{\text{Error MS}}$$

The significance of treatments was tested by F test by comparing the calculated F value with tabulated F value at 5% level of significance for the corresponding degree of freedom. The analysis of variance was set up as follows:

$$\text{Standard Error/plot} = \sqrt{\text{Error MS}}$$

There, F. test was observed to be significant, comparison was further extended by testing difference of any 2 treatments means against critical difference (CD) at 5% level of significance.

The calculation of CD at 5% was carried out with the help of following formula.

$$CD = SED_{\pm} \times t \text{ Value at 5\% error F}$$

Where,

$$CD = \text{Critical difference.}$$

$SED_{\pm}$  = Standard error of difference between two treatments means.

$$S.E. (\text{Treatment means}) = \sqrt{\frac{EMS}{r}}$$

Coefficient of variation =  $SED \times t$  values at 5%

$$= \sqrt{\frac{2EMS}{r \times t \text{ 5\% at Error d.f.}}}$$

**Parameters of variability**

**(i) Mean**

The mean value of each character was determined by dividing the total number of corresponding number of observations.

$$X = SX/N$$

Where,

SX is the summation of the variables

N is the number of observations.

**(ii) Range**

Lowest and highest values for each trait were recorded.

**Estimation of components of variation:**

The estimation procedure of variance components requires mating design that result in different types of relatives:

Using appropriate experimental design and Statistical analysis, Variance components calculated, Robinson *et al.* (1923).

Environmental Variance ( $\delta^2_e$ )

$$\delta^2_e = MSe$$

$$\text{Genotypic Variance } (\delta^2_g) = \frac{MSg - MSe}{r}$$

$$\text{Phenotypic Variance } (\delta^2_p) = \delta^2_g + \delta^2_e$$

The mean square due to error was subtracted from the mean square due to genotypes and their difference was divided by replications for obtaining the genotypic variance, which was calculated accordingly to the method suggested by Burton (1953).

**Standard error**

S.E. of the mean was calculated with the help of error mean square from ANOVA.

$$\begin{aligned} \text{S.E. (Mean)} &= \sqrt{\frac{\delta^2_{11}}{r}} \quad \text{or} \\ &= \sqrt{\frac{\text{Variance due to error}}{\text{Number of replications}}} \end{aligned}$$

**Phenotypic and genotypic coefficient of variability:**

Phenotypic and genotypic coefficient of variability were calculated as per the method suggested by Burton and Devane (1963). The same is as follows.

$$\begin{aligned} \text{Phenotypic coefficient of variation (PCV)} &= \sqrt{\frac{\text{phenotypic variance} \times 100}{\bar{X}}} \\ \text{Genotypic coefficient of variation (GCV)} &= \sqrt{\frac{\text{genotypic variance} \times 100}{\bar{X}}} \\ \text{ECV} &= \sqrt{\frac{\text{genotypic variance} \times 100}{\bar{X}}} \end{aligned}$$

Where  $\bar{X}$  is the mean of character?

**(iii) Heritability**

Heritability is the transmissibility of characteristics from parents to offspring. Heritability in a broad sense is the ratio of genotypic variance to total phenotypic variance in percentage.

Heritability in broad sense ( $h^2$ ) was calculated by the following formula suggested by Henson *et al.* (1956).

$$h^2 = \frac{\delta^2_g}{\delta^2_t}$$

$$h^2 = \frac{\delta^2_g}{\delta^2_p} \times 100 \quad \text{or}$$

Where,

$$\begin{aligned} \delta^2_g &= \text{genotypic variance} \\ \delta^2_p &= \text{phenotypic variance} \\ \delta^2_e &= \text{environmental variance} \end{aligned}$$

**(iv) Genetic advance**

To calculate the expected genetic advances the formula given by Lush (1949) and Johnson *et al.* (1950) was applied.

$$\begin{aligned} G &= \frac{\delta^2_g}{\delta^2_{ph}} K \delta_{ph} \\ &= h^2 \times K \cdot \delta_{ph} \end{aligned}$$

Where,

$$\begin{aligned} G &= \text{Genetic advance} \\ h^2 &= \text{heritability in broad} \\ \delta_{ph} &= \text{phenotypic standard deviation} \end{aligned}$$

K = Standardized selection differential which is 2.06 at 5% selection intensity (Lush, 1949) in large sample from normally distributed population.

Genetic advance as percent of mean was work out as:

$$GS (\%) = GS$$

Where,

$$\begin{aligned} GS &= \text{genetic advance} \\ X &= \text{grand mean of the character} \end{aligned}$$

**Estimation of correlation coefficient:**

Genotypic and phenotypic correlation coefficients were calculated from variance and covariance components. The calculations were based on the mean values of the characters. The method of computation was given by Panse and Shukhatme (1967).

a) Genotypic correlation coefficient (XY)

$$\begin{aligned} &= \frac{\text{Genotypic covariance XY}}{\sqrt{(\text{Genotypic variance X}) (\sqrt{\text{Genotypic variance Y}})}} \\ &= \frac{\text{Genotypic variance XY}}{\sqrt{(\delta^2_g \text{ X}) (\delta^2_g \text{ Y})}} \end{aligned}$$

b) Phenotypic correlation coefficient XY,  $r = \text{ph (XY)} = \frac{\text{Phenotypic covariance XY}}{\sqrt{(\delta^2_{\text{ph X}}) (\delta^2_{\text{ph Y}})}}$

The significance of 'r' values was tested at 5% and 1% from 'r' table at (V-2) degrees of freedom.

Where,

V is number of genotypes on which the observations were recorded.

**Test of significance of correlation:**

For the test the significance of correlation coefficient the following formula was used:

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

r = Correlation Coefficient  
n = Number of Observation

The calculated value of "t" was tested against table value of "t" at 5% and 1% level of significance with n-2 degrees of freedom for phenotypic correlation and error d.f.- for environmental correlation.

**Path coefficient analysis:**

The path coefficient was defined by Wright (1921a) as the ratio of standard deviation of all causes is constant, save whose variability kept changing. The path coefficient is a standardized partial regression coefficient that assesses one variables direct influence on another and allows the correlation coefficient to be separated into direct and indirect effects components (Wright 1921b). The concept of path analysis was later on elaborated by Dewey and Lu (1959).

**CAUSAL SYSTEM:**

The causal system demonstrates reciprocal linkage as indicated by the correlation coefficient and the direct effects as indicated by path coefficients.

The path coefficient was obtained by the simultaneous equations which expressed between correlation and path coefficient as suggested by Dewey and Lu (1959).

**a. Calculation of direct effect:**

$$\begin{aligned}
 r_{1.9} &= p_{1.9} + p_{2.9} + r_{1.3} + p_{3.9} + r_{1.4} + r_{1.5} + r_{1.6} p_{6.9} + r_{1.7}p_{7.9} + r_{1.8}p_{8.9} + r_{1.9}p_{9.9} \\
 r_{2.9} &= r_{2.9}p_{1.9} + p_{2.9} + r_{2.3}p_{3.9} + r_{2.4}p_{4.9} + r_{2.5} p_{5.9} + r_{2.6}p_{7.9} + r_{2.8}p_{8.9} + r_{2.9}p_{9.9} \\
 r_{3.9} &= r_{3.1}p_{1.9} + r_{3.2}p_{2.9} + p_{3.9} + r_{3.9}p_{4.10} \dots\dots r_{38}p_{89} \\
 r_{4.9} &= r_{42}p_{19} + r_{42}p_{29} + r_{43}p_{39} + \dots\dots\dots r_{48}p_{89} \\
 r_{5.9} &= r_{15}p_{19} + r_{42}p_{29} + r_{53}p_{39} + \dots\dots\dots r_{58}p_{89} \\
 r_{6.9} &= r_{62}p_{19} + r_{62}p_{29} + r_{63}p_{39} + \dots\dots\dots r_{68}p_{89} \\
 r_{7.9} &= r_{71}p_{19} + r_{72}p_{29} + r_{73}p_{39} + \dots\dots\dots r_{78}p_{89} \\
 r_{8.9} &= r_{81}p_{19} + r_{82}p_{29} + r_{83}p_{39} + \dots\dots\dots r_{89}p
 \end{aligned}$$

Where ‘r’ represents the correlation coefficient between the characters and ‘p’ indicates the effects of various characters on the dependent variable (the yield in this case).

**b. Calculation of indirect effect:**

The indirect effect can be computed by using the formula below which involves multiplying the value of coefficient by the correlation coefficient or appropriate rows and columns.

$$\text{Indirect effect} = r_{ij} \times P_{ij}$$

$$i = 1 \dots \dots \dots n$$

$$j = 1 \dots \dots \dots n$$

$$p_{ij} = P_{1y} P_{2y} \dots \dots P_{ny}$$

**c. Calculation of residual effect:**

The residual effects were calculated by the following formula:

$$\text{Residual effects} = 1 - R^2$$

Where,

$$R^2 = P_{1y} \cdot r_{1y} + P_{2y} \cdot r_{2y} + \dots \dots P_{ny} \cdot R_{ny}$$



## ***CHAPTER-4***

***EXPERIMENTAL***

***FINDINGS***

## ***EXPERIMENTAL FINDINGS***

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The present investigation entitled “**Studies on Genetic Variability, Heritability, Genetic Advance, Correlation Coefficient and Path Analysis in Tomato (*Solanum lycopersicum* L.)**” was carried out at Horticulture Research Farm-I, Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Rae Bareli Road, Lucknow (U.P.), India during the winter season of 2017-18 and 2018-19. In this chapter the results obtained from various characters are being presented in tables and described under the following head and sub headlines.

- 4.1** Analysis of variance
- 4.2** Mean performance of genotypes
- 4.3** Estimates of variability, heritability and genetic advance in percent of mean
- 4.4** Genotypic and Phenotypic Correlation coefficient
- 4.5** Path coefficient analysis

### **4.1 ANALYSIS OF VARIANCE:**

Analysis of variance (ANOVA) for the eighteen characters has been given in Table-4.1. The variances for different characters were divided in to replications, treatments and error. Observations were recorded on plant height (cm), number of branches per plant, days to 50% flowering, number of clusters per plant, number of flower per cluster, number of fruit per plant, average fruit weight (g), number of locules per fruit, pericarp thickness (mm), fruit length (cm), fruit width (cm), number of ridges on fruit, fruit yield per plant (g), fruit yield (kg/plot), fruit yield (q/ha), total soluble solids (<sup>0</sup>Brix) and vitamin C (mg/100g) were recorded.

**Table- 4.1.A: Analysis of variance for the nine characters of tomato.**

S. No.	Source of variation	D.F.	Characters								
			Plant height (cm)	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locules per fruit
1.	Replication I year	2	0.25	0.90	6.55	6.93	3.60	6.69	5.47	6.91	7.11
	II year		0.57	19.29	6.50	6.54	1.08	6.38	6.96	6.85	6.21
	Pooled		0.03	13.95	6.53	6.73	3.02	6.54	16.09	6.88	6.67
2.	Treatment I year	19	2.31	7.42	4.09	2.11	4.46	6.06	2.73	1.79	11.38
	II year		2.24	2.24	4.11	1.78	6.48	4.51	3.29	1.61	4.50
	Pooled		1.07	4.15	4.02	1.84	5.69	4.96	3.24	1.69	6.23
3.	Errors I year	38	0.46	0.21	0.30	0.41	0.29	0.23	0.38	0.44	0.14
	II year		0.47	0.32	0.29	0.45	0.23	0.28	0.33	0.46	0.28
	Pooled		0.45	0.23	0.30	0.45	0.18	0.26	0.17	0.45	0.25

**Table- 4.1.B: Analysis of variance for the nine characters of tomato.**

S. No.	Source of variation	D.F.	Characters								
			Pericarp thickness (mm/cm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)	T.S.S. (°Brix)	Vitamin C (mg/100g)
1.	Replication I year		6.94	7.02	5.98	6.25	6.94	6.94	6.94	2.28	1.86
	II year		6.62	6.93	6.08	6.34	6.97	6.96	6.97	2.88	0.84
	Pooled		6.79	6.98	6.03	6.30	6.95	6.95	6.95	1.49	0.98
2.	Treatment I year		7.07	1.77	11.90	15.53	9.26	9.26	9.26	1.92	1.66
	II year		3.16	1.47	9.95	11.86	9.22	9.23	9.23	0.93	4.07
	Pooled		4.29	1.87	10.88	13.39	9.23	8.86	9.23	2.10	0.55
3.	Error I year		0.20	0.44	0.14	0.11	0.17	0.17	0.17	0.48	0.48
	II year		0.34	0.24	0.16	0.14	0.17	0.17	0.17	0.55	0.32
	Pooled		0.29	0.47	0.15	0.12	0.17	0.17	0.17	0.34	0.36

## **4.2 Mean performance of genotype**

Mean value of genotypes in respect to various characters are presented in Table-4.2(A to E), respectively.

### **4.2.1: Plant height (cm):**

The perusal data revealed that the plant height (cm) ranged from 25.33 to 30.53 (2017-18) & 24.92 to 31.40 (2018-19) and 25.12 to 30.96 (Pooled data) respectively. The genotype Toleu- 32, consequently minimum plant height was observed, while maximum plant height had taken in genotype Pusa Sadabahar which was statistically with standard Selection- 7 during first year, second year and pooled data, respectively.

### **4.2.2: Number of branches per plant:**

In the present investigation, it was observed that the number of branches per plant ranged from 4.69 to 7.08 (2017-18) & 4.37 to 7.11 (2018-19) and 4.53 to 7.09 (Pooled data) respectively. The genotype Toleu- 32, consequently took minimum number of branches per plant was observed. While, maximum number of branches per plant had taken in genotype Pusa Sadabahar which was statistically followed by Selection- 7 during first year, second year and pooled data, respectively.

### **4.2.3: Days to 50 percent flowering:**

Days to 50 percent flowering ranged from 29.15 to 41.60 (2017-18) & 30.20 to 42.20 (2018-19) and 29.68 to 41.90 (Pooled data) consequently. The minimum days to 50 percent flowering was observed in genotype Pusa Sadabahar. While, maximum Days to 50 percent flowering taken in genotype Toleu-32 consequently pursued by Solan Vojr during first year & second year and pooled data.

### **4.2.4: Number of clusters per plant:**

The perusal data revealed that the number of clusters per plant ranged from 15.20 to 20.12 (2017-18) & 15.76 to 20.76 (2018-19) and 15.48 to 20.44 (Pooled data) respectively. The genotype Solan Vojr, minimum number of clusters per plant was observed, while maximum number of clusters per plant had taken in genotype Pusa

Sadabahar which was statistically at par with standard Selection- 7 during first year & second year and pooled data, respectively.

**4.2.5: Number of flowers per cluster:**

In the present investigation, it was observed that the number of flowers per plant ranged from 5.67 to 9.78 (2017-18) & 5.71 to 9.84 (2018-19) and 5.69 to 9.81 (Pooled data) respectively. The genotype Toleu- 32, consequently minimum number of flowers per plant was observed, while maximum number of flowers per plant had taken in genotype Pusa Sadabahar which was statistically followed by Selection- 7 during first year & second year and pooled data, respectively.

**4.2.6: Number of fruits per cluster:**

Number of fruits per cluster ranged from 3.20 to 5.12 (2017-18) & 3.13 to 5.04 (2018-19) and 3.17 to 5.08 (Pooled data) consequently. The minimum number of fruits per cluster was observed in genotype Toleu- 32. While, maximum number of fruits per cluster taken in genotype Pusa Sadabahar first year & second year and pooled data, respectively.



**Plate-8: An overview of tomato genotypes crop at flowering stage.**



**Plate-9: An overview of tomato genotypes crop at fruiting stage.**



**Plate-10: A general view of tomato genotypes crop at ripening stage.**



**Plate-11: A general view of tomato genotypes crop after harvesting**

**4.2.7: Number of fruits per plant:**

The perusal data clearly revealed that the number of fruits per plant ranged from 13.10 to 18.44 (2017-18) & 13.16 to 18.32 (2018-19) and 13.13 to 18.38(Pooled data) respectively. The genotype Toleu- 32, minimum number of fruits per plant was observed, while maximum number of fruits per plant had taken in genotype Pusa Sadabahar which was statistically at par with standard Selection- 7 during first year & second year and pooled data, respectively.

**4.2.8: Average fruits per plant:**

Average fruits per plant ranged from 41.88 to 53.20 (2017-18) & 42.02 to 52.88 in (2018-19) and 41.95 to 53.04 (Pooled data). The minimum average fruits per plant was observed in genotype Toleu- 32, while maximum average fruits per plant taken in genotype Pusa Sadabahar, respectively followed by Selection-7 in first year & second year and pooled data.

Table- 4.2.A: Mean performance of twenty genotypes of tomato.

Sl. No.	Genotypes	Characters											
		Plant height (cm)			Number of branches per plant			Days to 50 per cent flowering			Number of clusters per plant		
		2017-18	2018-19	Pooled	2017-18	2018-19	pooled	2017-18	2018-19	pooled	2017-18	2018-19	Pooled
1.	LA-3957	26.11	26.03	26.07	5.80	5.74	5.77	33.20	34.30	33.75	18.20	16.96	17.58
2.	Rio-Grande	27.30	26.30	26.80	5.74	5.77	5.75	39.15	40.10	39.63	16.18	17.45	16.82
3.	Punjab Barkha Bahar-2	28.90	27.74	28.32	6.06	6.40	6.23	30.60	31.20	30.90	19.10	18.60	18.85
4.	Kashi Aman	27.79	27.10	27.44	5.88	6.29	6.08	31.45	31.45	31.45	18.60	17.50	18.05
5.	Solan Vojr	25.64	25.33	25.48	5.24	5.66	5.45	41.10	41.70	41.40	15.20	15.76	15.48
6.	IIHR-2202	26.96	27.18	27.07	5.75	6.26	6.01	32.20	32.10	32.15	18.34	18.60	18.47
7.	VRT-103-6-1	26.22	26.84	26.53	4.75	5.25	5.00	38.12	37.45	37.79	16.12	17.42	16.17
8.	Kalyanpur typ-1	25.54	25.99	25.76	5.55	5.69	5.62	34.10	35.78	34.94	17.34	16.96	17.15
9.	Switizar Land	26.97	27.07	27.02	5.16	5.43	5.30	37.70	36.90	37.30	18.12	17.64	17.88
10.	Pusa Sadabahar	30.53	31.40	30.96	7.08	7.11	7.09	29.15	30.20	29.68	20.12	20.76	20.44
11.	VRT-02 (Pe)	26.03	26.07	26.05	4.75	5.77	5.26	34.96	35.38	35.17	16.45	17.36	16.91
12.	TLCV-16	26.11	25.99	26.06	5.55	5.94	5.75	36.30	35.60	35.95	17.42	16.96	17.19
13.	VRT-50	25.52	26.83	26.17	5.16	5.09	5.13	38.40	38.96	38.68	18.20	17.60	17.90
14.	Selection-7	29.70	29.32	29.51	6.07	6.66	6.37	30.45	30.60	30.53	19.42	20.45	19.94
15.	Toleu-32	25.33	24.92	25.12	4.69	4.37	4.53	41.60	42.20	41.90	15.34	16.12	15.73
16.	VRT-01	26.09	26.44	26.26	5.44	5.97	5.71	35.15	37.18	36.17	18.12	17.64	17.88
17.	H-86	26.22	26.34	26.28	4.99	5.19	5.09	34.20	32.45	33.33	17.60	18.12	17.86
18.	KT-8	25.54	26.02	25.78	4.81	5.03	4.92	38.55	37.78	38.17	18.16	17.12	17.64
19.	TLCV-28	26.97	26.32	26.64	5.81	5.97	5.89	34.78	33.20	33.99	18.12	17.62	17.87
20.	VRT-51	26.03	25.66	25.84	5.14	5.50	5.32	36.70	37.12	36.91	17.12	16.96	17.04
SEM ±		0.95	0.96	0.96	0.21	0.42	0.32	1.76	1.78	1.77	0.89	0.91	0.90
CD at 5%		2.80	2.84	2.82	0.63	1.23	0.93	5.19	5.25	5.22	2.63	2.64	2.64

Table- 4.2.B: Mean performance of twenty genotypes of tomato.

Sl. No.	Genotypes	Characters											
		Number of flowers per cluster			Number of fruits per cluster			Number of fruits per plant			Average fruit weight (g)		
		2017-18	2018-19	Pooled	2017-18	2018-19	pooled	2017-18	2018-19	pooled	2017-18	2018-19	Pooled
1.	LA-3957	7.33	7.40	7.37	3.78	4.02	3.90	15.44	15.12	15.28	46.22	46.88	46.55
2.	Rio-Grande	6.88	6.93	6.91	3.79	4.01	3.91	15.70	15.62	15.66	46.48	47.14	46.81
3.	Punjab Barkha Bahar-2	8.21	8.55	8.38	4.34	4.41	4.38	17.65	17.88	17.77	50.88	50.41	50.65
4.	Kashi Aman	8.20	8.37	8.29	3.88	3.96	3.92	16.88	17.12	17.50	50.55	49.82	50.19
5.	Solan Vojr	5.85	5.81	5.83	3.36	3.47	3.42	13.56	13.42	13.49	42.12	42.58	42.35
6.	IIHR-2202	7.98	8.23	8.11	3.84	3.90	3.87	16.44	16.56	16.50	49.12	49.34	49.23
7.	VRT-103-6-1	7.06	7.11	7.09	4.12	4.36	4.24	15.43	15.10	15.27	46.04	47.88	46.96
8.	Kalyanpur typ-1	7.11	7.07	7.10	4.36	4.22	4.29	14.88	15.08	14.98	44.15	43.76	43.96
9.	Switizar Land	6.77	6.91	6.84	4.32	4.56	4.44	15.22	14.88	15.05	45.88	46.02	45.95
10.	Pusa Sadabahar	9.78	9.84	9.81	5.12	5.04	5.08	18.44	18.32	18.38	53.20	52.88	53.04
11.	VRT-02 (Pe)	7.18	7.20	7.19	3.43	3.78	3.61	14.32	14.12	14.22	43.14	43.76	43.45
12.	TLCV-16	7.10	7.37	7.24	4.02	4.12	4.07	15.04	15.24	15.14	45.04	44.98	45.01
13.	VRT-50	6.97	7.07	7.02	3.42	3.56	3.49	15.66	15.52	15.59	46.48	47.08	46.78
14.	Selection-7	8.23	8.87	8.55	4.76	4.12	4.45	18.12	18.24	18.18	51.80	52.12	51.96
15.	Toleu-32	5.67	5.71	5.69	3.20	3.13	3.17	13.10	13.16	13.13	41.88	42.02	41.95
16.	VRT-01	6.89	7.05	6.97	3.48	3.76	3.62	15.56	15.28	15.42	47.14	48.12	47.63
17.	H-86	7.56	7.11	7.34	3.65	3.88	3.77	15.80	15.46	15.63	47.46	48.52	47.99
18.	KT-8	7.16	7.15	7.16	3.60	3.42	3.51	14.90	15.14	15.02	44.14	44.76	44.45
19.	TLCV-28	7.58	7.41	7.50	3.54	3.48	3.52	15.20	14.88	15.04	45.18	45.62	45.40
20.	VRT-51	6.88	6.93	6.91	3.48	3.68	3.58	15.12	15.22	15.17	44.76	45.14	44.95
SEm ±		0.42	0.38	0.40	0.20	0.21	0.21	0.82	0.78	0.80	2.34	2.36	2.35
CD at 5%		1.24	1.12	1.18	0.60	0.62	0.61	2.42	2.30	2.36	6.79	6.84	6.82

**4.2.9: Number of locules per fruit:**

The perusal of data given in Table-4.2 C. revealed that the number of locules per fruit ranged from 3.09 to 5.87 (2017-18) & 3.54 to 5.12 (2018-19) and 3.52 to 5.50 (Pooled data) respectively. The minimum number of locules per fruit was observed in Rio-Grande, while maximum number of locules per fruit had taken in genotype Punjab Barkha Bahar-2 during first year & second year and pooled data, respectively.

**4.2.10: Pericarp thickness (mm):**

In the present investigation, it observed that the pericarp thickness ranged from 2.81 to 4.72 (2017-18) & 3.01 to 4.69 (2018-19) and 2.91 to 4.62 mm (Pooled data), respectively. The genotype TLCV-28, consequently took minimum pericarp thickness was observed, while maximum pericarp thickness had taken in genotype VRT-103-6-1. (Table-4.2 C).

**4.2.11: Fruit length (cm):**

Data revealed given Table-4.2 C. that fruit length ranged from 5.19 to 6.53 (2017-18) & 5.26 to 6.64 (2018-19) and 5.23 to 6.59 cm (Pooled data) respectively. The genotype VRT-50, respectively took minimum fruit length was observed, while maximum fruit length had taken in Kashi Aman.

**4.2.12: Fruit width (cm):**

In the present investigation, it observed that the fruit width ranged from 4.36 to 7.98 (2017-18) & 4.72 to 7.91 (2018-19) and 4.62 to 7.91 cm (Pooled data) respectively. The minimum fruit width was observed in genotype Kashi Aman, while maximum fruit width had taken in genotype LA-3957. (Table-4.2 C).

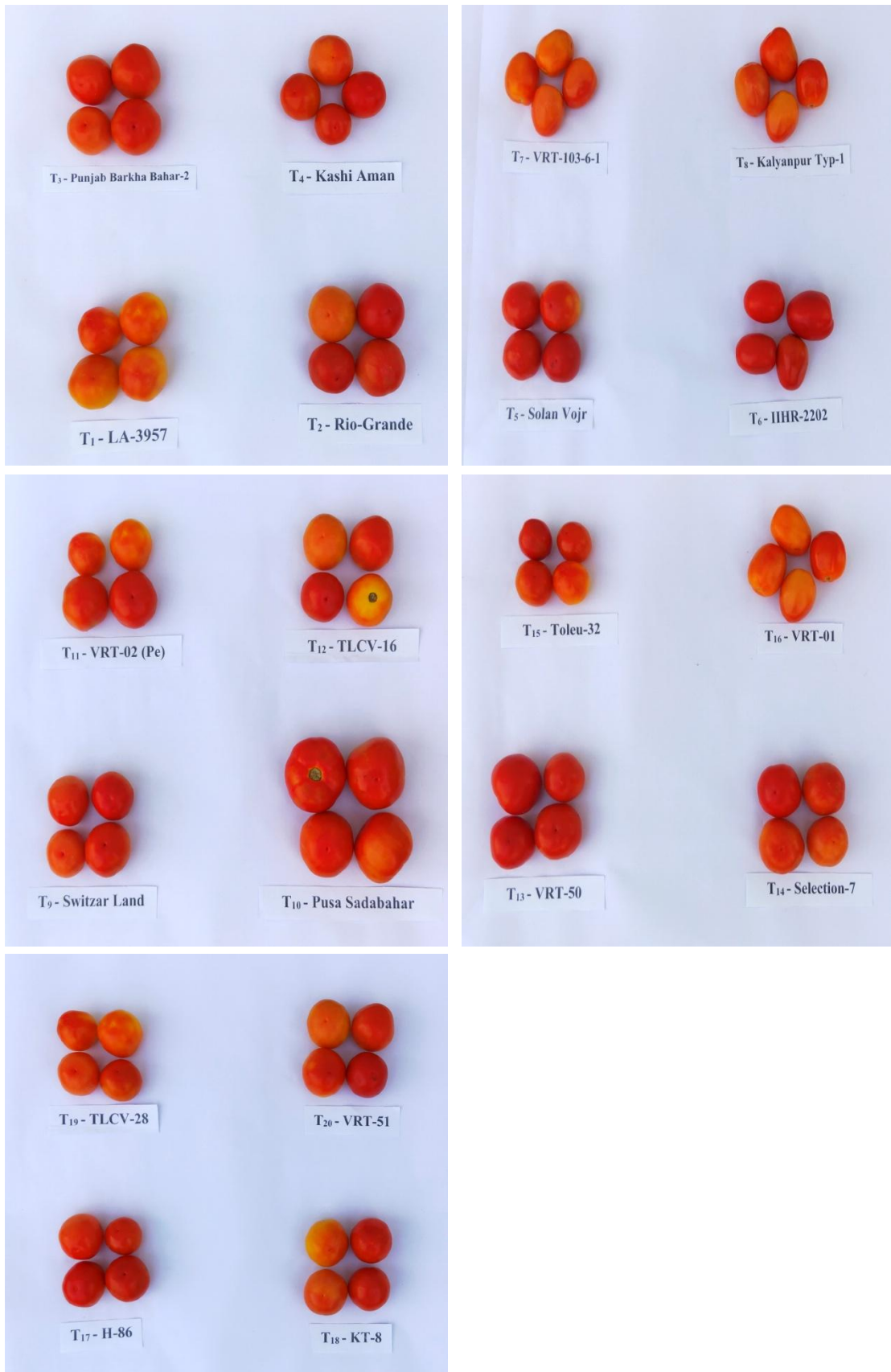
**4.2.13: Number of ridges on fruit:**

It was observed that the number of ridges on fruit ranged from 1.15 to 2.29 (2017-18) & 1.17 to 2.18 (2018-19) and 1.19 to 2.24 (Pooled data) respectively. The minimum number of ridges on fruit was observed in genotype Rio- Grande, while maximum number of ridges on fruit had taken in Kalyanpur type-1. (Table-4.2 D).

Table- 4.2.C: Mean performance of twenty genotypes of tomato.

Sl. No	Genotypes	Characters											
		Number of locules per fruit			Pericarp thickness (mm)			Fruit length (cm)			Fruit width (cm)		
		2017-18	2018-19	pooled	2017-18	2018-19	pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
1.	LA-3957	4.12	4.24	4.18	4.34	4.69	4.52	5.25	5.43	5.34	7.98	7.83	7.91
2.	Rio-Grande	3.50	3.54	3.52	4.03	3.96	3.99	5.62	5.84	5.73	6.84	7.01	6.93
3.	Punjab Barkha Bahar-2	5.87	5.12	5.50	4.36	4.57	4.47	6.05	6.12	6.09	5.02	5.22	5.12
4.	Kashi Aman	4.42	4.08	4.25	3.12	3.84	3.48	6.53	6.64	6.59	4.36	4.88	4.62
5.	Solan Vojr	4.83	4.33	4.58	4.38	3.96	4.17	5.26	5.42	5.34	7.88	7.64	7.76
6.	IIHR-2202	4.63	4.74	4.69	3.62	4.02	3.82	5.64	5.86	5.75	7.13	7.09	7.11
7.	VRT-103-6-1	4.42	5.08	4.75	4.55	4.68	4.62	6.02	5.98	6.00	4.86	5.02	4.94
8.	Kalyanpur typ-1	3.09	4.72	3.91	3.38	4.01	3.70	5.28	5.38	5.33	7.72	7.64	7.68
9.	Switzar Land	4.48	4.83	4.66	4.72	4.08	4.40	5.76	6.01	5.89	6.88	6.72	6.80
10.	Pusa Sadabahar	4.33	4.88	4.61	3.75	4.12	3.94	5.83	5.88	5.86	6.94	7.02	6.98
11.	VRT-02 (Pe)	4.13	4.63	4.38	3.53	3.96	3.75	5.44	5.65	5.55	7.03	6.88	6.96
12.	TLCV-16	3.57	3.84	3.71	4.42	4.02	4.22	6.01	5.96	5.99	5.12	5.32	5.22
13.	VRT-50	4.23	3.64	3.94	3.44	3.84	3.64	5.19	5.26	5.23	7.89	7.91	7.90
14.	Selection-7	5.63	4.12	4.88	3.86	4.08	3.97	6.18	6.08	6.13	5.34	5.45	5.40
15.	Toleu-32	5.57	5.08	5.33	4.46	4.52	4.49	5.84	6.02	5.93	6.54	6.42	6.48
16.	VRT-01	3.84	4.27	5.32	3.69	3.94	3.82	5.96	6.04	6.50	7.12	7.08	7.10
17.	H-86	4.34	4.06	4.06	3.89	4.07	3.98	6.04	5.84	5.94	4.86	4.72	4.79
18.	KT-8	4.86	4.23	4.55	3.51	3.84	3.68	5.78	5.70	5.74	5.04	5.24	5.14
19.	TLCV-28	4.66	4.12	4.39	2.81	3.01	2.91	5.26	5.43	5.35	7.64	7.48	7.56
20.	VRT-51	3.74	3.88	3.81	3.73	4.04	3.89	5.46	5.31	5.39	7.52	7.61	7.57
	SEM ±	0.21	0.23	0.22	0.19	0.21	0.21	0.28	0.28	0.28	0.36	0.35	0.36
	CD at 5%	0.63	0.67	0.65	0.57	0.61	0.59	0.82	0.83	0.83	1.05	1.05	1.05

**Plate-12: A general view of tomato genotypes crop after harvesting.**



**4.2.14: Fruit yield per plant (g):**

The perusal data given in Table-4.2 D. revealed that the fruit yield ranged from 548.63 to 981.01 (2017-18) & 552.98 to 968.76 (2018-19) and 550.81 to 974.89g (Pooled data) respectively. The minimum fruit yield was observed in Toleu-32, while maximum fruit yield had taken in genotype Pusa Sadabahar consequently pursued by Selection-7 during first year & second year and pooled data.

**4.2.15: Fruit yield (kg/plot):**

Fruit yield ranged from 8.78 to 15.70 (2017-18) & 8.85 to 15.50 (2018-19) and 8.82 to 15.12kg/plot (Pooled data) respectively. The minimum fruit yield was observed in Toleu-32, while maximum fruit yield per plant had taken in genotype Pusa Sadabahar consequently pursued by Selection-7 during first year & second year and pooled data. (Table-4.2 D).

**4.2.16: Fruit yield (q/ha):**

In the present investigation, it observed that the fruit yield ranged from 203.24 to 363.42 (2017-18) & 204.86 to 358.80 (2018-19) and 204.05 to 361.11 q/ha (Pooled data) respectively. The minimum fruit yield was observed in genotype Toleu-32, while maximum fruit yield had taken in genotype Pusa Sadabahar. (Table-4.2 D).

**4.2.17: Total Soluble Solids (<sup>0</sup>Brix):**

The perusal data mentioned in Table-4.2 E. revealed that the total soluble solids ranged from 4.02 to 5.61 (2017-18) & 4.31 to 5.73 (2018-19) and 4.17 to 5.49 <sup>0</sup>Brix (Pooled data) respectively. The minimum total soluble solids were observed in genotype LA-3957, while maximum total soluble solids had taken in genotype TLCV-28.

**4.2.18: Vitamin C (mg/100g):**

It was observed that the vitamin C ranged from 23.71 to 27.79 (2017-18) & 24.19 to 27.74 (2018-19) and 23.95 to 27.77mg/100g (Pooled data) respectively. The minimum vitamin C was observed in genotype LA-3957, while maximum vitamin C in genotype VRT-50 respectively followed by TLCV-16. (Table-4.2 E).

Table- 4.2.D: Mean performance of twenty genotypes of tomato.

Sl. No.	Genotypes	Characters											
		Number of ridge on fruit			Fruit yield per plant (g)			Fruit yield (kg/plot)			Fruit yield (q/ha)		
		2017-18	2018-19	pooled	2017-18	2018-19	pooled	2017-18	2018-19	pooled	2017-18	2018-19	Pooled
1.	LA-3957	1.32	1.36	1.34	713.63	708.83	711.23	11.41	11.34	11.38	264.12	262.50	263.31
2.	Rio-Grande	1.21	1.17	1.19	729.73	736.33	733.03	11.67	11.78	11.73	270.14	272.68	271.41
3.	Punjab Barkha Bahar-2	1.44	1.54	1.49	898.03	901.33	899.68	14.36	14.42	14.39	332.40	333.79	333.09
4.	Kashi Aman	1.56	1.63	1.60	853.28	852.92	853.10	13.65	13.66	13.66	315.98	315.97	315.98
5.	Solan Vojr	1.15	1.23	1.19	571.14	571.42	571.28	9.13	9.14	9.14	211.34	211.57	211.46
6.	IHR-2202	1.43	1.56	1.50	807.53	817.07	812.30	12.92	13.07	12.99	299.07	302.55	300.81
7.	VRT-103-6-1	1.81	1.76	1.79	710.39	722.99	716.69	11.37	11.57	11.47	263.19	267.82	265.51
8.	Kalyanpur typ-1	2.29	2.18	2.24	656.95	659.90	658.43	10.52	10.56	10.54	243.52	244.44	243.98
9.	Switizar Land	1.28	1.37	1.33	698.29	684.78	691.54	11.17	10.96	11.07	258.56	253.70	256.13
10.	Pusa Sadabahar	1.45	1.49	1.47	981.01	968.76	974.89	15.70	15.62	15.12	363.42	358.80	361.11
11.	VRT-02 (Pe)	1.66	1.76	1.71	617.76	617.89	617.83	9.88	9.89	9.89	228.70	228.71	228.71
12.	TLCV-16	1.78	1.65	1.72	677.41	685.50	681.46	10.83	10.97	10.90	250.69	253.94	252.32
13.	VRT-50	1.58	1.44	1.51	727.88	730.68	729.28	11.65	11.69	11.67	269.67	270.60	270.14
14.	Selection-7	1.17	1.28	1.23	938.62	950.67	944.64	15.02	15.21	15.11	347.68	352.08	349.88
15.	Toleu-32	1.44	1.59	1.52	548.63	552.98	550.81	8.78	8.85	8.82	203.24	204.86	204.05
16.	VRT-01	1.98	2.02	2.00	733.50	735.28	734.39	11.74	11.76	11.75	271.75	273.22	272.49
17.	H-86	2.12	1.98	2.05	760.30	750.12	755.21	12.16	12.00	12.08	281.48	277.77	279.63
18.	KT-8	2.04	2.03	2.04	657.69	677.67	667.68	10.52	10.84	10.68	243.51	250.93	247.22
19.	TLCV-28	1.88	1.96	1.92	687.65	678.83	683.24	11.01	10.86	10.94	254.86	251.39	253.13
20.	VRT-51	1.76	1.68	1.72	678.59	687.04	682.82	10.86	10.96	10.91	251.38	254.40	252.89
	SEM ±	0.08	0.08	0.08	37.47	37.28	37.38	0.60	0.60	0.60	13.88	13.81	13.85
	CD at 5%	0.25	0.25	0.25	110.54	109.97	110.26	1.77	1.76	1.77	40.94	40.73	40.84

Table- 4.2.E: Mean performance of twenty genotypes of tomato.

Sl. No.	Genotypes	Characters					
		T.S.S ( <sup>o</sup> Brix)			Vitamin-C (mg/100)		
		2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
1.	LA-3957	4.02	4.31	4.17	23.71	24.19	23.95
2.	Rio-Grande	4.64	5.42	5.03	24.84	25.03	24.94
3.	Punjab Barkha Bahar-2	4.56	5.31	4.94	24.52	24.74	24.63
4.	Kashi Aman	4.59	5.33	4.96	24.99	25.01	25.00
5.	Solan Vojr	4.84	5.62	5.23	25.16	25.09	25.13
6.	IIHR-2202	4.95	5.43	5.19	24.78	24.71	24.75
7.	VRT-103-6-1	5.21	5.29	5.25	25.09	25.33	25.21
8.	Kalyanpur typ-1	5.33	5.52	5.43	24.83	24.93	24.88
9.	Switizar Land	5.18	5.29	5.24	24.79	24.86	24.83
10.	Pusa Sadabahar	5.29	5.44	5.37	25.21	25.25	25.23
11.	VRT-02 (Pe)	4.52	5.51	5.02	25.01	25.05	25.03
12.	TLCV-16	6.04	6.27	6.16	27.37	27.48	27.43
13.	VRT-50	5.03	5.54	5.29	27.79	27.74	27.77
14.	Selection-7	5.05	5.73	5.39	25.52	25.21	25.37
15.	Toleu-32	4.79	5.39	5.09	25.33	25.70	25.52
16.	VRT-01	4.56	4.85	4.71	26.09	26.11	26.10
17.	H-86	5.61	5.37	5.49	26.22	26.18	26.20
18.	KT-8	5.03	5.32	5.18	25.54	25.87	25.71
19.	TLCV-28	5.52	5.45	5.49	26.97	26.17	26.57
20.	VRT-51	5.21	5.27	5.24	26.03	26.19	26.11
SEM ±		0.33	0.38	0.36	0.78	0.45	0.62
CD at 5%		0.98	1.01	0.99	2.26	1.32	1.79

**Plate-13: View of TSS (<sup>0</sup>Brix) estimation in tomato fruit under laboratory condition.**



**4.3.1: Estimates of variability, heritability and genetic advance as percent of mean for twenty characters in tomato 2017-18:**

Among the two years (2017-18 & 2018-19) and pooled data, estimate of variability, heritability and genetic advance. The data presented in Table 4.3(A, B&C) revealed highly significant for all the characters.

**4.3. 1. A: Genetic variability:**

The coefficient of variation value is presented in Table 4.3(A); the phenotypic coefficient variation (PCV) was superior to their individual genotypic coefficient of variation (GCV) for all the traits under study.

The widest range was recorded in fruit yield per plant (15805.54 - 11592.94) followed by (2168.70 - 1590.86), average fruit weight (20.82 - 4.36), days to 50% flowering (45.51 - 7.59), plant height (3.89 - 1.18), Vitamin C (2.21 - 0.40), while lowest range was observed in Number of ridges on fruit (0.12 - 0.10), followed by number of fruit per cluster (0.33 - 0.21) and number of locules per fruit (0.60 - 0.47), yield (3.79 - 2.74).

The highest coefficient of variation was recorded in number of ridges on fruit (21.77%) followed by fruit width (20.55%), days to 50% flowering (19.06%), number of locules per fruit (17.57%), fruit yield per plant (17.17%), pericarp thickness (15.08%), number of fruits per plant (14.89%) and number of flower per cluster (14.65%). The lowest coefficient of variation was observed in vitamin C (5.84%) pursued by plant height (7.87%) and average fruit weight (9.80%).

The maximum genotypic coefficient of variation was recorded in number of ridges on fruit (19.82%) followed by fruit width (18.20%), number of locules per fruit (15.48%), fruit yield (14.72%), fruit yield per plant (14.70%). Whereas, moderate genotypic coefficient of variation was observed in pericarp thickness (12.33%) while minimum genotypic coefficient of variation was calculated in vitamin C (2.48%) followed by plant height (4.06%).

**4.3.1. B: Heritability:**

Heritability value is presented in Table 4.3(A). The maximum heritability was recorded in number of ridges on fruit (91.04%) pursued by fruit width (88.56%),

number of locules per fruit (88.08%), fruit yield (85.64%), number of branches per plant (82.56%) and pericarp thickness (81.81) whereas, the minimum heritability was observed in days to 50% flowering (40.85) followed by vitamin C (42.42) and fruit length (45.16).

### **4.3.1. C: Genetic gain:**

The maximum genetic gain (%) was recorded in fruit yield per plant (20113.29%) followed by fruit yield (7451.04%), fruit yield q/ha (321.89%), days to 50% flowering (299.17%), average fruit weight (295.82%), fruit width (224.99%) and number of fruits per plant (169.09%). The minimum genetic gain was observed in fruit length (34.57%) respectively followed by TSS (45.68%) and number of ridges on fruit (62.16%).

**Table- 4.3.A: Estimates of variability, heritability and genetic advance as percent of mean for eighteen characters in tomato (2017-18)**

S. No.	Character	Range		Mean	Variance		PCV (%)	GCV (%)	h <sup>2</sup>	Genetic Advance	GA % of mean
		Min.	Max.		Phenotypic	Genotypic					
1.	Plant height (cm)	25.33	30.53	26.78	3.89	1.18	7.37	4.06	55.14	164.08	29.59
2.	Number of branches per plant	4.69	7.08	5.47	0.44	0.30	12.06	9.96	82.56	99.60	150.29
3.	Days to 50 percent flowering	29.15	41.60	35.39	45.51	7.59	19.06	7.79	40.85	299.17	35.41
4.	Number of clusters per plant	15.20	20.12	17.66	3.27	0.89	10.25	5.33	51.99	138.88	40.87
5.	Number of flowers per cluster	5.67	9.78	7.32	1.15	0.62	14.65	10.72	73.18	134.33	134.31
6.	Number of fruits per cluster	3.20	5.12	3.87	0.33	0.21	14.89	11.80	79.24	81.68	167.05
7.	Number of fruits per plant	13.10	18.44	15.62	3.19	1.17	11.43	6.91	60.51	169.09	65.49
8.	Average fruit weight (g)	41.88	53.20	46.58	20.82	4.36	9.80	4.48	45.76	295.82	29.06
9.	Number of locules per fruit	3.09	5.87	4.41	0.60	0.47	17.57	15.48	88.08	129.75	258.97
10.	Pericarp thickness (mm)	2.81	4.65	3.88	0.34	0.23	15.08	12.33	81.81	87.02	183.52
11.	Fruit length (cm)	5.19	6.53	5.72	0.29	0.06	9.48	4.28	45.16	34.57	27.29
12.	Fruit width (cm)	4.36	7.98	6.49	1.78	1.39	20.55	18.20	88.56	224.99	307.22
13.	Number of ridges on fruit	1.15	2.29	1.62	0.12	0.10	21.77	19.82	91.04	62.16	349.88
14.	Fruit yield per plant (g)	548.63	981.01	732.40	15805.54	11592.94	17.17	14.70	85.64	20113.29	235.19
15.	Fruit yield (kg/plot)	8.78	15.70	11.72	4.05	2.97	17.17	14.71	85.65	321.89	235.28
16.	Fruit yield (q/ha)	203.24	363.42	271.24	2168.70	1590.86	17.17	14.72	85.65	7451.04	235.28
17.	T.S.S. ( <sup>0</sup> Brix)	4.02	6.04	5.00	0.43	0.10	13.12	6.34	48.36	45.68	44.20
18.	Vitamin C (mg/100g)	23.71	27.79	25.49	2.21	0.40	5.84	2.48	42.42	87.52	14.56

**4.3.2: Estimates of variability, heritability and genetic advance as percent of mean for eighteen characters in tomato 2018-19:**

**4.3.2. A: Genetic variability:**

For all the traits studied, as given in Table-4.3.1 B. showed that the phenotypic coefficient variation (PCV) was greater than genotypic coefficient of variation (GCV).

The widest range was recorded in fruit yield per plant (15595.12 - 11425.85) followed by fruit yield q/ha (2139.57 - 1567.78), average fruit weight (20.15 - 3.42), days to 50% flowering (19.35 - 9.86), number of cluster per plant (3.11 - 0.64). While, the lowest range was observed in number of ridges on fruit (0.10 - 0.08) pursued by number of fruits per cluster (0.29 - 0.15).

The highest phenotypic coefficient of variation was recorded in number of ridges on fruit (19.12%) followed by fruit width (18.79%), fruit yield (17.01%), fruit yield per plant (17.00%), while the lowest phenotypic coefficient of variation was observed in vitamin C (4.32%) pursued by (7.42%).

The maximum genotypic coefficient of variation was recorded in number of ridges on fruit (16.93%) followed by fruit width (16.26%), fruit yield (14.56%), fruit yield per plant (14.55%), number of flower per cluster (12.01%) and number of fruits per cluster (9.98), Whereas, the minimum genotypic coefficient of variation (%) was observed in vitaminC (3.07%) pursued by fruit length (3.38%) and average fruit weight (3.94%).

**4.3.2. B: Heritability:**

The highest heritability was recorded in number of ridges on fruit (88.52%) respectively followed by fruit width (86.55%), fruit yield kg/plot (85.61%), fruit yield per plant (85.60%), number of flower per cluster (80.39%), number of fruit per cluster (73.44%), number of locules per plant (73.36%), while the lowest heritability was calculated in fruit length (36.87%) consequently pursued by average fruit weight (41.17%). (Table-4.3 B).

**4.3.2. C: Genetic gain:**

The maximum genetic gain (%) was recorded in fruit yield per plant (19961.20%) respectively followed by fruit yield (7394.39%), days to 50 percent flowering (530.53%), fruit yield kg/plot (319.57%), average fruit weight (254.39%), fruit width (198.98%) and number of fruits per plant (191.89%). The maximum genetic gain (%) was observed in fruit length (26.22%) pursued by pericarp thickness (48.91%).

**Table- 4.3.B: Estimates of variability, heritability and genetic advance as percent of mean for eighteen characters in tomato (2018-19)**

S. No.	Character	Range		Mean	Variance		PCV (%)	GCV (%)	h <sup>2</sup>	Genetic Advance	GA % of mean
		Min.	Max		Phenotypic	Genotypic					
1.	Plant height (cm)	24.92	31.40	26.75	3.94	1.15	7.42	4.01	54.06	160.57	30.81
2.	Number of branches per plant	4.37	7.11	5.75	0.73	0.21	14.89	8.05	54.04	69.33	15.36
3.	Days to 50 percent flowering	30.20	42.20	35.58	19.35	9.86	12.36	8.82	71.37	530.53	9.40
4.	Number of clusters per plant	15.76	20.76	17.68	3.11	0.64	9.97	4.53	45.42	113.21	34.39
5.	Number of flowers per cluster	5.71	9.84	7.40	1.22	0.79	14.94	12.01	80.39	160.17	5.75
6.	Number of fruits per cluster	3.13	5.04	3.94	0.29	0.15	13.59	9.98	73.44	67.48	7.96
7.	Number of fruits per plant	13.16	18.32	15.57	3.22	1.40	11.53	7.59	65.80	191.89	12.33
8.	Average fruit weight (g)	42.02	52.88	46.94	20.15	3.42	9.56	3.94	41.17	254.39	44.82
9.	Number of locules per fruit	3.54	5.12	4.37	0.34	0.18	13.33	9.78	73.36	73.26	8.13
10.	Pericarp thickness (mm)	3.01	4.69	4.06	0.22	0.09	11.53	7.47	64.74	48.91	12.83
11.	Fruit length (cm)	5.26	6.64	5.79	0.28	0.04	9.16	3.38	36.87	26.22	59.92
12.	Fruit width (cm)	4.72	7.91	6.51	1.50	1.12	18.79	16.26	86.55	198.98	3.78
13.	Number of ridges on fruit	1.17	2.18	1.63	0.10	0.08	19.12	16.93	88.52	52.70	3.50
14.	Fruit yield per plant (g)	552.98	968.76	734.55	15595.12	11425.85	17.00	14.55	85.60	19961.20	4.30
15.	Fruit yield (kg/plot)	8.85	15.60	11.75	4.00	2.93	17.01	14.56	85.61	319.57	4.30
16.	Fruit yield (q/ha)	204.86	358.80	272.09	2139.57	1567.78	17.00	14.55	85.60	7394.39	4.30
17.	T.S.S. ( <sup>0</sup> Brix)	4.31	6.27	5.38	0.42	-0.01	12.00	13.12	60.34	154.68	67.46
18.	Vitamin C (mg/100g)	24.19	27.74	25.54	1.22	0.62	4.32	3.07	71.12	132.43	27.12

**4.3.3: Estimates of variability, heritability and genetic advance as percent of mean for eighteen characters in pooled data:**

**4.3.3. A: Genetic variability:**

For all the traits under studied, The phenotypic coefficient of variation (PCV) was higher than their respective genotypic coefficient of variation (GCV) as given in Table-4.3.3 A.

The widest range was recorded for fruit yield per plant (15680.66 - 11489.85) followed by fruit yield (2151.40 - 1576.59), average fruit weight (20.40 - 3.80), Days to 50% flowering (18.84 - 9.45), Plant height (5.72 - 0.12), Vitamin C (4.16 - 0.74), number of clusters per plant (3.10 - 0.68), number of fruits per plant (3.23 - 1.38), while lowest range were recorded in number of ridges on fruit (0.11 - 0.09), Fruit yield (3.79 - 2.74).

Phenotypic coefficient variation was higher for number of ridges on fruit (20.25) followed by fruit width (20.25), fruit yield per plant (17.07%), fruit yield kg/plot (16.63), number of flower per cluster (14.58%), Number of locules per fruit (14.16%) and number of fruits per clusters (13.93), where as it was moderate for number of branches per plant (12.71%) followed by pericarp thickness (12.63%), Days to 50% flowering (12.33), number of fruits per plant (11.50%) and TSS (10.18%), the lowest phenotypic coefficient of variation was recorded in Vitamin C (7.99%) respectively followed by plant height (8.94%).

The maximum genotypic coefficient of variation was observed in number of ridges on fruit (18.17) consequently followed by fruit width (17.20), fruit yield (14.62%), fruit yield per plant (14.61%) and fruit yield (14.15), It was moderate for number of flower per cluster (11.38%), number of locules per fruit (11.28%), number of fruit per cluster (10.51%), pericarp thickness (9.14%), number of branches per plant (9.10%) and days to 50% flowering (8.66%). The minimum genotypic coefficient of variation was observed in plant height (1.31%) followed by (4.17%), average fruit weight (4.17%) and number of cluster per plant (4.67).

**4.3.3. B: Heritability:**

Heritability value in broad sense is presented in Table 4.3(C). The high value of broad sense heritability was recorded for all the characters. The highest heritability was recorded for number of ridges on fruit (89.72%) followed by fruit width (87.58%), fruit yield (85.61), fruit yield per plant (85.60%), fruit yield kg/plot (85.07%), number of locules per fruit (79.71%), number of flower per cluster (78.10%) and number of fruits per cluster (75.42%) whereas, the lowest heritability was recorded in plant height (14.62%) followed by vitamin C (42.23%) and average fruit weight (43.18%).

**4.3.3. C: Genetic gain:**

The maximum genetic advance (%) was recorded for fruit yield per plant (20017.72%) followed by fruit yield (7415.34%), days to 50% flowering (517.61), fruit yield kg/plot (308.25%), average fruit weight (271.78%), fruit width (211.62%), number of fruits per plant (190.43%), and number of flower per cluster (148.57%). The minimum genetic advance was observed in fruit length (37.83%) pursued by TSS (<sup>0</sup>brix) (40.41%) and plant height (42.47%). (Table-4.3 C).

**Table- 4.3.C: Estimates of variability, heritability and genetic advance as per cent of mean for eighteen characters in tomato (pooled data)**

S. No.	Character	Range		Mean	Variance		PCV (%)	GCV (%)	h <sup>2</sup>	Genetic Advance	GA % of mean
		Min.	Max		Phenotypic	Genotypic					
1.	Plant height (cm)	25.12	30.96	26.76	5.72	0.12	8.94	1.31	14.62	42.47	27.98
2.	Number of branches per plant	4.53	7.09	5.61	0.51	0.26	12.71	9.10	71.57	86.43	7.85
3.	Days to 50 percent flowering	29.68	41.90	35.49	18.84	9.45	12.23	8.66	70.84	517.61	9.68
4.	Number of clusters per plant	15.48	20.44	17.64	3.10	0.68	9.98	4.67	46.81	117.53	36.42
5.	Number of flowers per cluster	5.69	9.81	7.37	1.15	0.70	14.58	11.38	78.10	148.57	5.32
6.	Number of fruits per cluster	3.17	5.08	3.91	0.30	0.17	13.93	10.51	75.42	71.48	7.23
7.	Number of fruits per plant	13.13	18.38	15.62	3.23	1.38	11.50	7.52	65.41	190.43	7.91
8.	Average fruit weight (g)	41.95	53.04	46.76	20.40	3.80	9.66	4.17	43.18	271.78	39.87
9.	Number of locules per fruit	3.52	5.50	4.45	0.40	0.25	14.16	11.28	79.71	90.02	7.04
10.	Pericarp thickness (mm)	2.91	4.67	3.97	0.25	0.13	12.63	9.14	72.33	61.75	8.90
11.	Fruit length (cm)	5.23	6.59	5.78	0.31	0.07	9.61	4.57	47.51	37.83	50.31
12.	Fruit width (cm)	4.62	7.91	6.50	1.63	1.25	19.64	17.20	87.58	211.62	3.51
13.	Number of ridges on fruit	1.19	2.24	1.63	0.11	0.09	20.25	18.17	89.72	56.83	3.19
14.	Fruit yield per plant (g)	550.81	974.89	733.48	15680.66	11489.85	17.07	14.61	85.60	20017.72	4.28
15.	Fruit yield (kg/plot)	8.82	15.16	11.71	3.79	2.74	16.63	14.15	85.07	308.25	4.28
16.	Fruit yield (q/ha)	204.05	361.11	271.66	2151.40	1576.59	17.07	14.62	85.61	7415.34	4.28
17.	T.S.S. ( <sup>0</sup> Brix)	4.17	6.16	5.19	0.28	0.08	10.18	5.28	51.83	40.41	14.06
18.	Vitamin C (mg/100g)	23.95	27.77	25.52	4.16	-0.74	7.99	6.27	42.23	54.42	32.61

#### **4.4 Genotypic and Phenotypic Correlation Coefficient:**

The genotypic and phenotypic correlation coefficient of parent for eighteen characters of tomato has been presented in Table 4.4(A,B,C,D,E & F). Yield is considered to be the most important trait, on the basis of yield potential of parents are included in breeding programmer to developed inbred line/hybrid.

#### **4.4. A: Genotypic correlation coefficient for different pairs of characters in tomato (2017-18).**

The correlation coefficient at genotypic level in (2017-18) has been presented in Table 4.4(A), it was observed fruit yield (q/ha) had positive significant correlation with number of cluster per plant (0.898) followed by number of branches per plant (0.897) and negatively and significant correlation with fruit width (0.492) fruit yield (kg/plot) observed that positive significant correlation with number of branches per plant (0.898) and negatively significant correlation with pericarp thickness (0.318). fruit yield per plant (g) has positive significant correlation with number of branches per plant (0.897). Vitamin C (mg/100g) was that significant correlation with number of ridges on fruit (0.635) and negatively and significantly correlation with pericarp thickness (0.518) total soluble solids has show positive and significant correlation with day to 50 percent flowering. Pericarp thickness had positive significant and correlation with average fruit weight (0.293) and negatively significant and correlation with number of clusters per plant (0.876). Average fruit weight was observed postive significant and correlation with number of fruit per plant (0.466) and negative significant and correlation with day to 50 percent flowering. Number of fruits per cluster has showed significant correlation with number of branches per plant (0.824). Days to 50 percent showed negatively and non significant correlation.

Table- 4.4.A: Genotypic correlation coefficient for different pairs of characters in 20 parents of tomato (2017-18)

S. No.	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>o</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	1.228	-1.169	1.250	1.146	1.141	1.567	0.529	0.502	-0.060	0.911	-0.392	-0.586**	-0.218	-1.048*	1.255	1.255	1.255
2.	Number of branches per plant		-0.926*	1.051	0.969	0.824**	1.046	0.447	0.042	-0.227	0.249	0.059	-0.348	-0.257	-0.228	0.897**	0.898**	0.897**
3.	Days to 50 percent flowering			-1.904	-1.319*	-1.164*	-1.164	-0.399**	-0.348**	0.095	-1.149**	0.002	-0.145	0.262**	0.439**	-1.240	-1.240	-1.240
4.	Number of clusters per plant				1.200	0.543	1.626	0.084	-0.046	-0.876**	-0.453	-0.542	-0.245	-0.282	0.104	0.897	0.898	0.898**
5.	Number of flowers per cluster					0.855	1.346	0.234	0.079	-0.485	0.463	-0.374	-0.067	0.005	-0.057	1.040	1.041	1.040
6.	Number of fruits per cluster						1.132	0.443	-0.046	-0.018	0.095	-0.430	-0.303	0.092	-0.479	0.717	0.717	0.717
7.	Number of fruits per plant							0.466*	0.323	-0.189	0.921**	-0.415	-0.237	-0.340	-0.103	1.397	1.398	1.397
8.	Average fruit weight (g)								0.024	0.293**	0.181	-0.040	-0.602	-0.624**	-0.600	0.355	0.355	0.355
9.	Number of locules per fruit									0.111	0.164	-0.465	-0.536	-0.607	-0.231	0.168	0.167	0.167
10.	Pericarp thickness (mm)										-0.214	-0.282	-0.586	-0.253	-0.518**	-0.316	-0.318**	-0.318
11.	Fruit length (cm)											-1.738**	-0.309	-0.163	-0.073	0.436**	0.435	0.436
12.	Fruit width (cm)												-0.238	-0.151	-0.008	-0.493	-0.492	-0.492**
13.	Number of ridges on fruit													0.621	0.635**	-0.337	-0.336	-0.336
14.	T.S.S. ( <sup>o</sup> Brix)														0.446**	-0.313	-0.311	-0.311
15.	Vitamin C (mg/100g)															-0.201	-0.199	-0.199
16.	Fruit yield per plant (g)																1.000	1.000
17.	Fruit yield (kg/plot)																	1.000
18.	Fruit yield (q/ha)																	1.000

**4.4. B: Genotypic correlation coefficient for different pairs of characters in tomato (2018-19):**

At the genotypic correlation (2018-19) has been presented in Table 4.4(B). It was observed that fruit yield (q/ha) and positive significant correlation with number of fruits per cluster (0.589) and negative and significant correlation with TSS (0.808). Fruit yield (kg/plot) was observed positive significant correlation with number of fruit per cluster (0.590) and negative and significantly correlation with TSS (0.780). Fruit width showed positive and significant correlation with day to 50 percent flowering (0.234) and negative and significant correlation with average fruit weight (0.807). Fruit length had positive significant correlation with number of flower per cluster (0.705) followed by number of branches per plant (0.654).however negatively and significant correlation with pericarp thickness (0.505). Average fruit weight showed positive and significant correlation with number of fruits per plant (0.937) followed by number of clusters per plant (0.807). Number of fruit per cluster had showed positive and significant correlation with number of flower per cluster (0.825). Day to 50 percent flowering showed negatively and non significantly correlation.

Table- 4.4.B: Genotypic correlation coefficient for different pairs of characters in 20 parents of tomato (2018-19)

S. No	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>o</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	1.535	-1.107	1.908	1.295	1.117	0.370*	0.852**	0.305	0.075	0.786	-0.228	-0.369	-1.466	-0.298	0.254	0.498*	1.252
2.	Number of branches per plant		-1.463	1.445	1.202	0.940	1.256	1.329	0.032	-0.230	0.654**	-0.029	-0.308	0.114	-0.561**	1.098	1.099	1.099
3.	Days to 50 percent flowering			-2.214**	-1.208**	-1.208**	-1.677**	-1.994	-0.502**	-0.358*	-1.865**	0.234*	-0.288	-3.962	0.299	-1.285**	-1.286**	-1.284***
4.	Number of clusters per plant				1.450	0.481	0.839	0.807**	-0.381	-0.782	-0.803	-0.719**	-0.581**	-0.899	-0.217	1.054	1.053	1.053
5.	Number of flowers per cluster					0.825**	1.215	0.654	0.138	-0.020	0.705**	-0.303	-0.119	0.542	-0.234	1.070	1.071	1.070
6.	Number of fruits per cluster						0.515	0.498	0.148	0.078	-0.136	-0.385	-0.376	-1.060	-0.440	0.592	0.590**	0.589**
7.	Number of fruits per plant							0.937**	-0.324*	-0.360	-0.030	-0.631	-0.430	-0.696	-0.230	1.026	1.026	1.026
8.	Average fruit weight (g)								-0.444	-0.442**	-0.189	-0.802**	-0.592	-3.693	-0.287	1.113	1.113	1.113
9.	Number of locules per fruit									0.322	-0.249	-0.340	-0.005	-3.011	-0.664**	-0.125	-0.126	-0.127
10.	Pericarp thickness (mm)										-0.505*	-0.521	-0.555	-1.198**	-0.509	-0.113	-0.113	-0.114
11.	Fruit length (cm)											-1.836	-0.606**	-1.422	-0.423	0.382	0.383	0.382
12.	Fruit width (cm)												-0.288	-3.933	-0.045	-0.485	-0.487*	-0.485*
13.	Number of ridges on fruit													-0.902	0.308*	-0.342	-0.341	-0.339
14.	T.S.S. ( <sup>o</sup> Brix)														0.303	-0.804**	-0.780**	-0.808**
15.	Vitamin C (mg/100g)															-0.228	-0.226	-0.224
16.	Fruit yield per plant (g)																1.000	1.000
17.	Fruit yield (kg/plot)																	1.000
18.	Fruit yield (q/ha)																	1.000

**4.4. C: Genotypic correlation coefficient for different pairs of characters in tomato (pooled data):**

The correlation coefficient at genotypic level in pooled data has been portrayed in Table 4.4(C). It is evident from the data that fruit yield (q/ha) had positive significant correlation with number of fruits per plant (0.996) followed by number of branches per plant (0.831) and number of fruits per cluster (0.749). However negatively and significantly correlation with day to 50 percent flowering (0.835). Fruit yield (kg/plot) had observed that positive and significant correlation with number of cluster per plant (0.975) followed by plant height (0.937) and negative and significant correlation with days to 50 percent flowering (0.835) followed by (0.350). Fruit yield per plant was positive and significant correlation with number of fruits per plant (0.996) followed by number of cluster per plant (0.975), however negatively and significantly correlation with day to 50 percent flowering (0.835). Fruit width has showed positive and significantly correlation with day to 50 percent flowering (0.267) and negative and significant correlation with average fruit width (0.397). Fruit length was observed positively and significantly correlation with average fruit weight (0.959) followed by (0.445). Pericarp thickness had showed positive and significantly correlation with average fruit weight (0.667) followed by number of fruits per cluster (0.298). Number of locules per fruit had showed positively and significantly correlation with average fruit weight (0.846) followed by plant height (0.340). Average fruit had taken positive and significantly correlation with number of flower per cluster (0.945) however, negatively and significantly correlation with day to 50 percent flowering (0.592). Day to 50 percent flowering showed negatively and non-significantly correlation.

Table- 4.4.C: Genotypic correlation coefficient for different pairs of characters in 20 parents of tomato (pooled data)

S. No.	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>o</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	0.892	-0.795	0.968	0.927**	0.848**	0.930	1.109	0.340**	-0.047	0.445**	-0.226	-0.340*	0.057	-0.220	0.937	0.937**	0.937
2.	Number of branches per plant		-0.848**	0.820	0.870	0.733	0.842	1.113	0.024	-0.224	0.256	0.014	-0.304	-0.135	-0.237**	0.831	0.832	0.831**
3.	Days to 50 percent flowering			-0.936**	-0.935	-0.689**	-0.843**	-0.592**	-0.256	0.153	-0.340	0.267**	-0.033	0.019	0.181	-0.835**	-0.835**	-0.835**
4.	Number of clusters per plant				0.988**	0.770	0.987**	0.902	0.264	-0.204	0.363	-0.214	-0.094	-0.066	-0.045	0.975**	0.975**	0.975
5.	Number of flowers per cluster					0.778	0.934**	0.945**	0.233	-0.230	0.385	-0.280	-0.076	-0.087	-0.166	0.928	0.928	0.928
6.	Number of fruits per cluster						0.768	1.160	0.096	0.298*	0.350	-0.232	-0.172	0.112	-0.356	0.751	0.750	0.749**
7.	Number of fruits per plant							1.010	0.230	-0.110	0.484	-0.346*	-0.201	-0.146	-0.150	0.996**	0.996	0.996**
8.	Average fruit weight (g)								0.846**	0.667**	0.959**	-0.088	-0.942	-0.061	-0.624**	1.042	1.045	0.642*
9.	Number of locules per fruit									0.493	0.423	-0.397**	-0.264	-0.269	-0.545	0.273	0.274	0.272
10.	Pericarp thickness (mm)										0.246	-0.233	-0.449*	-0.366*	-0.416	-0.066*	-0.068	-0.069
11.	Fruit length (cm)											-0.835	-0.084	-0.057	-0.147	0.517	0.517	0.517
12.	Fruit width (cm)												-0.161	-0.224	-0.028	-0.349*	-0.350	-0.349
13.	Number of ridges on fruit													0.258	0.340	-0.228	-0.227	-0.226
14.	T.S.S. ( <sup>o</sup> Brix)														0.757	-0.152	-0.152	-0.153
15.	Vitamin C (mg/100g)															-0.162	-0.162	-0.161
16.	Fruit yield per plant (g)																1.000	1.000
17.	Fruit yield (kg/plot)																	1.000
18.	Fruit yield (q/ha)																	1.000

**4.4. D: Phenotypic correlation coefficient for different pairs of characters of tomato (2017-18).**

As data of 2017-18 has been given in Table-4.4 D. clearly showed that fruit yield (q/ha) had taken positively and significantly correlation with number of cluster per plant (0.837) followed by number of fruit per cluster (0.799). However, negatively and significantly correlation with day to 50 percent (0.367). Fruit yield (kg/plot) showed positive and significant correlation with number of cluster per plant (0.837) and negative and significantly correlation with days to 50 percent flowering (0.367). Vitamin C had taken positive and significantly correlated with average fruit weight (0.242). TSS was observed that positive and significantly correlation with number of ridges on fruit (0.306) and negatively and significantly correlation with average fruit weight (0.247). Fruit length found positive and significant correlation with number of cluster per plant (0.654) followed by number of locules per fruit (0.484). Number of fruit per cluster had taken positive and significant correlation with number of cluster per plant (0.741) followed by number of flower per cluster (0.588). However, negatively and significantly correlation with day to 50 percent flowering (0.206).

Table- 4.4.D: Phenotypic correlation coefficient for different pairs of characters in 20 parents of tomato (2017-18)

S. No	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruit per cluster	Number of fruit per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>o</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	0.499	-0.440**	0.382	0.592	0.521	0.441	0.289	0.237	-0.035	0.231	-0.178	-0.287*	-0.120	0.164	0.608	0.608	0.608
2.	Number of branches per plant		-0.541**	0.450	0.579**	0.539	0.544	0.356	0.028	-0.156	0.102	0.038	-0.262	-0.032	-0.134**	0.638	0.639	0.638
3.	Days to 50 percent flowering			-0.081	-0.450	-0.206*	-0.568**	-0.081	0.117	0.444*	0.257	0.318*	0.186	0.111*	0.068	-0.367*	-0.367*	-0.367*
4.	Number of clusters per plant				0.603	0.741**	0.369	0.259	0.379**	0.112	0.654**	0.141	0.227*	0.017	-0.003	0.837**	0.837**	0.837**
5.	Number of flowers per cluster					0.588**	0.526	0.198	0.139	-0.184	0.314	-0.164	0.032	-0.081	-0.149	0.738	0.738	0.738
6.	Number of fruits per cluster						0.421	0.492*	0.250	0.331	0.573	-0.026	0.024	0.103	-0.168	0.799	0.799**	0.799**
7.	Number of fruits per plant							0.248	0.098	-0.169	0.158	-0.276*	-0.173	-0.063	-0.119	0.609	0.609	0.609
8.	Average fruit weight (g)								0.140	0.379*	0.306	0.086	-0.427*	-0.247**	-0.242*	0.421	0.420	0.420
9.	Number of locules per fruit									0.350	0.484*	-0.149	-0.244	-0.203	-0.119	0.365	0.364	0.364
10	Pericarp thickness (mm)										0.430	0.057	-0.210	-0.038	-0.217	0.066	0.064	0.065
11	Fruit length (cm)											-0.288	0.233	0.056	-0.065	0.622	0.622	0.622
12	Fruit width (cm)												-0.009	-0.022	-0.011	-0.144*	-0.143*	-0.143*
13	Number of ridges on fruit													0.306**	0.218	-0.061	-0.059	-0.060
14	T.S.S. ( <sup>o</sup> Brix)														0.343**	-0.072	-0.071	-0.071
15	Vitamin C (mg/100g)															-0.085	-0.085	-0.084
16	Fruit yield per plant (g)																1.000	1.000
17	Fruit yield (kg/plot)																	1.000
18	Fruit yield (q/ha)																	1.000

**4.4. E: Phenotypic correlation coefficient for different pairs of characters of tomato (2018-19).**

The correlation coefficient at phenotypic correlation level of 2018-19 has been depicted in Table 4.4(E), showed that fruit yield (q/ha) had positive significant correlation with number of fruits per plant (0.965) followed by number of clusters per plant (0.867). However, negatively and significantly correlation with day to 50 percent flowering (0.258). Fruit yield (kg/plant) found positive and significant correlation with number of fruits per plant (0.965) followed by fruit length (0.594) and negatively and significantly correlated with Vitamin C (0.143). Number of ridges on fruit had taken positive and significant correlation with number of locules per fruit (0.307) followed by (0.179). Fruit width found positive and significant correlation with day to 50 percent flowering (0.473) and negatively and significantly correlation with number of flower per cluster (0.187). Fruit length had taken positive and significant correlation with average fruit weight (0.746) followed by number of clusters per plant (0.693). Pericarp thickness was found positive and significant correlation with number of locules per fruit (0.668) followed by number of fruit per cluster (0.550). Number of fruit per plant had positive and significant correlation with number of cluster per plant (0.921). However, negatively and significantly correlation with number of fruit per plant (0.084). Whereas, Days to 50 percent flowering and number of branches per plant showed negative and non significant correlation.

Table- 4.4.E: Phenotypic correlation coefficient for different pairs of characters in 20 parents of tomato (2018-19)

S. No.	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruit per cluster	Number of fruit per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>o</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	-0.302	-0.358	0.472	0.575	0.450	0.495	0.472	0.137	0.030	0.157	-0.104	-0.154	0.188	-0.084	0.584	0.584	0.584
2.	Number of branches per plant		-0.398	0.379	0.577	0.391	0.463	0.384	0.032	-0.080	0.151	-0.009	-0.141	0.116	-0.121	0.524	0.524	0.524
3.	Days to 50 percent flowering			0.070	-0.542	-0.021	-0.084**	0.043	0.278	0.418	0.286	0.473*	0.179*	0.038	0.118	-0.259*	-0.259	-0.258*
4.	Number of clusters per plant				0.549	0.763	0.921**	0.930**	0.476	0.445	0.693*	0.156	0.172	0.148	-0.089	0.867	0.867	0.867**
5.	Number of flowers per cluster					0.502	0.659	0.579	0.100	0.011	0.227	-0.187*	-0.070	-0.035	-0.183	0.745	0.745	0.745
6.	Number of fruits per cluster						0.759	0.752	0.539**	0.550**	0.590	0.087	0.062	0.094	-0.242**	0.721	0.720	0.719
7.	Number of fruits per plant							0.942	0.352	0.417	0.690	0.011	0.091	0.120	-0.120	0.965**	0.965**	0.965**
8.	Average fruit weight (g)								0.405	0.495	0.746* *	0.062	0.114	0.062	-0.102	0.911	0.911	0.911
9.	Number of locules per fruit									0.668**	0.563	0.118	0.307*	0.015	-0.363**	0.266	0.266	0.265
10.	Pericarp thickness (mm)										0.587	0.084	0.030	-0.052	-0.261	0.323	0.324	0.324
11.	Fruit length (cm)											-0.127	0.228	0.142	-0.138	0.593	0.594**	0.593
12.	Fruit width (cm)												0.004	-0.071	-0.033	-0.110	-0.111	-0.110*
13.	Number of ridges on fruit													0.023	0.184	-0.029	-0.028	-0.026
14.	T.S.S. ( <sup>o</sup> Brix)														0.198	0.071	0.070	0.069
15.	Vitamin C (mg/100g)															-0.142	-0.143*	-0.142
16.	Fruit yield per plant (g)																1.000	1.000
17.	Fruit yield (kg/plot)																	1.000
18.	Fruit yield (q/ha)																	1.000

**4.4. F: Phenotypic correlation coefficient for different pairs of characters of tomato (pooled data)**

At the phenotypic correlation coefficient of tomato in pooled data has been given projected in Table-4.4 F, it was observed that fruit yield (q/ha) found positive and significant correlation with number of fruits per plant (0.977) followed by number of clusters per plant (0.893) and negatively and significantly correlated with day to 50 percent flowering (0.178). Fruit yield (kg/plot) had taken significant correlation with number of clusters per plant (0.893) followed by number of fruits per cluster (0.816). Fruit yield per plant was observed that positive and significant correlation with average fruit weight (0.976) and negative and significant correlation with day to 50 percent flowering (0.178). Number of ridges on fruit showed positive and significant correlation with days to 50 percent flowering (0.252). However, negatively and significantly correlated with average fruit weight (0.340) fruit width had positive and significant correlation with days to 50 percent flowering (0.463). Fruit length showed positive and significant correlation with average fruit weight (0.944) followed by number of clusters per plant (0.784). Pericarp thickness had positive and significant correlation with number of fruits per cluster (0.587) and negatively significantly correlated with number of branches per plant (0.117). Number of locules per fruit showed positive and significant correlation with average fruit weight (0.903) followed by number of clusters per plant (0.677). Whereas, days to 50 percent flowering showed negatively and non significant correlation.

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Table- 4.4.F: Phenotypic correlation coefficient for different pairs of characters in 20 parents of tomato (pooled data)

S. No.	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locule per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>o</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	0.307	-0.357	0.372	0.532**	0.436	0.387	0.539	0.157	-0.025	0.166	-0.120	-0.182	0.075	0.113*	0.528	0.529	0.529
2.	Number of branches per plant		-0.392*	0.348**	0.513	0.411	0.434	0.576	0.022	-0.117*	0.118	0.009	-0.190	0.038	-0.092	0.517	0.517	0.517
3.	Days to 50 percent flowering			0.157	-0.421	0.037	-0.208**	0.149	0.331	0.519	0.398	0.463**	0.252*	0.079	0.063	-0.178*	-0.178	-0.178*
4.	Number of clusters per plant				0.532	0.856**	0.627**	0.918**	0.677*	0.457	0.784**	0.262	0.293	0.092	-0.036	0.893	0.893**	0.893**
5.	Number of flowers per cluster					0.534	0.502	0.605**	0.200	-0.068	0.253	-0.150	-0.010	-0.108	-0.167*	0.685	0.685	0.685
6.	Number of fruits per cluster						0.585	1.067	0.488	0.587**	0.664	0.123	0.139	0.128*	-0.187	0.816	0.816**	0.816
7.	Number of fruits per plant							0.717	0.318	0.143	0.424	-0.083*	-0.003	0.026	-0.117	0.729	0.729	0.977**
8.	Average fruit weight (g)								0.903*	0.813	0.944**	0.254	-0.340**	0.083	-0.287*	0.976**	0.978	0.729**
9.	Number of locules per fruit									0.731	0.745	0.072	0.126	0.008	-0.281	0.509	0.510	0.509
10.	Pericarp thickness (mm)										0.654	0.157	-0.016	-0.030*	-0.229	0.284	0.283	0.283
11.	Fruit length (cm)											-0.054	0.301	0.092	-0.088	0.657	0.658	0.658
12.	Fruit width (cm)												0.064	-0.030	-0.022	-0.046	-0.047	-0.146*
13.	Number of ridges on fruit													0.151	0.180	0.026	0.027	0.027
14.	T.S.S. ( <sup>o</sup> Brix)														0.252	0.011	0.010	-0.174*
15.	Vitamin C (mg/100g)															-0.098	-0.099*	-0.098*
16.	Fruit yield per plant (g)																1.000	1.000
17.	Fruit yield (kg/plot)																	1.000
18.	Fruit yield (q/ha)																	1.000

#### **4.5 Path Coefficient Analysis:**

The path analysis was performed to have a better understanding of the genotypic relationship between the genotypic correlation coefficient of yield with contributing factors. Through path coefficient analysis in germplasm, the genotypic correlation coefficient was partitioned into direct and indirect effects Table 5(A,B,C,D,E & F).

##### **4.5. A: Analysis of genotypic path coefficients (direct and indirect effects) of tomato yield contributing of characters (2017-18).**

Genotypic coefficient analysis of tomato yield contributing character (Direct and indirect effect) in 2017-18. The highest positive direct effect on fruit yield (q/ha) was exhibited by number of fruits per plant (0.004) followed by number of fruits per cluster (0.003), Pericarp thickness (0.002) number of locules per fruit (0.001), Fruit yield per plant (0.001), Vitamin C (0.001) and TSS (0.001). Whereas, highest negative and direct and indirect effect towards fruit yield (q/ha) was exhibited by fruit yield (q/ha) (-0.522) followed by fruit yield kg/plot (-0.306), number of ridges on fruit (-0.006), Days to 50 percent flowering (-0.005), number of flower per cluster (-0.004) and fruit width (-0.003).

Table- 4.5.A: Genotypic path coefficient analysis (direct and indirect effect) of yield contributing of characters of tomato (2017-18)

S. No.	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>0</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	-0.002	-0.006	0.002	-0.004	0.004	0.004	-0.001	0.000	0.001	0.000	0.000	-0.001	0.000	0.000	-0.001	1.914	-0.655
2.	Number of branches per plant	-0.003	-0.005	0.001	-0.004	0.003	0.003	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	1.368	-0.468
3.	Days to 50 percent flowering	0.002	0.004	-0.001	0.007	-0.004	-0.005	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	-1.891	0.647
4.	Number of clusters per plant	-0.003	-0.005	0.003	-0.004	0.004	0.002	-0.001	0.000	0.000	0.003	0.000	-0.002	0.000	0.000	0.000	1.368	-0.469
5.	Number of flowers per cluster	-0.002	-0.005	0.002	-0.004	0.003	0.003	-0.001	0.000	0.000	0.002	0.000	-0.001	0.000	0.000	0.000	1.586	-0.543
6.	Number of fruits per cluster	-0.002	-0.004	0.002	-0.002	0.003	0.004	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	1.093	-0.374
7.	Number of fruits per plant	-0.003	-0.005	0.002	-0.006	0.004	0.004	0.000	0.000	0.000	0.001	0.000	-0.001	0.000	0.000	0.000	2.131	-0.729
8.	Average fruit weight (g)	-0.001	-0.002	0.001	0.000	0.001	0.002	0.000	0.001	0.000	-0.001	0.000	0.000	0.000	0.000	-0.001	0.542	-0.185
9.	Number of locules per fruit	-0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	-0.001	0.000	0.000	0.000	0.256	-0.087
10.	Pericarp thickness (mm)	0.000	0.001	0.000	0.003	-0.002	0.000	0.000	0.000	0.000	-0.004	0.000	-0.001	0.000	0.000	-0.001	-0.482	0.166
11.	Fruit length (cm)	0.001	0.003	-0.002	-0.001	0.002	0.003	-0.002	0.001	-0.432	0.705	-0.003	0.001	-0.005	0.003	0.002	0.104	0.512
12.	Fruit width (cm)	-0.002	-0.001	0.002	0.002	0.001	0.000	0.000	0.000	0.000	0.001	0.000	-0.006	0.000	0.000	0.000	0.666	-0.227
13.	Number of ridges on fruit	0.001	0.000	0.000	0.002	-0.001	-0.002	0.000	0.000	-0.001	0.001	0.000	0.003	0.000	0.000	0.000	-0.752	0.257
14.	T.S.S. ( <sup>0</sup> Brix)	0.001	0.002	0.000	0.001	0.000	-0.001	0.000	-0.001	-0.001	0.002	0.000	-0.001	-0.001	0.000	0.001	-0.515	0.175
15.	Vitamin C (mg/100g)	0.000	0.001	0.000	0.001	0.000	0.000	0.000	-0.001	-0.001	0.001	0.000	0.000	0.000	0.001	0.001	-0.477	0.162
16.	Fruit yield per plant (g)	0.002	0.001	-0.001	0.000	0.000	-0.002	0.000	-0.001	0.000	0.002	0.000	0.000	0.000	0.001	0.001	-0.306	0.104
17.	Fruit yield (kg/plot)	-0.003	-0.004	0.002	-0.003	0.003	0.003	-0.001	0.000	0.000	0.001	0.000	-0.002	0.000	0.000	0.000	1.525	-0.522
18.	Fruit yield (q/ha)	-0.003	-0.004	0.002	-0.003	0.003	0.003	-0.001	0.000	0.000	0.001	0.000	-0.002	0.000	0.000	0.000	1.525	-0.522

**4.5. B: Analysis of genotypic path coefficients (direct and indirect effects) of tomato yield contributing of characters (2018-19).**

The highest positive genotypic path coefficient analysis (direct and indirect) on fruit yield (q/ha) was exhibited by fruit yield kg/plot (1.829) followed by fruit yield per plant (0.186), number of clusters per plant (0.005), number of fruits per cluster (0.005), number of locules per fruit (0.002) and pericarp thickness (0.001). Whereas, the maximum negative (direct and indirect) effect toward fruit yield q/ha was exhibited by number of fruits per plant (-0.234), average fruit weight (-0.007), number of ridges on fruit (-0.003), number of flower per cluster (-0.003) and day to 50 percent flowering (-0.001).

**4.5. C: Analysis of genotypic path coefficients (direct and indirect effects) of tomato yield contributing of characters (pooled data).**

The highest positive effect fruit yield (q/ha) was presented in Table-4.5 C. was exhibited by fruit yield kg/plot (1.430) fruit yield per plant (g) (0.057), number of ridges on fruit (0.051), number of fruits per plant (0.038), , number of fruits per cluster (0.031) and number of locules per fruit (0.027). However, the maximum negative (direct and indirect) effect towards fruit yield (q/ha) was exhibited by number of branches per plant (-0.199), day to 50 percent flowering (-0.079), number of cluster per plant (-0.050), fruit length (-0.044), TSS (-0.037), vitamin c (-0.034) and number of flower per cluster (-0.033).

Table- 4.5.B: Genotypic path coefficient analysis (direct and indirect effect) of yield contributing of characters of tomato (2018-19).

S. No.	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>0</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	<b>0.000</b>	-0.001	-0.005	-0.005	0.006	0.002	-0.017	0.004	0.000	0.000	-0.001	0.000	-0.001	0.000	-1.020	2.291	-0.312
2.	Number of branches per plant	-0.001	<b>-0.001</b>	-0.007	-0.004	0.006	0.002	-0.016	0.003	0.000	0.000	-0.001	0.000	-0.001	0.000	-0.893	2.011	0.026
3.	Days to 50 percent flowering	0.001	0.001	<b>0.005</b>	0.006	-0.006	-0.003	0.021	-0.005	0.001	0.000	0.002	0.000	-0.001	0.000	1.045	-2.353	0.108
4.	Number of clusters per plant	-0.001	-0.001	-0.010	<b>-0.003</b>	0.007	0.001	-0.011	0.002	0.000	0.001	0.001	-0.001	-0.001	0.000	-0.857	1.926	-2.107
5.	Number of flowers per cluster	-0.001	-0.001	-0.006	-0.004	<b>0.005</b>	0.002	-0.015	0.003	0.000	0.000	-0.001	0.000	0.000	0.000	-0.870	1.959	-0.204
6.	Number of fruits per cluster	-0.001	0.003	-0.002	-0.456	0.111	<b>-0.234</b>	0.002	-0.201	0.134	0.156	0.210	0.306	0.405	0.231	-0.310	0.471	-2.312
7.	Number of fruits per plant	-0.001	-0.001	-0.006	-0.001	0.004	0.002	<b>-0.007</b>	0.001	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.482	1.079	-0.312
8.	Average fruit weight (g)	-0.001	-0.001	-0.008	-0.002	0.006	0.001	-0.013	<b>0.002</b>	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.834	1.876	0.241
9.	Number of locules per fruit	-0.001	-0.001	-0.009	-0.002	0.006	0.001	-0.012	0.002	<b>0.001</b>	0.001	0.000	-0.001	-0.001	0.000	-0.906	2.036	-0.246
10.	Pericarp thickness (mm)	0.000	0.000	-0.002	0.001	0.001	0.000	0.004	-0.001	-0.001	<b>0.000</b>	0.000	-0.001	0.000	0.000	0.102	-0.230	-0.102
11.	Fruit length (cm)	0.000	0.000	-0.002	0.002	0.000	0.000	0.005	-0.001	0.000	-0.001	<b>0.001</b>	-0.001	-0.001	0.000	0.092	-0.207	-0.345
12.	Fruit width (cm)	0.000	-0.001	-0.009	0.002	0.003	0.000	0.000	0.000	0.000	0.001	-0.001	<b>-0.003</b>	-0.001	0.000	-0.311	0.701	-0.254
13.	Number of ridges on fruit	0.000	0.000	0.001	0.002	-0.001	-0.001	0.008	-0.002	0.000	0.001	0.002	0.002	<b>-0.001</b>	0.000	0.394	-0.891	-0.458
14.	T.S.S. ( <sup>0</sup> Brix)	0.000	0.000	-0.001	0.002	-0.001	-0.001	0.005	-0.001	0.000	0.001	0.001	0.000	0.002	<b>0.000</b>	0.278	-0.623	0.231
15.	Vitamin C (mg/100g)	0.000	0.000	0.001	0.001	-0.001	-0.001	0.003	-0.001	0.001	0.001	0.001	0.000	0.001	-0.001	<b>0.186</b>	-0.414	0.212
16.	Fruit yield per plant (g)	-0.001	-0.001	-0.006	-0.003	0.005	0.001	-0.013	0.003	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.813	<b>1.829</b>	0.946
17.	Fruit yield (kg/plot)	-0.001	-0.001	-0.006	-0.003	0.005	0.001	-0.013	0.003	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.813	1.829	<b>-2.341</b>
18.	Fruit yield (q/ha)	<b>0.001</b>	<b>-0.002</b>	<b>0.714</b>	<b>0.011</b>	<b>-0.456</b>	<b>0.321</b>	<b>0.114</b>	<b>0.204</b>	<b>-0.506</b>	<b>0.213</b>	<b>-0.406</b>	<b>0.002</b>	<b>-0.001</b>	<b>-0.214</b>	<b>0.314</b>	<b>-0.213</b>	<b>-2.009</b>

Table- 4.5.C: Genotypic path coefficient analysis (direct and indirect effect) of yield contributing of characters of tomato (pooled data)

S. No.	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>0</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	<b>-0.199</b>	-0.071	0.040	-0.032	0.028	0.032	0.007	0.030	0.003	0.002	0.008	-0.012	0.013	0.003	0.007	-0.264	1.340
2.	Number of branches per plant	-0.178	<b>-0.079</b>	0.042	-0.027	0.027	0.028	0.006	0.030	0.000	0.010	0.004	0.001	0.011	-0.008	0.008	-0.234	1.189
3.	Days to 50 percent flowering	0.158	0.067	<b>-0.050</b>	0.031	-0.029	-0.026	-0.006	-0.016	-0.002	-0.007	-0.006	0.014	0.001	0.001	-0.006	0.235	-1.194
4.	Number of clusters per plant	-0.193	-0.065	0.047	<b>-0.033</b>	0.030	0.029	0.008	0.025	0.002	0.009	0.006	-0.011	0.003	-0.004	0.002	-0.275	1.394
5.	Number of flowers per cluster	-0.184	-0.069	0.047	-0.032	<b>0.031</b>	0.029	0.007	0.026	0.002	0.010	0.007	-0.014	0.003	-0.005	0.006	-0.261	1.327
6.	Number of fruits per cluster	-0.169	-0.058	0.034	-0.025	0.024	<b>0.038</b>	0.006	0.032	0.001	-0.013	0.006	-0.012	0.006	0.006	0.012	-0.211	1.073
7.	Number of fruits per plant	-0.185	-0.067	0.042	-0.032	0.029	0.029	<b>0.008</b>	0.028	0.002	0.005	0.008	-0.018	0.007	-0.008	0.005	-0.281	1.424
8.	Average fruit weight (g)	-0.221	-0.088	0.029	-0.030	0.029	0.044	0.008	<b>0.027</b>	0.008	-0.030	0.017	-0.005	0.035	-0.003	0.021	-0.293	1.494
9.	Number of locules per fruit	-0.068	-0.002	0.013	-0.009	0.007	0.004	0.002	0.023	<b>0.009</b>	-0.022	0.007	-0.020	0.010	-0.015	0.018	-0.077	0.391
10.	Pericarp thickness (mm)	0.009	0.018	-0.008	0.007	-0.007	0.011	-0.001	0.018	0.005	<b>-0.044</b>	0.004	-0.012	0.017	-0.021	0.014	0.019	-0.098
11.	Fruit length (cm)	-0.089	-0.020	0.017	-0.012	0.012	0.013	0.004	0.026	0.004	-0.011	<b>0.017</b>	-0.043	0.003	-0.003	0.005	-0.146	0.740
12.	Fruit width (cm)	0.045	-0.001	-0.013	0.007	-0.009	-0.009	-0.003	-0.002	-0.004	0.010	-0.015	<b>0.051</b>	0.006	-0.013	0.001	0.098	-0.500
13.	Number of ridges on fruit	0.068	0.024	0.002	0.003	-0.002	-0.007	-0.002	-0.026	-0.002	0.020	-0.001	-0.008	<b>-0.037</b>	0.015	-0.012	0.064	-0.324
14.	T.S.S. ( <sup>0</sup> Brix)	-0.011	0.011	-0.001	0.002	-0.003	0.004	-0.001	-0.002	-0.003	0.016	-0.001	-0.012	-0.010	<b>-0.034</b>	-0.026	0.043	-0.218
15.	Vitamin C (mg/100g)	0.044	0.019	-0.009	0.001	-0.005	-0.013	-0.001	-0.017	-0.005	0.018	-0.003	-0.001	-0.013	0.043	<b>0.057</b>	0.046	-0.231
16.	Fruit yield per plant (g)	-0.013	0.032	-0.002	-1.002	0.456	-0.043	-0.008	0.022	-0.009	-0.025	0.021	0.543	-0.342	0.008	-0.027	<b>0.034</b>	-1.102
17.	Fruit yield (kg/plot)	-0.187	-0.066	0.042	-0.032	0.028	0.028	0.008	0.028	0.003	0.003	0.009	-0.018	0.008	-0.009	0.005	-0.282	<b>1.430</b>
18.	Fruit yield (q/ha)	<b>-0.187</b>	<b>-0.066</b>	<b>0.042</b>	<b>-0.032</b>	<b>0.028</b>	<b>0.028</b>	<b>0.008</b>	<b>0.028</b>	<b>0.003</b>	<b>0.003</b>	<b>0.009</b>	<b>-0.018</b>	<b>0.008</b>	<b>-0.009</b>	<b>0.005</b>	<b>-0.282</b>	<b>1.430</b>

**4.5. D: Phenotypic path coefficient analysis (direct and indirect) effect on yield contributing of character of tomato (2017-18).**

Highest positive (direct and indirect) effect on fruit yield (q/ha) was exhibited by pericarp thickness (0.004), number of fruits per plant (0.002) and number of branches per plant, Days to 50 percent flowering, number of clusters per plant and average fruit weight (0.001). However, negative (direct and indirect) effect on fruit yield (q/ha) was exhibited by fruit yield per plant (g) (-0.076), number of flower per cluster (-0.002) and fruit length (-0.001).

**4.5. E: Phenotypic path coefficient analysis (direct and indirect) effect on yield contributing of character of tomato (2018-19).**

The maximum positive (direct and indirect) effect on fruit yield (q/ha) was exhibited by fruit yield kg/plot (0.932), fruit length (0.002), number of clusters per plant (0.002) and day to 50 percent flowering (0.001) while, the maximum negative (direct and indirect) effect of fruit yield (q/ha) was exhibited by fruit yield per plant (-0.013), average fruit weight (-0.013), number of flower per cluster (-0.003), number of locules per fruit (-0.003), number of fruits per cluster (-0.002) and number of fruits per plant (-0.001) was observed.

**4.5. F: Phenotypic path coefficient analysis (direct and indirect) effect on yield contributing of character of tomato (pooled data).**

Highest phenotypic path coefficient analysis (direct and indirect) effect of fruit yield (q/ha) was exhibited by fruit yield (kg/plot) (0.531), fruit yield per plant (g) (0.049), number of fruits per plant (0.018), pericarp thickness (0.010), number of locules per fruit (0.007) and fruit width (0.004). However, the highest negative (direct and indirect) effect on fruit yield (q/ha) was exhibited by number of flower per cluster (-0.050), fruit length (-0.008), Day to 50 percent flowering (-0.003) and number of fruits per cluster (-0.001).

Table- 4.5.D: Phenotypic path coefficient analysis (direct and indirect effect) of yield contributing of characters of tomato (2017-18)

S. No.	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>0</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	<b>0.000</b>	0.000	0.000	-0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.542	0.067
2.	Number of branches per plant	0.000	<b>0.000</b>	0.000	-0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.569	0.070
3.	Days to 50 percent flowering	0.000	0.000	<b>0.000</b>	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	-0.327	-0.040
4.	Number of clusters per plant	0.000	0.000	0.000	<b>-0.002</b>	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.746	0.092
5.	Number of flowers per cluster	0.000	0.000	0.000	-0.001	<b>0.000</b>	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.658	0.081
6.	Number of fruits per cluster	0.000	0.000	0.000	-0.002	0.000	<b>0.002</b>	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.712	0.088
7.	Number of fruits per plant	0.000	0.000	0.000	-0.001	0.000	0.001	<b>0.000</b>	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.543	0.067
8.	Average fruit weight (g)	0.000	0.000	0.000	-0.001	0.000	0.001	0.000	<b>0.000</b>	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.375	0.046
9.	Number of locules per fruit	-0.001	0.003	0.456	-0.002	0.003	-0.412	0.107	0.000	<b>0.004</b>	-0.342	0.212	0.134	-0.005	0.001	-0.546	0.372	-0.007
10.	Pericarp thickness (mm)	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.001	<b>-0.001</b>	0.000	0.000	0.000	0.000	0.000	0.325	0.040
11.	Fruit length (cm)	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	-0.002	<b>0.000</b>	0.000	0.000	0.000	0.000	0.059	0.007
12.	Fruit width (cm)	0.000	0.000	0.000	-0.002	0.000	0.001	0.000	0.000	0.000	-0.001	0.000	<b>0.000</b>	0.000	0.000	0.000	0.555	0.068
13.	Number of ridges on fruit	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	<b>0.000</b>	0.000	0.000	-0.128	-0.016
14.	T.S.S. ( <sup>0</sup> Brix)	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	<b>0.000</b>	0.000	0.000	0.000
15.	Vitamin C (mg/100g)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	<b>0.000</b>	-0.064	-0.008
16.	Fruit yield per plant (g)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	<b>-0.076</b>	-0.009
17.	Fruit yield (kg/plot)	0.000	0.000	0.000	-0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.891	<b>0.109</b>
18.	Fruit yield (q/ha)	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>-0.002</b>	<b>0.000</b>	<b>0.001</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.891</b>	<b>0.109</b>

Table- 4.5.E: Phenotypic path coefficient analysis (direct and indirect effect) of yield contributing of characters of tomato (2018-19)

S. No.	Character	Number of branches per plant	Number of flowering percent Days to 50	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>0</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	<b>0.000</b>	0.000	-0.001	-0.001	-0.001	-0.001	-0.008	-0.001	0.000	0.000	0.000	0.000	-0.001	0.000	0.053	0.545	-2.131
2.	Number of branches per plant	0.000	<b>0.001</b>	-0.001	-0.001	-0.001	-0.001	-0.008	-0.001	0.000	0.000	0.000	0.000	-0.001	0.000	0.048	0.488	-0.715
3.	Days to 50 percent flowering	0.000	0.000	<b>0.002</b>	0.000	0.001	0.000	0.001	0.000	-0.001	0.001	0.001	0.002	0.001	0.000	-0.024	-0.242	-0.346
4.	Number of clusters per plant	0.000	0.000	0.000	<b>-0.003</b>	-0.001	-0.001	-0.016	-0.003	-0.001	0.001	0.001	0.001	0.001	0.000	0.079	0.808	-1.123
5.	Number of flowers per cluster	-0.001	0.003	-0.004	0.001	<b>-0.002</b>	0.003	-0.004	-0.562	0.743	-0.546	-0.002	0.004	-1.002	0.008	0.003	0.564	-1.521
6.	Number of fruits per cluster	0.000	0.000	-0.001	-0.002	-0.001	<b>-0.001</b>	-0.011	-0.002	0.000	0.000	0.000	-0.001	0.000	0.000	0.068	0.695	-2.121
7.	Number of fruits per plant	0.000	0.000	0.000	-0.002	-0.001	-0.001	<b>-0.013</b>	-0.002	-0.001	0.001	0.001	0.000	0.000	0.000	0.065	0.671	-1.189
8.	Average fruit weight (g)	0.000	0.000	0.000	-0.003	-0.001	-0.001	-0.017	<b>-0.003</b>	-0.001	0.001	0.001	0.000	0.000	0.000	0.088	0.900	-2.001
9.	Number of locules per fruit	0.000	0.000	0.000	-0.003	-0.001	-0.001	-0.016	-0.003	<b>-0.001</b>	0.001	0.001	0.000	0.001	0.000	0.083	0.849	-1.118
10.	Pericarp thickness (mm)	0.000	0.000	0.000	-0.001	0.000	-0.001	-0.006	-0.001	-0.003	<b>0.002</b>	0.001	0.000	0.001	0.000	0.024	0.248	-2.082
11.	Fruit length (cm)	0.000	0.000	0.001	-0.001	0.000	-0.001	-0.007	-0.001	-0.002	0.003	<b>0.001</b>	0.000	0.000	0.000	0.029	0.302	-2.312
12.	Fruit width (cm)	0.000	0.000	0.000	-0.002	0.000	-0.001	-0.012	-0.002	-0.002	0.002	0.002	<b>-0.001</b>	0.001	0.000	0.054	0.554	0.001
13.	Number of ridges on fruit	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	<b>0.000</b>	0.000	-0.010	-0.103	-0.874
14.	T.S.S. ( <sup>0</sup> Brix)	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	0.000	-0.001	0.000	0.000	0.000	0.005	<b>0.000</b>	-0.003	-0.026	-0.783
15.	Vitamin C (mg/100g)	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	-0.001	0.000	0.000	0.001	0.001	<b>-0.013</b>	-0.134	-0.543
16.	Fruit yield per plant (g)	0.000	0.000	0.000	-0.002	-0.001	-0.001	-0.017	-0.003	-0.001	0.001	0.001	0.000	0.000	0.000	0.091	<b>0.932</b>	-2.112
17.	Fruit yield (kg/plot)	0.000	0.000	0.000	-0.002	-0.001	-0.001	-0.017	-0.003	-0.001	0.001	0.001	0.000	0.000	0.000	0.091	0.932	<b>-1.001</b>
18.	Fruit yield (q/ha)	<b>0.001</b>	<b>0.002</b>	<b>0.001</b>	<b>-0.003</b>	<b>0.002</b>	<b>-0.476</b>	<b>-0.321</b>	<b>0.241</b>	<b>0.005</b>	<b>-0.576</b>	<b>1.000</b>	<b>-0.243</b>	<b>1.000</b>	<b>0.001</b>	<b>-0.003</b>	<b>0.432</b>	<b>-2.001</b>

Table- 4.5.F: Phenotypic path coefficient analysis (direct and indirect effect) of yield contributing of characters of tomato (pooled data)

S. No.	Character	Number of branches per plant	Days to 50 percent flowering	Number of clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Average fruit weight (g)	Number of locules per fruit	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	Number of ridges on fruit	T.S.S. ( <sup>0</sup> Brix)	Vitamin C (mg/100g)	Fruit yield per plant (g)	Fruit yield (kg/plot)	Fruit yield (q/ha)
1.	Plant height (cm)	-0.003	-0.001	0.000	-0.018	0.000	0.003	0.000	0.004	0.002	0.000	0.001	-0.001	-0.002	0.000	0.001	0.264	0.281
2.	Number of branches per plant	-0.001	-0.004	0.000	-0.017	0.000	0.003	0.000	0.004	0.000	0.001	0.000	0.000	-0.002	0.000	0.000	0.258	0.275
3.	Days to 50 percent flowering	0.001	0.002	<b>0.000</b>	-0.008	0.000	0.000	0.000	0.001	0.003	-0.004	0.002	0.006	0.003	0.000	0.000	-0.089	-0.094
4.	Number of clusters per plant	-0.001	-0.001	0.000	-0.050	0.000	0.007	0.000	0.007	0.007	-0.004	0.003	0.003	0.003	0.000	0.000	0.445	0.474
5.	Number of flowers per cluster	-0.001	-0.002	0.000	-0.026	<b>-0.001</b>	0.004	0.000	0.004	0.002	0.001	0.001	-0.002	0.000	0.000	-0.001	0.342	0.363
6.	Number of fruits per cluster	-0.001	-0.002	0.000	-0.042	0.000	<b>0.008</b>	0.000	0.008	0.005	-0.005	0.003	0.001	0.002	0.000	-0.001	0.407	0.433
7.	Number of fruits per plant	-0.001	-0.002	0.000	-0.031	0.000	0.004	<b>0.018</b>	0.005	0.003	-0.001	0.002	-0.001	0.000	0.000	-0.001	0.364	0.387
8.	Average fruit weight (g)	-0.001	-0.002	0.000	-0.046	0.000	0.008	0.001	<b>0.007</b>	0.009	-0.006	0.004	0.003	-0.004	0.000	-0.001	0.487	0.519
9.	Number of locules per fruit	0.000	0.000	0.000	-0.034	0.000	0.004	0.000	0.007	<b>0.010</b>	-0.006	0.003	0.001	0.001	0.000	-0.001	0.254	0.271
10.	Pericarp thickness (mm)	0.000	0.000	0.000	-0.023	0.000	0.004	0.000	0.006	0.007	<b>-0.008</b>	0.003	0.002	0.000	0.000	-0.001	0.142	0.150
11.	Fruit length (cm)	0.000	0.000	0.000	-0.039	0.000	0.005	0.000	0.007	0.007	-0.005	<b>0.004</b>	-0.001	0.003	0.000	0.000	0.328	0.349
12.	Fruit width (cm)	0.001	0.000	0.002	-0.003	0.026	-0.003	0.072	-0.034	-0.050	0.004	0.002	<b>-0.001</b>	0.032	-0.028	0.034	0.262	-0.428
13.	Number of ridges on fruit	0.000	0.000	0.000	-0.013	0.000	0.001	0.000	0.002	0.001	-0.001	0.000	0.012	<b>0.001</b>	0.000	0.000	-0.023	-0.025
14.	T.S.S. ( <sup>0</sup> Brix)	0.000	0.001	0.000	-0.015	0.000	0.001	0.000	-0.003	0.001	0.000	0.001	0.001	0.011	<b>0.000</b>	0.001	0.013	0.014
15.	Vitamin C (mg/100g)	0.000	0.000	0.000	-0.005	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.002	-0.001	<b>0.026</b>	0.005	0.005
16.	Fruit yield per plant (g)	0.000	0.000	0.000	0.002	0.000	-0.001	0.000	-0.002	-0.003	0.002	0.000	0.000	0.002	0.000	0.005	<b>0.049</b>	-0.053
17.	Fruit yield (kg/plot)	-0.001	-0.002	0.000	-0.044	0.000	0.006	0.001	0.007	0.005	-0.002	0.003	-0.001	0.000	0.000	0.000	0.499	<b>0.531</b>
18.	Fruit yield (q/ha)	<b>-0.001</b>	<b>-0.002</b>	<b>0.000</b>	<b>-0.044</b>	<b>0.000</b>	<b>0.006</b>	<b>0.001</b>	<b>0.007</b>	<b>0.005</b>	<b>-0.002</b>	<b>0.003</b>	<b>-0.001</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.499</b>	<b>0.531</b>



## ***CHAPTER-5***

### ***DISCUSSION***

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*DISCUSSION*

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The present investigation entitled “**Studies on Genetic Variability, Heritability, Genetic Advance, Correlation Coefficient and Path Analysis in Tomato (*Solanum lycopersicum* L.)**” was carried out at Horticulture Research Farm-I, Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Rae Bareli Road, Lucknow (U.P.), India during the winter season of 2017-18 and 2018-19. The response of genetic variability, heritability, genetic advance, correlation coefficient and path analysis of tomato. The results are discussed in the light of literature available and research works reported by earlier workers on tomato and other allied crops relevant and logical explanation have been given wherever possible.

**Results and discussion**

Analysis of variance revealed that the genotypes registered extremely significant variation for all of the features and indicating the presence of substantial variability for these characters (Table-1). As a result, there is a lot of scope for selection. Examining the range of variance is one method of measuring the variability. For majority of characters the phenotypic variance and phenotypic coefficient of variation were slightly higher than corresponding genotypic variance and genotypic coefficient of variation indicating that the characters were subjected to less environmental influence.

The knowledge of genetic variability, heritability and genetic advance is tough to be important in forecasting response for superior line selection and yield attributing components qualities with a high relationship to yield in order to get further information on the above facts; the current investigation conducted the following experiments.

**5.1 Analysis of variance for the design of experiments****5.2 Mean performance of genotypes**

**5.3** Estimates of variability, heritability and genetic advance in percent of mean

**5.4** Genotypic and phenotypic correlation coefficient

**5.5** Path coefficient analysis

### **5.1 ANALYSIS OF VARIANCE:**

Table-4.1. clearly shows that the result of the analysis of variance (ANOVA) for the eighteen characters. Replications, treatments and error were used to partition the variances for distinct characters. Plant height (cm), number of branches per plant, days to 50% flowering, number of clusters per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, average fruit weight(g), number of locules per fruit, pericarp thickness (mm), fruit length (cm), fruit width (cm), number of ridges on fruit, fruit yield per plant (g), fruit yield (kg/plot), fruit yield (q/ha), total soluble solids and vitamin c (mg/100g) were all recorded.

### **5.2 MEAN PERFORMANCE OF GENOTYPE:**

Table- 4.2(A-E) indicates that the mean value of genotypes in relation to several characters.

#### **5.2.1: Plant height (cm)**

The perusal of data clearly revealed that the plant height (cm) ranged from 25.33 to 30.53, (2017-18) & 24.92 to 31.40(2018-19) and 25.12 to 30.96 (pooled data) respectively. The genotype Toleu- 32, took minimum plant height. while maximum plant height had taken in genotype Pusa Sadabahar which was statistically at par with standard Selection-7 during first year, second year and pooled data, respectively.

#### **5.2.2: Number of branches per plant**

In the present investigation, it was observed that the number of branches per plant ranged from 4.69 to 7.08, (2017-18) & 4.37 to 7.11(2018-19) and 4.53 to 7.09 (Pooled data) respectively. The genotype Toleu- 32, took minimum number of branches per

plant. while maximum number of branches per plant had taken in genotype Pusa Sadabahar which was statistically followed by Selection- 7 during first year & second year and pooled data, respectively (Table 4.2.A).

### **5.2.3: Days to 50 percent flowering**

Days to 50 percent flowering ranged from 29.15 to 41.60 (2017-18) & 30.20 to 42.20 (2018-19) and 29.68 to 41.90 (Pooled data). The minimum days to 50 percent flowering was observed in genotype Pusa Sadabahar. While maximum Days to 50 percent flowering taken in genotype Toleu-32 consequently pursued by Solan Vojr during first year & second year and pooled data (Table 4.2.A), respectively.

### **5.2.4: Number of clusters per plant**

The perusal data revealed that the number of clusters per plant ranged from 15.20 to 20.12 (2017-18) & 15.76 to 20.76 (2018-19) and 15.48 to 20.44 (Pooled data) respectively. The genotype Solan Vojr, consequently took minimum number of clusters per plant was observed, while maximum number of clusters per plant had taken in genotype Pusa Sadabahar which was statically at per with standard Selection- 7 during first year & second year and pooled data, respectively (Table 4.2.A).

### **5.2.5: Number of flowers per cluster**

In the present investigation, it was observed that the number of flowers per plant ranged from 5.67 to 9.78 (2017-18) & 5.71 to 9.84 (2018-19) and 5.69 to 9.81(Pooled data) respectively. The genotype Toleu- 32, consequently took minimum number of flowers per plant was observed, while maximum number of flowers per plant had taken in genotype Pusa Sadabahar which was statistically followed by Selection- 7 during first year & second year and pooled data, respectively (Table 4.2.B).

### **5.2.6: Number of fruits per cluster**

Number of fruits per cluster ranged from 3.20 to 5.12 (2017-18) & 3.13 to 5.04 (2018-19) and 3.17 to 5.08 (Pooled data). The minimum number of fruits per cluster was observed in genotype Toleu- 32. While maximum number of fruits per cluster taken in genotype Pusa Sadabahar, respectively first year & second year and pooled data (Table 4.2.B).

**5.2.7: Number of fruits per plant**

The perusal data revealed that the number of fruits per plant ranged from 13.10 to 18.44 (2017-18) & 13.16 to 18.32 (2018-19) and 13.13 to 18.38 (Pooled data) respectively. The genotype Toleu- 32, consequently took minimum number of fruits per plant was observed, while maximum number of fruits per plant had taken in genotype Pusa Sadabahar which was statically at par with standard Selection- 7 during first year & second year and pooled data, respectively (Table 4.2.B).

**5.2.8: Average fruits per plant**

Average fruits per plant ranged from 41.88 to 53.20 (2017-18) & 42.02 to 52.88 (2018-19) and 41.95 to 53.04 (Pooled data) consequently. The minimum average fruits per plant was observed in genotype Toleu- 32, while maximum average fruits per plant taken in genotype Pusa Sadabahar, respectively followed by Selection-7 in first year & second year and pooled data accordingly (Table 4.2.B).

**5.2.9: Number of locules per fruit**

The perusal data revealed that the number of locules per fruit ranged from 3.09 to 5.87 (2017-18) & 3.54 to 5.12 (2018-19) and 3.52 to 5.50 (Pooled data) respectively. The minimum number of locules per fruit was observed in Rio-Grande, while maximum number of locules per fruit had taken in genotype Punjab Barkha Bahar during first year & second year and pooled data, respectively (Table 4.2.C).

**5.2.10: Pericarp thickness (mm)**

In the present investigation, it was observed that the pericarp thickness ranged from 2.81 to 4.72 (2017-18) & 3.01 to 4.69 (2018-19) and 2.91 to 4.62 (Pooled data) respectively. The genotype TLCV-28, consequently took minimum pericarp thickness was observed, while maximum pericarp thickness had taken in genotype VRT-103-6-1. (Table 4.2.C).

**5.2.11: Fruit length (cm)**

Data revealed that fruit length ranged from 5.19 to 6.53 (2017-18) & 5.26 to 6.64 (2018-19) and 5.23 to 6.59 (Pooled data) respectively. The genotype VRT-50,

respectively took minimum fruit length was observed, while maximum fruit length had taken in Kashi Aman (Table 4.2.C).

#### **5.2.12: Fruit width (cm)**

In the present investigation, it was observed that the fruit width ranged from 4.36 to 7.98 (2017-18) & 4.72 to 7.91 (2018-19) and 4.62 to 7.91 (Pooled data) respectively. The minimum fruit width was observed in genotype Kashi Aman, while maximum fruit width had taken in genotype LA-3957 (Table 4.2.C).

#### **5.2.13: Number of ridges on fruit**

We observed that the number of ridges on fruit ranged from 1.15 to 2.29 (2017-18) & 1.17 to 2.18 (2018-19) and 1.19 to 2.24 (Pooled data) respectively. The minimum number of ridges on fruit was observed in genotype Rio- Grande, while maximum number of ridges on fruit had taken in Kalyanpur type-1 (Table 4.2.D).

#### **5.2.14: Fruit yield per plant (g)**

The perusal data revealed that the fruit yield ranged from 548.63 to 981.01 (2017-18) & 552.98 to 968.76 (2018-19) and 550.81 to 974.89 (Pooled data) respectively. The minimum fruit yield was observed in Toleu-32, while maximum fruit yield had taken in genotype Pusa Sadabahar consequently pursued by Selection-7 during first year & second year and pooled data (Table 4.2.D).

#### **5.2.15: Fruit yield (kg/plot)**

Fruit yield ranged from 8.78 to 15.70 (2017-18) & 8.85 to 15.50 (2018-19) and 8.82 to 15.12 (Pooled data) respectively. The minimum fruit yield was observed in Toleu-32, while maximum fruit yield per plant had taken in genotype Pusa Sadabahar consequently pursued by Selection-7 during first year & second year and pooled data (Table 4.2.D).

#### **5.2.16: Fruit yield (q/ha)**

In the present investigation, we observed that the fruit yield ranged from 203.24 to 363.42 (2017-18) & 204.86 to 358.80 (2018-19) and 204.05 to 361.11 (Pooled data)

respectively. The minimum fruit yield was observed in genotype Toleu-32, while maximum fruit yield had taken in genotype Pusa Sadabahar (Table 4.2.D).

### **5.2.17: Total Soluble Solids (<sup>0</sup>Brix)**

The perusal data revealed that the total soluble solids ranged from 4.02 to 5.61 (2017-18) & 4.31 to 5.73 (2018-19) and 4.17 to 5.49 (Pooled data) respectively. The minimum total soluble solids were observed in genotype LA-3957, while maximum total soluble solids had taken in genotype TLCV-28 (Table 4.2.E).

### **5.2.18: Vitamin C (mg/100g)**

It was observed that the vitamin C ranged from 23.71 to 27.79 (2017-18) & 24.19 to 27.74 (2018-19) and 23.95 to 27.77 (Pooled data) respectively. The minimum vitamin C was observed in genotype LA-3957, while maximum vitamin C had taken in genotype VRT-50 respectively followed by TLCV-16 (Table 4.2.E).

## **5.3: Estimates of variability, heritability and genetic advance in percent of mean**

During two years data (2017-18 & 2018-19) and pooled data recorded on estimate of variability, heritability and genetic advance all of the features clearly revealed as extremely important (Table 4.3 A, B&C).

### **5.3.1: Genetic variability:**

The phenotypic coefficient of variation (PCV) was greater than the genotypic coefficient of variation (GCV) for all of the traits tested (Table 4.3.A).

The widest range was recorded for fruit yield per plant (15680.66 - 11489.85) followed by fruit yield (2151.40 - 1576.59), average fruit weight (20.40 - 3.80), Days to 50% flowering (18.84 - 9.45), plant height (5.72 - 0.12), Vitamin C (4.16 - 0.74), number of clusters per plant (3.10 - 0.68), number of fruits per plant (3.23 - 1.38), while lowest range were recorded in number of ridges on fruit (0.11 - 0.09) and Fruit yield (3.79 - 2.74) (Table 4.3.A ).

Phenotypic coefficient variation was higher for number of ridges on fruit (20.25) followed by fruit width (20.25), fruit yield per plant (17.07%), fruit yield kg/plot (16.63), number of flower per cluster (14.58%), number of locules per fruit (14.16%) and number of fruits per clusters (13.93), where as it was moderate for number of branches per plant (12.71%) followed by Pericarp thickness (12.63%), Days to 50%

flowering (12.33), number of fruits per plant (11.50%) and TSS (10.18%), the lowest phenotypic coefficient of variation was recorded in Vitamin C (7.99%) respectively followed by plant height (8.94%) these results conformity with findings of **Dar and Sharma (2011)**, who announced that investigation of coefficient of variation uncovered that size of phenotypic coefficient of variation was higher than genotypic coefficient of variation for every one of the characters under examination. The higher estimations of phenotypic coefficient of variation (PCV) were recorded for higher number of ridges on fruit, fruit width, fruit yield per plant, yield quintal per hectare, normal natural product weight, number of organic products per plant though high genotypic coefficient of variation (GCV) was recorded with 0-carotene in tomato.

The maximum genotypic coefficient of variation was observed in number of ridges on fruit (18.17) consequently followed by fruit width (17.20), fruit yield (14.62%), fruit yield per plant (14.61%) and fruit yield (14.15), it was moderate for number of flower per cluster (11.38%), number of locules per fruit (11.28%), number of fruit per cluster (10.51%), pericarp thickness (9.14%), number of branches per plant (9.10%) and days to 50% flowering (8.66%). The minimum genotypic coefficient of variation was observed in plant height (1.31%) followed by (4.17%), average fruit weight (4.17%) and number of cluster per plant (4.67).

This shows the prospect of a stronger selection response for the qualities mentioned above. **Dar and Sharma (2011)** and **Rani and Anitha (2011)** both mentioned the high PCV and GCV estimates for these characters (2011) Fruit length, diameter of fruit, and total soluble solids all showed moderate variability (TSS). For days up to 50% flowering, low GCV and PCV were found. **Sahanur et al. (2012)** and **Madhurina and Paul (2012)** both found moderate and low variability in these parameters.

### **5.3.2: Heritability:**

Table 4.3(C) shows the heritability value in a wide sense. All of the characters were found to have a high level of broad sense heritability. Number of ridges on fruit (89.72%) had the highest heritability followed by fruit width (87.58%), fruit yield (85.61), fruit yield per plant (85.60%), fruit yield kg/plot (85.07%), number of locules per fruit (79.71%), number of flowers per cluster (78.10%) and number of fruits per

cluster (75.42%) plant height (14.62%) had the lowest heritability followed by vitamin C (42.23%) and average fruit weight (43.18%) in the study (Table 4.3.C)

Heritability is a measurement of information that aids breeders in selecting genotypes for further use. The greater heritability, the more genotypic elements are involved in the expression of the traits had strong heritability and genetic advance in percent of means with the exception of days to 50 percent flowering in genetic advance. These results corroborated with the findings of **Joshi and Singh (2003)**, **Singh et al. (2006)**; **Maurya et al. (2011)** and **Tasisa et al. (2011)**.

### **5.3: Genetic gain:**

The highest genetic advance percentage was observed for fruit yield per plant (20017.72%) followed by fruit yield (7415.34%), days to 50% flowering (517.61), fruit yield kg/plot (308.25%), average fruit weight (271.78%), fruit width (211.62%), number of fruits per plant (190.43%), and number of flower per cluster (148.57%). The minimum genetic advance was observed in fruit length (37.83%) pursued by TSS (<sup>0</sup>brix) (40.41%) and plant height (42.47%). Thus, these traits which exhibited high heritability in broad sense and high expected genetic advance as per cent of mean may be considered to be largely governed by additive gene action and therefore, could be effectively improved through selection. High genetic gain have also been reported for most of the yield and yield attributing traits this conformity with the results **Mahesha et al. (2006)**, **Kumari et al.(2007)**, **Saeed et al. (2007)**, **Prema et al. (2011)**, **Tasisa et al. (2011)**, **Madhurina and Paul (2012)** and **Sahanur et al. (2012)**.

### **5.4 Genotypic and Phenotypic Correlation coefficient**

#### **5.4.1: Genotypic correlation coefficient :**

The correlation coefficient at genotypic level in pooled data has been presented in Table (4.4.C). It was observed that fruit yield (q/ha) had positive significant correlation with number of fruits per plant (0.996) followed by number of branches per plant (0.831). However negatively and significantly correlation with day to 50 percent flowering (0.835). Fruit yield (kg/plot) had observed that positive and significant correlation with number of cluster per plant (0.975) followed by plant height (0.937) and negative and significant correlation with days to 50 percent flowering (0.835) followed by (0.350). Fruit yield per plant was positive and

significant correlation with number of fruits per plant (0.996) followed by number of cluster per plant (0.975), however negatively and significantly correlation with day to 50 percent flowering (0.835). Fruit width has showed positive and significantly correlation with day to 50 percent flowering (0.267) and negative and significant correlation with average fruit width (0.397). Fruit length was observed positively and significantly correlation with average fruit weight (0.959) followed by (0.445). Pericarp thickness had showed positive and significantly correlation with average fruit weight (0.667) followed by number of fruits per cluster (0.298). Number of locules per fruit had showed positively and significantly correlation with average fruit weight (0.846) followed by plant height (0.340). Average fruit had taken positive and significantly correlation with number of flower per cluster (0.945). However, negatively and significantly correlation with day to 50 percent flowering (0.592). Day to 50 percent flowering showed negatively and non-significantly correlation (Table 4.4.C). The present findings are quite close to the results of **Naidu (2001)** and **Jogi (2007)**. The current findings are consistent with previous researchers findings (**Parsad and Parsad, 1971; Singh and Singh, 1980; Manivannan, 1985; Sidhu and Singh, 1989; Kanthaswami et al. 1994 and Wang et al. 1998**).

#### **5.4.2: Phenotypic correlation coefficient:**

At the phenotypic correlation coefficient of tomato in pooled data in Table 4.4(F), it was observed that fruit yield (q/ha) found positive and significant correlation with average fruit weight (0.977) followed by (0.893) and negatively and significantly correlated with day to 50 percent flowering (0.178). Fruit yield (kg/plot) had taken significant correlation with number of clusters per plant (0.893) followed by number of fruits per cluster (0.816). Fruit yield per plant was observed that positive and significant correlation with average fruit weight (0.976) and negative and significant correlation with day to 50 percent flowering (0.178). Number of ridges on fruit showed positive and significant correlation with days to 50 percent flowering (0.252). However, negatively and significantly correlated with average fruit weight (0.340) fruit width had positive and significant correlation with days to 50 percent flowering (0.463). Fruit length show positive and significant correlation with average fruit weight (0.944) followed by number of clusters per plant (0.784). Pericarp thickness had positive and significant correlation with number of fruits per cluster (0.587) and negatively significantly correlated with number of branches per plant (0.117). Number

of locules per fruit showed positive and significant correlation with average fruit weight (0.903) followed by number of clusters per plant (0.677). Whereas, days to 50 percent flowering showed negatively and non-significant correlation (Table 4.4.F). The findings are analogous to the results of **Singh *et al.* (2000)**; **Nair, P.I. and Thambu Raj, S. (1995)**; **Padma *et al.* (2002)**.

### 5.5: Path coefficient analysis :

The path analysis was performed to have a better understanding of the relationship between the genotypic correlation coefficient of yield with contributing factors. Through path coefficient analysis in germplasm, In order to divide the genotypic correlation coefficient into direct and indirect effects (Table 4.5.C).

#### 5.5.1: Genotypic path coefficient analysis:

The highest positive effect fruit yield (q/ha) was exhibited by fruit yield kg/plot (1.430) fruit yield per plant (g) (0.057), Number of ridges on fruit (0.051), Number of fruits per plant (0.038), , Number of fruits per cluster (0.031) and number of locules per fruit (0.027). However, the maximum negative (direct and indirect) effect towards fruit yield (q/ha) was exhibited by number of branches per plant (-0.199), day to 50 percent flowering (-0.079), number of cluster per plant (-0.050), fruit length (-0.044), TSS (-0.037), vitamin c (-0.034) and number of flower per cluster (-0.033) (Table 4.5.C). This is in agreement with the findings of **Saleem *et al.* (2013)**.

#### 5.5.2: Phenotypic path coefficient analysis:

Highest was exhibited by Fruit yield (kg/plot) (0.531), fruit yield per plant (g) (0.049), number of fruits per plant (0.018), pericarp thickness (0.010), number of locules per fruit (0.007) and fruit breadth (0.004) had the highest phenotypic path coefficient analysis (direct and indirect) effect on fruit yield (q/ha) (0.004). Number of flowers per cluster (-0.050), Fruit length (-0.008), Day to 50 percent flowering (-0.003) and number of fruits per cluster had the most negative (direct and indirect) effects on fruit yield (q/ha) (-0.001). Overall all of the qualities had a beneficial on yield per plant either directly or indirectly (Table 4.5.F). This results is quite close to the report of **Kumar and Dudhi (2011)** and **Hidaytullah *et al.* (2008)** findings.

**Bodende (2002)** and **Hayder *et al.* (2007)** also previously discovered that plant height, fruit weight and fruit length were directly responsible for the determination of tomato fruit yield. **Lakshmi and Mani (2004)**, **Mehta and Asati (2008)** and **Indu Rani *et al.* (2010)** also found similar results in (2010).



## *CHAPTER-6*

*SUMMARY*

*AND*

*CONCLUSION*

## SUMMARY AND CONCLUSION

The present investigation entitled “**Studies on Genetic Variability, Heritability, Genetic Advance, Correlation Coefficient and Path Analysis in Tomato (*Solanum lycopersicum* L.)**” was carried out at Horticulture Research Farm-I, Department Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Rae Bareilly Road, Lucknow (U.P.), India during the rabi season of 2017-18 and 2018-19. The response of genetic variability, heritability, genetic advance, correlation coefficient and path analysis of tomato. The results are discussed in the light of literature available and research works reported by earlier workers on tomato and other allied crops relevant and logical explanation have been given wherever possible.

The following studies were conducted in the present investigation in order to generate additional knowledge on the aforesaid facts.

### 6.1 Analysis of variance for the design of experiments

### 6.2 Mean performance of genotypes

### 6.3 Estimates of variability, heritability and genetic advance in percent of mean

### 6.4 Genotypic and phenotypic correlation coefficient

### 6.5 Path coefficient analysis

1. The plant height (cm) ranged from 25.33 to 30.53 (2017-18) & 24.92 to 31.40 (2018-19) and 25.12 to 30.96 (pooled data) correspondingly, according to the data. As a result the genotype Toleu- 32 took shortest plant height.
2. The number of branches per plant ranged vary between 4.69 to 7.08 (2017-18) & 4.37 to 7.11(2018-19) and 4.53 to 7.09 (pooled data) in the current study. As a result the genotype Toleu- 32 took the minimum number of branches per plant.

3. Days to 50 percent flowering ranged from 29.15 to 41.60 (2017-18) & 30.20 to 42.20 (2018-19) and 29.68 to 41.90 (pooled data) consequently. In genotype Pusa Sadabahar the minimum days to 50 percent flowering were recorded.
4. In the present investigation it was found that the number of clusters per plant ranged from 15.20 to 20.12 (2017-18) & 15.76 to 20.76 (2018-19) and 15.48 to 20.44 (pooled data) respectively. The genotype Solan Vojr, consequently took minimum number of clusters per plant was observed.
5. The perusal data explicated that the number of flowers per plant varied from 5.67 to 9.78 (2017-18) & 5.71 to 9.84 (2018-19) and 5.69 to 9.81 (pooled data) in the current study. The genotype Toleu- 32, consequently took minimum number of flowers per plant was taken.
6. Number of fruits per cluster ranged from 3.20 to 5.12 (2017-18) & 3.13 to 5.04 (2018-19) and 3.17 to 5.08 (pooled data) consequently. The minimum number of fruits per cluster was observed in genotype Toleu- 32.
7. In the present investigation it was observed that the number of fruits per plant ranged from 13.10 to 18.44 (2017-18) & 13.16 to 18.32 (2018-19) and 13.13 to 18.38 (pooled data) respectively. The genotype Toleu- 32, consequently took minimum number of fruits per plant was observed.
8. Average fruits per plant ranged from 41.88 to 53.20 (2017-18) & 42.02 to 52.88 (2018-19) and 41.95 to 53.04 (pooled data) consequently. The minimum average fruits per plant was observed in genotype Toleu- 32.
9. In the present investigation it was observed that the number of locules per fruit ranged from 3.09 to 5.87 (2017-18) & 3.54 to 5.12 (2018-19) and 3.52 to 5.50 (pooled data) respectively. The minimum number of locules per fruit was observed in Rio-Grande.
10. The perusal of data revealed that the pericarp thickness ranged from 2.81 to 4.72 (2017-18) & 3.01 to 4.69 (2018-19) and 2.91 to 4.62 mm, (pooled data) respectively. The genotype TLCV-28, consequently took minimum pericarp thickness was observed.

11. Data clearly apparent that fruit length ranged from 5.19 to 6.53 (2017-18) & 5.26 to 6.64 (2018-19) and 5.23 to 6.59 cm, (pooled data) respectively. The genotype VRT-50, respectively took minimum fruit length had taken.
12. In the present investigation, it was obvious that the fruit width ranged from 4.36 to 7.98 (2017-18) & 4.72 to 7.91(2018-19) and 4.62 to 7.91 cm, (pooled data) respectively. The minimum fruit width was observed in genotype Kashi Aman.
13. In the present investigation it was observed that the number of ridges on fruit ranged from 1.15 to 2.29 (2017-18) & 1.17 to 2.18 (2018-19) and 1.19 to 2.24 (pooled data) respectively. The minimum number of ridges on fruit was observed in genotype Rio- Grande.
14. The perusal data clearly revealed that the fruit yield ranged from 548.63 to 981.01 (2017-18) & 552.98 to 968.76 (2018-19) and 550.81 to 974.89g, (pooled data) respectively. The minimum fruit yield was observed in Toleu-32.
15. Fruit yield ranged from 8.78 to 15.70 (2017-18) & 8.85 to 15.50 (2018-19) and 8.82 to 15.12kg/plot, (pooled data) respectively. The minimum fruit yield was observed in Toleu-32.
16. The perusal of data revealed that the fruit yield ranged from 203.24 to 363.42 (2017-18) & 204.86 to 358.80 (2018-19) and 204.05 to 361.11 q/ha, (pooled data) respectively. The minimum fruit yield was observed in genotype Toleu-32.
17. In the present investigation it elucidated that the total soluble solids ranged from 4.02 to 5.61(2017-18) & 4.31 to 5.73 (2018-19) and 4.17 to 5.490Brix, (pooled data) respectively. The minimum total soluble solids were observed in genotype LA-3957.
18. In the current study it was observed that the vitamin C ranged from 23.71 to 27.79 (2017-18) & 24.19 to 27.74 (2018-19) and 23.95 to 27.77mg/100g, (pooled data) respectively. The minimum vitamin C was observed in genotype LA-3957.

19. The widest range was recorded for fruit yield per plant (15680.66 - 11489.85) followed by fruit yield (2151.40 - 1576.59), Average fruit weight (20.40 - 3.80). While, lowest range were recorded in Number of ridges on fruit (0.11 - 0.09), Fruit yield (3.79 - 2.74).
20. The highest phenotypic coefficient of variation was found in the number of ridges on fruit (20.25) followed by fruit width (20.25), and fruit yield per plant (17.07%). The lowest phenotypic coefficient of variation was found in Vitamin C (7.99%) followed by plant height (8.94%).
21. The maximum genotypic coefficient of variation was observed in number of ridges on fruit (18.17) consequently, followed by fruit width (17.20), fruit yield (14.62%). The minimum genotypic coefficient of variation was observed in plant height (1.31%) followed by (4.17%), average fruit weight (4.17%).
22. The high value of broad sense heritability was recorded for all the characters. The highest heritability was recorded for number of ridges on fruit (89.72%) followed by fruit width (87.58%) whereas, the lowest heritability was recorded in plant height (14.62%) followed by vitamin C (42.23%).
23. The maximum genetic advance (%) was recorded for fruit yield per plant (20017.72%) followed by fruit yield (7415.34%), days to 50% flowering (517.61). The minimum genetic advance was observed in fruit length (37.83%) pursued by TSS (Obrix) (40.41%) and plant height (42.47%).
24. The correlation coefficient at genotypic level in fruit yield (q/ha) had positive significant correlation with number of fruits per plant (0.996) followed by number of branches per plant (0.831). However, negatively and significantly correlation with day to 50 percent flowering (0.835). fruit yield (kg/plot) had observed that positive and significant correlation with number of cluster per plant (0.975) followed by plant height (0.937) and negative and significant correlation with days to 50 percent flowering (0.835) followed by (0.350). fruit yield per plant was positive and significant correlation with number of fruits per plant (0.996) followed by number of cluster per plant (0.975), however negatively and significantly correlation with day to 50 percent flowering

(0.835). fruit width has showed positive and significantly correlation with day to 50 percent flowering (0.267) and negative and significant correlation with average fruit width (0.397). Fruit length was observed positively and significantly correlation with average fruit weight (0.959) followed by (0.445). pericarp thickness had showed positive and significantly correlation with average fruit weight (0.667) followed by number of fruits per cluster (0.298). number of locules per fruit had showed positively and significantly correlation with average fruit weight (0.846) followed by plant height (0.340). average fruit had taken positive and significantly correlation with number of flower per cluster (0.945). However, negatively and significantly correlation with day to 50 percent flowering (0.592).

25. At the phenotypic correlation coefficient of tomato, it was observed that fruit yield (q/ha) found positive and significant correlation with average fruit weight (0.977) followed by (0.893) and negatively and significantly correlated with day to 50 percent flowering (0.178). fruit yield (kg/plot) had taken significant correlation with number of clusters per plant (0.893) followed by number of fruits per cluster (0.816). Fruit yield per plant was observed that positive and significant correlation with average fruit weight (0.976) and negative and significant correlation with day to 50 percent flowering (0.178). number of ridges on fruit showed positive and significant correlation with days to 50 percent flowering (0.252). However, negatively and significantly correlated with average fruit weight (0.340) fruit width had positive and significant correlation with days to 50 percent flowering (0.463). fruit length show positive and significant correlation with average fruit weight (0.944) followed by number of clusters per plant (0.784). pericarp thickness had positive and significant correlation with number of fruits per cluster (0.587) and negatively significantly correlated with number of branches per plant (0.117). Number of locules per fruit showed positive and significant correlation with average fruit weight (0.903) followed by number of clusters per plant (0.677).
26. Fruit yield (kg/plot) (1.430) fruit yield per plant (g) (0.057), number of ridges on fruit (0.051), number of fruits per plant (0.038), number of fruits per cluster (0.031) and number of locules per fruit all had the most positive (direct and

effect on fruit production (q/ha) (0.027). Number of branches per plant (-0.199), day to 50 percent flowering (-0.079), number of cluster per plant (-0.050), fruit length (-0.044), TSS (-0.037), vitamin c (-0.034) and number of flower per cluster (-0.033) had the most unfavorable (direct and indirect) effects on fruit yield (q/ha) (-0.033).

- 27.** Fruit yield (kg/plot) (0.531), fruit yield per plant (g) (0.049), number of fruits per plant (0.018), pericarp thickness (0.010), number of locules per fruit (0.007) and fruit breadth (0.007) had the highest phenotypic path coefficient analysis effect on fruit yield (q/ha) (0.004). Number of flowers per cluster (-0.050), fruit length (-0.008), days to 50 percent flowering (-0.003) and number of fruits per cluster had the most negative effects on fruit yield (q/ha) (-0.001).

## **CONCLUSION**

On the basis of above results obtained in the present investigation, consisting twenty genotypes of tomato namely, LA-3957, Rio-Grande, Punjab Barkha Bahar-2, Kashi Aman, Solan Vojr, IIHR-2202, VRT-103-6-1, Kalyanpur typ-1, Switizar Land, Pusa Sadabahar, VRT-02 (Pe), TLCV-16, VRT-50, Selection-7, Toleu-32, VRT-01, H-86, KT-8, TLCV-28 and VRT-51. It can be concluded that the maximum phenotypic genotypic variance and genetic advance were observed for fruit yield per plant (g). The highest of PCV and GCV were recorded in number of ridges on fruit. Similarly, the maximum correlation coefficient at genotype level and phenotypic level were observed in fruit yield (q/ha). The results of path coefficient for parents were recorded the highest positive direct effect towards fruit yield (q/ha) was elucidated by fruit yield (kg/plot).



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## ***APPENDICES***

## APPENDICES

### MECHANICAL AND CHEMICAL ANALYSIS OF SOIL

Before sowing soil sample were drawn out by random method from different places in the field and a composite sample was prepared and subjected to mechanical and chemical analysis the samples were sieved with 0.55 mm sieves. The mechanical, chemical and physical analysis of soils are given as under:

#### Analysis of the soil (Experimental field)

Constituents	Values (%)
Sand	58.21
Silt	21.26
Clay	20.53

#### Chemical Analysis

Contituents	Values (%)	Method
Total N <sub>2</sub>	0.0380	Kjeldhal Method
Available P <sub>2</sub> O <sub>5</sub> kg/ha	18.60	Olsen Method
Available K <sub>2</sub> O	238.00	Morgan Mathod
Organic Carban	0.64	Black Method

#### Physical Characters

Items	Values(%)
pH	7.60
EC	0.30
Bulk Density	1.48
Particle Density	2.56
Pore Space	41.88
Permeability	5.06
M.E.	21.20

**Appendix-1: Analysis of variance of plant height (cm) in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.35	0.68	0.25	3.24
<b>Treatment</b>	19	118.93	6.26	2.31	1.87
<b>Error</b>	38	102.94	2.71	0.46	1.61
<b>Total</b>	59	223.23			

**Appendix-2: Analysis of variance of plant height (cm) in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	3.20	1.60	0.57	3.24
<b>Treatment</b>	19	118.51	6.24	2.24	1.87
<b>Error</b>	38	105.88	2.79	0.47	1.61
<b>Total</b>	59	227.58			

**Appendix-3: Analysis of variance of plant height (cm) in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	74.27	37.14	0.03	3.24
<b>Treatment</b>	19	113.29	5.96	1.07	1.87
<b>Error</b>	38	212.65	5.60	0.45	1.61
<b>Total</b>	59	400.21			

**Appendix-4: Analysis of variance of number of branches per plant in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	0.25	0.13	0.90	3.24
<b>Treatment</b>	19	19.55	1.03	7.42	1.87
<b>Error</b>	38	5.27	0.14	0.21	1.61
<b>Total</b>	59	25.07			

**Appendix-5: Analysis of variance of number of branches per plant in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	20.07	10.03	19.29	3.24
<b>Treatment</b>	19	22.11	1.16	2.24	1.87
<b>Error</b>	38	19.77	0.52	0.32	1.61
<b>Total</b>	59	61.94			

**Appendix-6: Analysis of variance of number of branches per plant in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	3.45	1.72	13.95	3.24
<b>Treatment</b>	19	19.59	1.03	4.15	1.87
<b>Error</b>	38	9.44	0.25	0.23	1.61
<b>Total</b>	59	32.48			

**Appendix-7: Analysis of variance of days to 50% flowering in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	121.41	60.70	6.55	3.24
<b>Treatment</b>	19	720.48	37.92	4.09	1.87
<b>Error</b>	38	352.37	9.27	0.30	1.61
<b>Total</b>	59	1194.26			

**Appendix-8: Analysis of variance of days to 50% flowering in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	123.51	61.75	6.50	3.24
<b>Treatment</b>	19	742.26	39.07	4.11	1.87
<b>Error</b>	38	360.83	9.50	0.29	1.61
<b>Total</b>	59	1226.60			

**Appendix-9: Analysis of variance of days to 50% flowering in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	122.50	61.25	6.53	3.24
<b>Treatment</b>	19	717.10	37.74	4.02	1.87
<b>Error</b>	38	356.57	9.38	0.30	1.61
<b>Total</b>	59	1196.16			

**Appendix-10: Analysis of variance of number of clusters per plant in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	33.10	16.55	6.93	3.24
<b>Treatment</b>	19	95.86	5.05	2.11	1.87
<b>Error</b>	38	90.81	2.39	0.41	1.61
<b>Total</b>	59	219.77			

**Appendix-11: Analysis of variance of number of clusters per plant in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	32.28	16.14	6.54	3.24
<b>Treatment</b>	19	83.46	4.39	1.78	1.87
<b>Error</b>	38	93.80	2.47	0.45	1.61
<b>Total</b>	59	209.55			

**Appendix-12: Analysis of variance of number of clusters per plant in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	32.76	16.38	6.73	3.24
<b>Treatment</b>	19	84.66	4.46	1.84	1.87
<b>Error</b>	38	91.93	2.42	0.45	1.61
<b>Total</b>	59	209.35			

**Appendix-13: Analysis of variance of number of flowers per cluster in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	3.85	1.92	3.60	3.24
<b>Treatment</b>	19	45.26	2.38	4.46	1.87
<b>Error</b>	38	20.30	0.53	0.29	1.61
<b>Total</b>	59	69.41			

**Appendix-14: Analysis of variance of number of flowers per cluster in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	0.94	0.47	1.08	3.24
<b>Treatment</b>	19	53.32	2.81	6.48	1.87
<b>Error</b>	38	16.45	0.43	0.23	1.61
<b>Total</b>	59	70.71			

**Appendix-15: Analysis of variance of number of flowers per cluster in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	5.76	2.88	3.02	3.24
<b>Treatment</b>	19	48.61	2.56	5.69	1.87
<b>Error</b>	38	17.08	0.45	0.18	1.61
<b>Total</b>	59	71.45			

**Appendix-16: Analysis of variance of number of fruits per cluster in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.66	0.83	6.69	3.24
<b>Treatment</b>	19	14.27	0.75	6.06	1.87
<b>Error</b>	38	4.71	0.12	0.23	1.61
<b>Total</b>	59	20.64			

**Appendix-17: Analysis of variance of number of fruits per cluster in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.69	0.84	6.38	3.24
<b>Treatment</b>	19	11.34	0.60	4.51	1.87
<b>Error</b>	38	5.03	0.13	0.28	1.61
<b>Total</b>	59	18.06			

**Appendix-18: Analysis of variance of number of fruits per cluster in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.68	0.84	6.54	3.24
<b>Treatment</b>	19	12.07	0.64	4.96	1.87
<b>Error</b>	38	4.87	0.13	0.26	1.61
<b>Total</b>	59	18.61			

**Appendix-19: Analysis of variance of number of fruits per plant in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	22.09	11.05	5.47	3.24
<b>Treatment</b>	19	104.91	5.52	2.73	1.87
<b>Error</b>	38	76.78	2.02	0.38	1.61
<b>Total</b>	59	203.78			

**Appendix-20: Analysis of variance of number of fruits per plant in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	25.42	12.71	6.96	3.24
<b>Treatment</b>	19	114.23	6.01	3.29	1.87
<b>Error</b>	38	69.43	1.83	0.33	1.61
<b>Total</b>	59	209.07			

**Appendix-21: Analysis of variance of number of fruits per plant in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	25.61	12.80	16.09	3.24
<b>Treatment</b>	19	113.83	5.99	3.24	1.87
<b>Error</b>	38	70.19	1.85	0.17	1.61
<b>Total</b>	59	209.62			

**Appendix-22: Analysis of variance of average fruit weight (g) in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	227.38	113.69	6.91	3.24
<b>Treatment</b>	19	561.34	29.54	1.79	1.87
<b>Error</b>	38	625.60	16.46	0.44	1.61
<b>Total</b>	59	1414.32			

**Appendix-23: Analysis of variance of average fruit weight (g) in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	229.17	114.58	6.85	3.24
<b>Treatment</b>	19	512.73	26.99	1.61	1.87
<b>Error</b>	38	635.97	16.74	0.46	1.61
<b>Total</b>	59	1377.87			

**Appendix-24: Analysis of variance of average fruit weight (g) in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	228.28	114.14	6.88	3.24
<b>Treatment</b>	19	532.18	28.01	1.69	1.87
<b>Error</b>	38	630.76	16.60	0.45	1.61
<b>Total</b>	59	1391.22			

**Appendix-25: Analysis of variance of number of locules per fruit in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.92	0.96	7.11	3.24
<b>Treatment</b>	19	29.15	1.53	11.38	1.87
<b>Error</b>	38	5.12	0.13	0.14	1.61
<b>Total</b>	59	36.19			

**Appendix-26: Analysis of variance of number of locules per fruit in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.95	0.97	6.21	3.24
<b>Treatment</b>	19	13.40	0.71	4.50	1.87
<b>Error</b>	38	5.96	0.16	0.16	1.61
<b>Total</b>	59	21.30			

**Appendix-27: Analysis of variance of number of locules per fruit in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.98	0.99	6.67	3.24
<b>Treatment</b>	19	17.13	0.90	6.23	1.87
<b>Error</b>	38	5.50	0.14	0.25	1.61
<b>Total</b>	59	24.61			

**Appendix-28: Analysis of variance of pericarp thickness (mm) in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.57	0.79	6.94	3.24
<b>Treatment</b>	19	15.20	0.80	7.07	1.87
<b>Error</b>	38	4.30	0.11	0.20	1.61
<b>Total</b>	59	21.07			

**Appendix-29: Analysis of variance of pericarp thickness (mm) in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.69	0.84	6.62	3.24
<b>Treatment</b>	19	7.67	0.40	3.16	1.87
<b>Error</b>	38	4.87	0.13	0.34	1.61
<b>Total</b>	59	14.20			

**Appendix-30: Analysis of variance of pericarp thickness (mm) in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.63	0.82	6.79	3.24
<b>Treatment</b>	19	9.79	0.52	4.29	1.87
<b>Error</b>	38	4.56	0.12	0.29	1.61
<b>Total</b>	59	15.98			

**Appendix-31: Analysis of variance of fruit length (cm) in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	3.29	1.64	7.02	3.24
<b>Treatment</b>	19	7.87	0.41	1.77	1.87
<b>Error</b>	38	8.90	0.23	0.44	1.61
<b>Total</b>	59	20.06			

**Appendix-32: Analysis of variance of fruit length (cm) in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	3.37	1.68	6.93	3.24
<b>Treatment</b>	19	6.80	0.36	1.47	1.87
<b>Error</b>	38	9.23	0.24	0.48	1.61
<b>Total</b>	59	19.40			

**Appendix-33: Analysis of variance of fruit length (cm) in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	3.36	1.68	6.98	3.24
<b>Treatment</b>	19	8.52	0.45	1.87	1.87
<b>Error</b>	38	9.09	0.24	0.47	1.61
<b>Total</b>	59	20.97			

**Appendix-34: Analysis of variance of fruit width (cm) in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	4.59	2.29	5.98	3.24
<b>Treatment</b>	19	86.70	4.56	11.90	1.87
<b>Error</b>	38	14.56	0.38	0.14	1.61
<b>Total</b>	59	105.85			

**Appendix-35: Analysis of variance of fruit width (cm) in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	4.56	2.28	6.08	3.24
<b>Treatment</b>	19	71.00	3.74	9.95	1.87
<b>Error</b>	38	14.26	0.38	0.16	1.61
<b>Total</b>	59	89.82			

**Appendix-36: Analysis of variance of fruit width (cm) in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	4.57	2.29	6.03	3.24
<b>Treatment</b>	19	78.42	4.13	10.88	1.87
<b>Error</b>	38	14.42	0.38	0.15	1.61
<b>Total</b>	59	97.42			

**Appendix-37: Analysis of variance of number of ridges on fruit in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	0.27	0.13	6.25	3.24
<b>Treatment</b>	19	6.26	0.33	15.53	1.87
<b>Error</b>	38	0.81	0.02	0.11	1.61
<b>Total</b>	59	7.33			

**Appendix-38: Analysis of variance of number of ridges on fruit in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	0.27	0.13	6.34	3.24
<b>Treatment</b>	19	4.76	0.25	11.86	1.87
<b>Error</b>	38	0.80	0.02	0.14	1.61
<b>Total</b>	59	5.83			

**Appendix-39: Analysis of variance of number of ridges on fruit in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	0.27	0.13	6.30	3.24
<b>Treatment</b>	19	5.39	0.28	13.39	1.87
<b>Error</b>	38	0.81	0.02	0.12	1.61
<b>Total</b>	59	6.46			

**Appendix-40: Analysis of variance of fruit yield per plant (kg) in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	58459.54	29229.77	6.94	3.24
<b>Treatment</b>	19	740836.89	38991.42	9.26	1.87
<b>Error</b>	38	160079.00	4212.61	0.17	1.61
<b>Total</b>	59	959375.42			

**Appendix-41: Analysis of variance of fruit yield per plant (kg) in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	58088.72	29044.36	6.97	3.24
<b>Treatment</b>	19	73.489.37	38446.81	9.22	1.87
<b>Error</b>	38	158432.22	4169.27	0.17	1.61
<b>Total</b>	59	947010.31			

**Appendix-42: Analysis of variance of fruit yield per plant (kg) in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	58273.96	29136.98	6.95	3.24
<b>Treatment</b>	19	734546.73	38660.35	9.23	1.87
<b>Error</b>	38	159250.78	4190.81	0.17	1.61
<b>Total</b>	59	952071.48			

**Appendix-43: Analysis of variance of fruit yield (kg/plot) in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	14.96	7.48	6.94	3.24
<b>Treatment</b>	19	189.72	9.99	9.26	1.87
<b>Error</b>	38	40.98	1.08	0.17	1.61
<b>Total</b>	59	245.66			

**Appendix-44: Analysis of variance of fruit yield (kg/plot) in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	14.87	7.43	6.96	3.24
<b>Treatment</b>	19	187.19	9.85	9.23	1.87
<b>Error</b>	38	40.56	1.07	1.07	1.61
<b>Total</b>	59	242.62			

**Appendix-45: Analysis of variance of fruit yield (kg/plot) in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	14.73	7.37	6.95	3.24
<b>Treatment</b>	19	176.34	9.28	8.86	1.87
<b>Error</b>	38	39.80	1.05	0.17	1.61
<b>Total</b>	59	230.87			

**Appendix-46: Analysis of variance of fruit yield (q/ha) in (2017-18).**

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Cal	F- Tab
Replication	2	8017.31	4008.66	6.94	3.24
Treatment	19	#####	5350.43	9.26	1.87
Error	38	#####	577.84	0.17	1.61
Total	59	#####			

**Appendix-47: Analysis of variance of fruit yield (q/ha) in (2018-19).**

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Cal	F- Tab
Replication	2	7971.05	3985.53	6.97	3.24
Treatment	19	#####	5275.13	9.23	1.87
Error	38	#####	571.79	0.17	1.61
Total	59	#####			

**Appendix-48: Analysis of variance of fruit yield (q/ha) in Pooled data.**

Source of Variations	D.F.	Sum of Squares	Mean Squares	F-Cal	F- Tab
Replication	2	7994.19	3997.09	6.95	3.24
Treatment	19	#####	5304.58	9.23	1.87
Error	38	#####	574.81	0.17	1.61
Total	59	#####			

**Appendix-49: Analysis of variance of T.S.S. (°Brix) in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.50	0.75	2.28	3.24
<b>Treatment</b>	19	11.99	0.63	1.92	1.87
<b>Error</b>	38	12.51	0.33	0.33	1.61
<b>Total</b>	59	26.00			

**Appendix-50: Analysis of variance of T.S.S. (°Brix) in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	2.47	1.23	2.88	3.24
<b>Treatment</b>	19	7.56	0.40	0.93	1.87
<b>Error</b>	38	16.24	0.43	0.55	1.61
<b>Total</b>	59	26.27			

**Appendix-51: Analysis of variance of T.S.S. (°Brix) in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	2.70	1.35	1.49	3.24
<b>Treatment</b>	19	8.17	0.43	2.10	1.87
<b>Error</b>	38	7.77	0.20	0.34	1.61
<b>Total</b>	59	18.64			

**Appendix-52: Analysis of variance of vitamin C (mg/100g) in (2017-18).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	6.15	3.08	1.86	3.24
<b>Treatment</b>	19	57.16	3.01	1.66	1.87
<b>Error</b>	38	68.94	1.81	0.48	1.61
<b>Total</b>	59	132.25			

**Appendix-53: Analysis of variance of vitamin C (mg/100g) in (2018-19).**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	1.01	0.50	0.84	3.24
<b>Treatment</b>	19	46.57	2.45	4.07	1.87
<b>Error</b>	38	22.88	0.60	0.32	1.61
<b>Total</b>	59	70.46			

**Appendix-54: Analysis of variance of vitamin C (mg/100g) in Pooled data.**

<b>Source of Variations</b>	<b>D.F.</b>	<b>Sum of Squares</b>	<b>Mean Squares</b>	<b>F-Cal</b>	<b>F- Tab</b>
<b>Replication</b>	2	64.83	32.42	0.98	3.24
<b>Treatment</b>	19	50.80	2.67	0.55	1.87
<b>Error</b>	38	186.24	4.90	0.36	1.61
<b>Total</b>	59	301.87			