VARIABILITY STUDIES IN PEA

(*Pisum sativum* L.)

BY

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B.Sc. (Agri.)

DEPARTMENT OF HORTICULTURE

COLLEGE OF AGRICULTURE, LATUR

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PARBHANI- 431 402 (M.S.) INDIA

2019

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DISSERTATION

Submitted to

Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani

in partial fulfilment of the requirement for the

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MASTER OF SCIENCE

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IN

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DEPARTMENT OF HORTICULTURE

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2019

CANDIDATE'S DECLARATION

I hereby declare that this dissertation

or part thereof has not been

previously submitted by me

for a degree of any

University or

Institution

Place : Latur **Ban S. J.**

Date : 30/05/2019 **Reg. No. 2017H/07ML**

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M.Sc. (Agri.), Ph.D. (Hort.)
Associate Professor,
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College of Agriculture,
Latur - 413 512 (M.S.)

CERTIFICATE - I

This is to certify that the dissertation entitled **"VARIABILITY STUDIES IN PEA (*Pisum sativum* L.)"** Submitted by **Mr. BAN SHYAM JAYENDRA** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (Horticulture)** in the subject of **VEGETABLE SCIENCE** is the result of original research work carried out by him under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree.

I also certified that, the dissertation or part there of has not been previously submitted by him for a degree of any university.

Place : Latur
Date : 30/05/2019

(V. S. Jagtap)
Research Guide

CERTIFICATE - II

This is to certify that the dissertation entitled **" VARIABILITY STUDIES IN PEA (*Pisum sativum* L.)"** submitted by **Mr. BAN SHYAM JAYENDRA** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (Horticulture)** in the subject of **VEGETABLE SCIENCE** has been approved by the student's advisory committee after *viva-voce* examination in collaboration with the external examiner.

( )

External Examiner

(V. S. Jagtap)
Research Guide and Chairman
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Member of Advisory committee:

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Associate Dean and Principal
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"Something is always better than nothing"

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Above all I bow my head before God, almighty whose blessing gave me the strength to make this a successful venture.

Place : Latur ***(Ban S. J.)***

Date : 30/05/2019 ***2017H/07ML***

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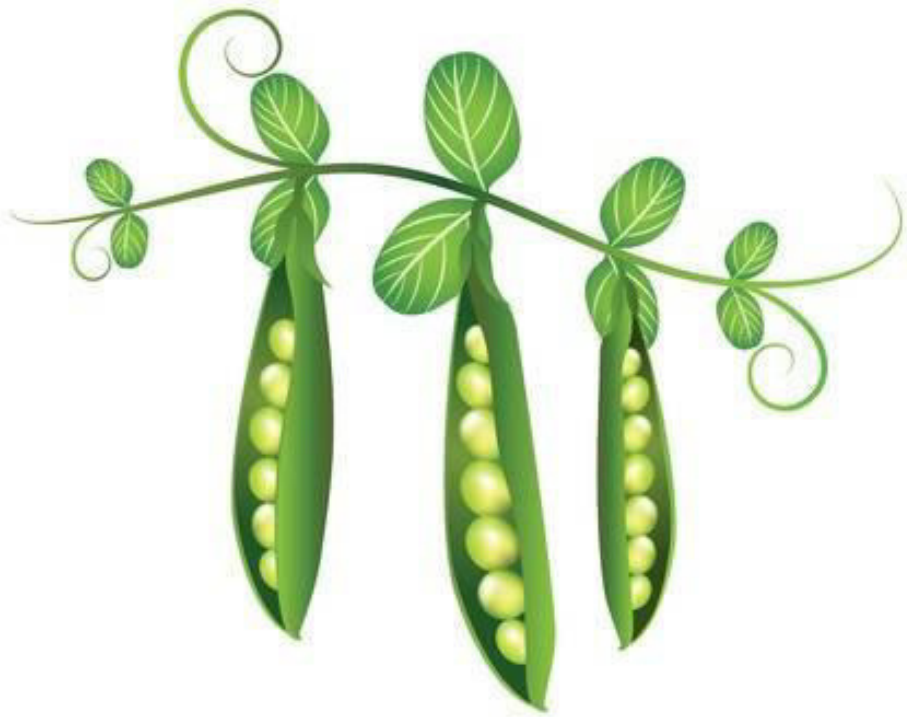
ABBREVIATIONS

&	-	And
$\overline{X}$	-	Mean
Σ	-	Summation
@	-	At the rate of
/	-	Per
%	-	Per cent
*	-	Significant at 5 per cent
**	-	Significant at 1 per cent
^{o}C	-	Degree centigrade
cm	-	Centimeter
cm^2	-	Square centimeter
CV	-	Coefficient of variation
CD	-	Critical Difference
d.f.	-	Degrees of freedom
et.al.	-	Et alia, and other
Fig.	-	Figure
FYM	-	Farm yard manure
g	-	Gram (s)
GA	-	Genetic advance
GCV	-	Genotypic coefficient of variation
ha	-	Hectare
ha^{-1}	-	Per hectare
i.e.	-	that is
kg	-	Kilogram (s)
kg^{-1}	-	Per kilogram
m	-	meter (s)
m^2	-	Square meter
max	-	Maximum
min	-	Minimum
NS	-	Non-significant

PCV	-	Phenotypic coefficient of variation
PLW	-	Physiological loss of weight
q	-	quintal (s)
r	-	Correlation coefficient
rg	-	Genotypic correlation
rp	-	Phenotypic correlation
RBD	-	Randomized Block Design
T.S.S.	-	Total soluble solid
viz.	-	Like



ABSTRACT

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VARIABILITY STUDIES IN PEA (*Pisum sativum* L.)

By

BAN SHYAM JAYENDRA

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2019

Research guide : Dr. V. S. Jagtap

Department : Horticulture

The present investigation entitled "Variability studies in pea (*Pisum sativum* L.)" was carried out during *rabi* season, 2017-18 at the Instructional Cum-Research-Farm, Department of Horticulture, College of Agriculture, Latur, VNMKV, Parbhani. The study was undertaken on twenty one genotypes of pea by using Randomized Block Design with two replications.

Pea sowing was done on 29th November 2017 at the spacing of 30 cm x 15 cm. In each treatment there were 111 plants of each genotype in a replication. Five plants were randomly selected from each treatment to record observations on twenty characters.

A wide range of variation observed among the genotypes for all the characters. The high genotypic coefficient of variation as well as phenotypic coefficient of variation were observed for number of primary branches per plant, green pod yield per hectare, green pod yield per plot, green pod yield per

plant, pod length, number of seeds per green pod and number of pods per cluster.

The high heritability were found for plant height, number of primary branches per plant, days to initiation of first flowering, days to 50 per cent flowering, days to first picking, number of pickings, number of clusters per plant, number of pods in cluster, pod length, number of seeds per green pod, physiological loss of weight, T.S.S. content, green pod yield per plant, green pod yield per plot and green pod yield per hectare. High values of genetic advance were recorded for number of primary branches per plant, green pod yield per hectare, green pod yield per plot, pod length, green pod yield per plant, number of seeds per green pod, number of pods per cluster, number of clusters per plant, plant height, number of pickings, days to first picking, days to initiation of first flowering and days to 50 per cent flowering.

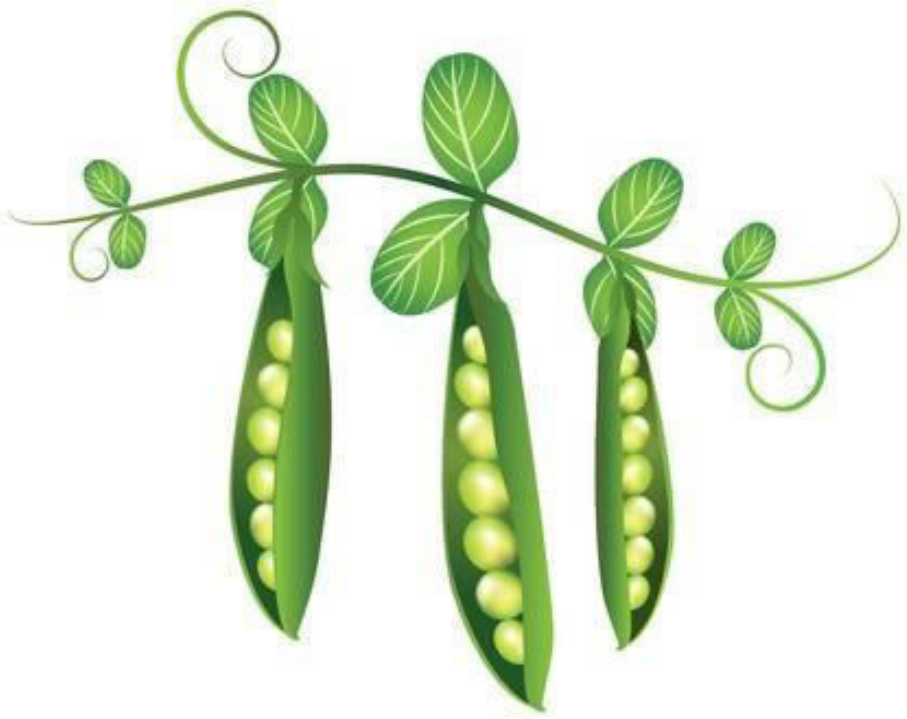
The green pod yield per plant exhibited positive and significant correlation with pod length, number of seed per green pod, green pod yield per plot and green pod yield per hectare at both genotypic and phenotypic levels.

Path coefficient analysis revealed that number of primary branches per plant, days to 50 per cent flowering, number of clusters per plant, number of pods per cluster, number of seeds per green pod and green pod yield per hectare were found positive and direct effect on green pod yield per plant, while plant height days to first flowering, days to first picking, number of pickings, pod length, crop duration and green pod yield per plot were found negative direct effect on green pod yield per plant.

The range and mean performance of yield, yield contributing components and quality traits revealed that, Phule Priya, Chandrapur Local and AP-3 were found superior than the rest of the genotypes. The genotype ‘AP-3’ was found early variety as observed from the characters days to first flowering, days to 50 per cent flowering and days to first picking. For the quality character, the genotype AP-3 and Chandrapur Local were found to be superior

for T.S.S. AP-1 and Parbhani Local were found for minimum physiological loss of weight.

Thus, it can be concluded that, from the present investigation the genotype Phule Priya, Chandrapur Local and AP-3 were superior for yield and yield contributing characters and for the quality characters AP-3, Chandrapur Local, AP-1 and Parbhani Local were found superior than the rest of genotypes. The genotypes Phule Priya, Chandrapur Local, AP-3, AP-1 and Parbhani Local were found superior in yield and quality contributing characters in the Marathwada region for commercial cultivation and for further improvement of pea through breeding programme.



INTRODUCTION

Chapter-I

INTRODUCTION

Pea (*Pisum sativum* L.) chromosome number 2n=14 one of the most important annual herbaceous legume crops of India, it is a popular as well as economically important winter vegetable crops. It is probably originated in south western Asia, possibly in North western India, Pakistan or adjacent areas of former USSR and Afghanistan. Pea belongs to genus *Pisum* of Leguminosae family. The genus *Pisum* contains following eight species *Pisum abyssinicum*, *P. sativum spp. arvense* (Field pea), *P. sativum spp. hortense* (Garden pea), *P. aucheri, P. elatius* (Ancestor of pea), *P. formosum, P. fulvum, P. syriacum* (Choudhary *et al.* 2000).

Pea is a very common nutritious vegetable grown throughout the world and it is the third important grain legume globally after beans and chickpea (Tyagi *et al*. 2012). Dry peas are used as livestock feed and human food, but recent reports have described field peas as potential ingredients for aquaculture feeds. The green pea seeds and immature pods have the best balance of vitamins. The immature seeds of green pods are also consumed after frying and in the preparation of vegetarian dishes. The consumption of green pod pea is very high compared to other vegetables. Large proportion of peas is processed (canned, frozen or dehydrated) for consumption in off season. Being a proteinous vegetable, it forms a valuable dish in the vegetarian diet. Dry peas are used as whole, split as dhal, roasted, parched, boiled and made into flour.

The nutritive value of green pea (per 100 g of edible portion) is protein 6.2 g, fat 0.4 g, carbohydrate 16.9 g, iron 1.2 mg, phosphorus 102 mg, vitamin C 27 mg, vitamin B_1 0.28 mg, vitamin B_2 0.11 mg, vitamin B_3 2.8 mg. (Duke 1981, Hulse 1994). It is an excellent food for human consumption taken either as a vegetable or in soup.

In India, pea is cultivated on 4,19,380 hectares with annual production of 39, 13,310 MT. Maximum area under pea is in the Uttar Pradesh followed

by Madhya Pradesh, Jharkhand, Himachal Pradesh, Punjab, Chhattisgarh, Uttarakhand, Haryana, Bihar and it is also cultivated in Andhra Pradesh, Odisha, Maharashtra and Rajasthan (Anon., 2018). In Maharashtra area and production is increasing day by day. The short winter season (November-January) has limitations in the productivity and the wide differences in day and night temperature during the growing season and also deteriorate the quality of produce. Early bulking varieties with high yield, reproducing to high day temperatures and maintaining good quality, would play an important role in increasing adaptability of this crop in Maharashtra.

The cultivars of pea are classified in three categories early season, mid season and late season depending upon their duration from sowing to maturity. The early varieties are now a day's getting more popularity because of better price in market and their short duration enables the farmers to fit it in multicropping system. The mid season varieties are capable of high yielding but these are sold at lesser price in the market if early and mid-season varieties are sown late in November, crops suffers from powdery mildew, which reduces the yield (Chet *et al*. 2010).

The inclusion of pea in crop rotation is very significant agronomical practice. The pea is good predecessor to other crops as it enriches the soil with the nodule bacteria which live in its root and it fixes nitrogen which becomes available to other plants.

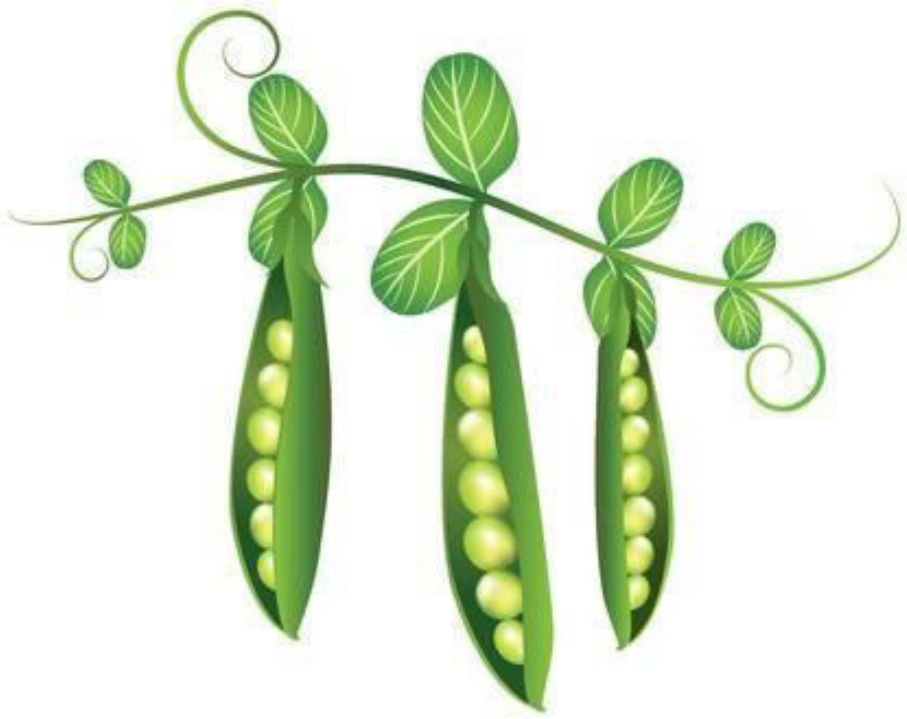
The extent of variability existed in the germplasm, which offers a better opportunity to select desirable genotype. The subsequent study of variability and inter-relations among the different characters helps to proceed further for effective selection. The basic information which have a plant breeder for producing new hybrids, the extent of variability should be required in a particular crop species. Larger variability ensures better chances of producing new derived varieties. The collection of germplasm from different sources provides raw material to the plant breeder. An access to wide variety of these

resources constitutes an essential component of successful crop improvement programmes. The genetic variability for all characters, among genotypes, correlations between different characters and quality characters needs to be studied for selection of better type of pea germplasm in Marathwada region. Considering the importance of pea it is needs to generate more information on nature and magnitude of variability in pea for yield and yield contributing characters which are present in germplasm pool. It is important basic prerequisite for starting breeding programme to identifying superior lines or varieties. Considering these things and above facts, the present investigation was undertaken with the following objectives.

1. To study genetic variability in pea germplasms.

2. To estimate the genotypic and phenotypic co-relation among the yield and its component characters.

3. To estimate direct and indirect effect of different component characters with respect to green pod yield.



REVIEW OF LITERATURE

Chapter-II

REVIEW OF LITERATURE

Pea (*Pisum sativum* L.) is one of the most important popular vegetable grown in India and abroad. It has been looked upon by many early workers including Mendel as an interesting genetic material. The published literature on evaluation of varieties for different characters, variability, estimation of genetic parameters like heritability and genetic advance in different quantitative characters is a prerequisite for a successful breeding programme. The review presented in this chapter under different heading.

2.1 Genetic Variability

2.2 Heritability and Genetic Advance

2.3 Correlation Analysis

2.4 Path Coefficient Analysis

2.1 Genetic Variability

Singh and Singh (2006) studied the thirty one advance lines including six varieties of pea for genetic variability and observed that the high GCV and PCV for seed yield per plant (26.11, 26.47) and pods per plant (22.98, 23.78). Moderate GCV and PCV were observed for plant height (19.30, 19.45), branches per plant (15.01, 18.01) and 100 seed weight (13.34, 14.02).

Kaur *et al.* (2007) studied that, the genetic variability in thirty five advance generation lines of pea and observed the GCV and PCV high for reaction to powdery mildew (50.02, 50.38), internodal length (45.48, 45.88), plant height (35.21, 35.88), green pod yield per plant (33.19, 33.38) and node at which first fertile pod develops (30.40, 32.19).

Nawab *et al.* (2008) studied the genetic variability, correlation and path coefficient of different traits conducted on twelve pea genotypes and found significant differences among genotypes for days to emergence (2.09), days to

50 per cent flowering (63.54), number of pods per plant (136.53), weight of pods per plant (293.48), pod length (0.60), number of seeds per pod (0.79), 100-seed weight (105.69) and green pod yield (8.67).

Choudhary *et al.* (2010) revealed that, the existence of considerable amount of genetic variability for all the characters studied except pod breadth. Number of pods per plant (44.51, 47.46), green pod yield per plant (48.55, 52.26) and plant height (43.92, 45.15) exhibited higher values of genotypic and phenotypic coefficient of variation in pea.

Singh *et al*. (2011) studied that, the genetic variability and association studies in segregating population of the field pea for grain yield and other yield component traits. Twenty F_2 field pea genotypes were observed GCV and PCV highest in case of grain yield per plant (18.11, 45.32), plant height (21.22, 23.87), number of clusters per plant (18.16, 33.05) and number of pods per plant (14.58, 33.17).

Tiwari and Lavanya (2012) studied variability and association among characters in field pea crosses in F_4 generation. Recorded high GCV and PCV for seed yield per plant (26.34, 28.53).

Basaiwala *et al.* (2013) reported that, the moderate to high GCV and PCV were recorded in field pea for pod bearing length (92.21, 92.69), plant height (48.02, 48.19), seed yield plant (26.98, 28.85), pods per plant (23.44, 24.55), harvesting index (17.98, 19.25), seeds per pod (6.99, 15.09) and hundred seed weight (8.16, 11.17).

Jaiswal *et al.* (2013) studied that, the genetic variability analysis in field pea observed high GCV and PCV were recorded for plant height (48.10, 48.42) and seed yield per plant (24.36, 33.69).

Pal and Singh (2013) studied on twenty five genotypes and reported that PCV higher as compared to GCV for all the characters of garden pea, The GCV and PCV were lowest for shelling percentage (3.16, 3.42) and highest for plant height (37.48, 37.50).

Siddika *et al.* (2013) studied the twenty six advanced lines of vegetable pea. Analysis of variance showed significant differences among the genotypes for all characters *viz.* days to fifty percent flowering (231.85), days to fifty percent harvesting (320.53), plant height (1557.27), pods per plant (4.90), pod length (245.96), pod breadth (9.60), 100 green seed weight (190.69) and seed yield per plant (9.51).

Ahmad *et al.* (2014) observed that, analysis of variance was highly significant for all characters studied except plant height (199.81). The highest genotypic and phenotypic co-efficient of variation were recorded for pod per plant (31.62, 31.99) followed by seed yield per plant (22.87, 23.65), cluster per plant (18.81, 20.21) and lowest was noted for days to maturity (1.88, 2.15).

Selvi *et al.* (2014) studied that, the genetic variability in twenty six varieties of pea. High GCV and PCV were observed for number of leaves at vegetative stage (21.53, 25.51), number of tendrils (56.37, 61.55), internodal length (21.61, 31.17), days to first flowering (21.01, 21.32), plant height at flowering stage (26.38, 31.56) and number of leaves at flowering stage (28.23, 34.50), number of seeds per pod (20.38, 21.71), individual pod weight (32.69, 33.55), individual seed weight (26.04, 29.13), pod coat weight (38.42, 39.58), leaf area (45.59, 45.98), 100 seed weight (32.62, 32.63) and shelling percentage (24.78, 25.44).

Singh and Lavanya (2014) evaluated fifteen field pea genotypes and observed GCV and PCV highest for number of pods per plant (29.05, 29.11) followed by plant height (25.43, 25.55) indicating the presence of high amount of variation and role of environment on the expression of these traits, while seed index (11.52, 11.38), seed yield per plant (11.12, 11.65) and number of seeds per pod (10.80, 11.06) had GCV and PCV of medium magnitude. The magnitude were low in GCV and PCV for pod length (7.98, 8.26), days to 50 per cent flowering (7.08, 7.11) and days to maturity (1.43, 1.49).

Kumar *et al.* (2015) studied that, variability and association of important characters with yield in garden pea. Analysis of variance showed significant differences among the genotypes for all the morphological characters under study. The genotypic and phenotypic coefficients of variation were high for total soluble solids (39.36, 44.79), total sugars (35.66, 40.59), pod yield per hectare (36.18, 39.67) and total phenols (35.99, 37.08).

Pandey *et al.* (2015) studied twenty six genotypes of garden pea. The phenotypic coefficient of variation was invariably higher than their corresponding genotypic coefficient of variation for most of the characters. High genotypic coefficient of variation as well as phenotypic coefficient of variation was observed for plant height (25.94, 25.58), pod yield per plant (25.28, 25.32), number of pods per plant (21.89, 24.22) and pod yield per hectare (20.34, 20.62).

Georgieva *et al*. (2016) conducted an experiment on genetic evaluation of five genotypes of forage pea. Analysis of variance showed significant differences among genotypes for the traits like pod width (0.013), seeds per plant (29.459), seed weight per plant (1.514) and 1000 seed weight (2525.669). High PCV and GCV observed for seeds per plant (11.22, 13.35) and seed weight per plant (15.23, 14.55). Moderate were observed for most of traits except pod length (3.20, 1.95) and pod width (4.92, 6.35).

Katoch *et al.* (2016) studied variability on forty five diverse garden pea recombinant inbreeds and three standard checks. They observed that the magnitude of PCV higher than GCV for all the traits. High PCV and GCV were recorded for protein content (20.82, 20.20), ascorbic acid (19.19, 17.85), plant height (17.90, 16.85) and pod yield per plant (20.26, 17.95).

Khandait *et al.* (2016) studied that, the genetic variability in fifteen diverse cowpea *(vigna unguiculata* L.) genotypes. The analysis of variance revealed highly significant variance for all the traits depicting greater variability in the existing material. The Phenotypic coefficient variance and Genotypic coefficient variance were highest for characters *viz*., number of

flower cluster per plant (49.79, 47.57), number of pods per plant (35.69, 34.24), number of pods per cluster (27.86, 25.44), number of branches at 30 DAS (24.94), pod weight (24.81, 23.79), and pod length (23.83, 23.62).

Tambolkar *et al*. (2016) studied the genetic variability in fifteen pea genotypes. The analysis of variance revealed highly significant variance for all the traits. The Phenotypic coefficient variance and Genotypic coefficient variance were high for characters viz., number of pickings (17.50, 14.34), plant height (25.13, 23.94), days to initiation of first flowering (22.80, 21.35), number of clusters per plant (39.88, 38.53), pod length (25.70, 22.95), number of seeds per green pod (22.71, 20.48), pod yield per plant (30.64, 28.53), pod yield per plot (33.93, 32.44) and pod yield per hectare (33.72, 32.67) where crop duration (10.38, 7.57) is moderate for PCV and low for GCV.

Thakur *et al.* (2016) studied on fifteen diverse garden pea genotypes and reported the GCV and PCV were found moderate for most of the traits except for pod width (7.70, 15.69).

Afreen *et al*. (2017) studied on fifteen traits in twenty one different genotypes of garden pea and observed that the GCV and PCV values were high for plant height (36.76, 39.35), seed weight per pod (22.14, 26.95) and number of primary branches per plant (21.54, 26.55).

Devi *et al.* (2017) evaluated forty three diverse pea genotypes. High PCV and GCV estimates for days to fifty per cent flowering (40.55, 40.25), days to marketable maturity (36.94, 36.75) and TSS (31.74, 28.25) revealed that sufficient variability is present among the genotypes.

Gautam *et al.* (2017) studied genetic variability, character association and path coefficient analysis were carried out for yield and yield contributing characters for twenty four diverse genotype of pea. The characters namely plant height (33.92, 33.55), weight of seeds per pod (29.03, 27.25), number of pods per plant (24.35, 23.07), number of branches per plant (27.58, 24.08) and pod

yield per plant (24.81, 24.47) showed high magnitude for phenotypic and genotypic coefficient of variation.

Gudadinni *et al*. (2017) studied twenty six genotypes of garden pea. High values of GCV and PCV were observed for characters *viz.,* pod yield per plant (20.84, 22.12) pod yield per plot (20.84, 22.12) and days to first flowering (21.14, 21.26) which indicates the presence of high genetic variation.

Santhosha *et al.* (2017) studied genetic variability in forty three cluster bean genotypes and observed high GCV and PCV for number of branches 90 DAS (60.17, 63.56), number of branches 45 DAS (55.64, 60.73), number of clusters per plant (27.29, 30.22), green pod yield per plant (24.69, 26.27), green pod yield per plot (20.10, 23.09), green pod yield per hectare (20.10, 23.09) and number of pods per cluster (21.32, 26.66).

Sharma *et al*. (2017) studied genetic variability and correlation analysis in twenty genotypes of pea. GCV and PCV were high for primary branches per plant (23.45, 28.27) followed by seed yield per plant (18.52, 23.52) and pod per plant (18.81, 22.94).

Srinivas *et al*. (2017) studies on genetic variability, heritability and genetic advance were carried out with thirty genotype of cowpea [*Vigna unguiculata* (L.) Walp] for 16 traits. Significant differences among the genotypes for all the characters indicating existence of ample variability in the experimental material for all the characters. High to moderate range of variation was observed for important yield components. The estimate of genotypic and phenotypic coefficient of variation were high for number of branches per plant, pod yield per plot, total number of pods per plant, number of seeds per pod.

Toppo *et al.* (2017) was conducted an experiment to estimate the variability and character association of different qualitative characters on seed yield of twenty nine field pea genotypes. The analysis of variance revealed that the sufficient variability was present in the material studied for almost all the

qualitative characters. Among the different quality parameters the moderate genotypic and phenotypic coefficient of variation ware recorded for swelling index (10.069, 14.293).

Ali *et al.* (2018) studied thirty four and forty eight genotypes of garden pea in *kharif* and *rabi* seasons, respectively, during 2017. Genotypes were grown in RBD design with two replications and revealed that GCV and PCV were high for days to first flowering, plant height, days to 50 per cent flowering (during both seasons), pod yield (during *kharif*), weight of hundred fresh and dry seeds (during *rabi*).

Barcchiya *et al.* (2018) studied twelve genotypes of pea. Analysis of variance showed wide range of variability was observed for days to 50 per cent flowering (443.046), days to maturity (415.610), plant height at maturity (1029.900), branches per plant (3.205), effective node per plant (1.703), pods per plant (26.179), pod length (1.588), seeds per pod (1.799), green pod yield per plant (522.770), weight of hundred seed (460.373), seed yield per plant (166.772), biological yield per plant (0.582), harvest index (26.244), shelling percent (84.132), protein (11.758) and TSS (8.291).

Gupta *et al*. (2018) studied on genetic variability were carried out among twenty genotypes of pea. GCV and PCV were high observed for plant height (27.62, 27.65), number of pods per plant (21.27, 21.32) and length of first fruiting node (21.13, 21.17).

Kaur *et al.* (2018) conducted an experiment on genetic variability with ten diverse genotypes of garden pea. The phenotypic coefficient varied from 4.44 % (pod per plant) to 48.80% (pod yield per plant). The genotypic coefficient of variation varied from 1.48% (number of pods per plant) to 31.97 % (pod weight).

Lal *et al.* (2018) studied that, the one hundred twenty field pea (*Pisum sativum* L. *var. Arvense*) genotypes was evaluated and observed higher GCV (30.414) was recorded for number of seeds per pod followed by seed yield per

plant (28.874). Higher PCV (35.597) was recorded for plant height followed by number of seeds per pod (30.460).

Thouseem *et al*. (2018) studied genetic parameters in seed yield components of cowpea and observed the high GCV and PCV were observed for pod weight (47.73, 52.12) followed by number of pod clusters per plant (24.99, 31.36), seed yield per plant (24.43, 31.72), 100 seed weight (24.07, 24.13), pod length (23.66, 23.81), number of pods per cluster (20.86, 21.32) and number of pods per plant (20.66, 27.21).

2.2 Heritability and Genetic Advance

Heritability in broad sense is the ratio of genotypic variance to total variance in non-segregating population. Thus, heritability denotes the proportion of phenotypic variance that is due to genotype which is heritable (Hanson *et al*., 1956). The estimates of heritability are influenced by various factors, *viz*. type of genetic material, sample size, sampling method, conduct of experiment, method of calculation and effect of linkage (Fehr, 1987). Selection of a trait should fairly be easy if heritability of that trait is very high. This is because there would be a close correspondence between genotype and phenotype due to a relatively smaller contribution of environment to the phenotype. High heritability indicates the existence of additive genes in the expression of traits that could be easily exploited (Bharadwaj *et al*., 2007) and high broad sense heritability estimate indicate genetic variances with lesser influence of the environment and the potential effectiveness of selection of the hybrids for traits of interest (Allard, 1960). Nevertheless, for a trait with low heritability, selection may be considerably difficult or virtually impractical due to the masking effect of the environment on the genotypic effects (Singh, 1991).

Genetic advance is directly related with the heritability as it gives an idea about the expected genetic changes on account of selection applied for a particular trait. Heritability often fails to provide the estimates of absolute

variability. It is thus important to use heritability values with genetic advance which will give expected gain based on selection.

Singh and Singh (2006) reported that the estimates of heritability in the broad sense were high for all characters except number of days to flowering (56.70) and pod length (46.70) in garden pea. High expected genetic advance coupled with high heritability estimates were predicted for seed yield per plant (3.20, 49.76), number of pods per plant (90.80, 45.99) and plant height (95.70, 39.60) indicating the low variation due to the environment.

Kaur *et al.* (2007) estimated the heritability varied from number of pods per plant (43.46) to peroxidase activity (99.97) in pea. High heritability estimates were recorded for all the characters studied except for number of pods per plant (43.46). The genetic advance as percentage of mean was high for reaction to powdery mildew (l02.31), internodal length (92.87), plant height (71.15) and green pod yield per plant (67.98).

Nawab *et al.* (2008) studied the heritability and genetic advance in garden pea and observed that the green pod yield per plot (84.27, 23.49) showed high heritability and high genetic advance per cent of mean. Where, weight of pods per plant (80.37, 13.57) showed high heritability and moderate genetic advance per cent of mean.100-seed weight (90.86, 7.37) and number of pods per plant (78.62, 3.00) showed high heritability and low genetic advance per cent of mean.

Choudhary *et al.* (2010) revealed that, the high estimates of heritability and genetic advance were observed for plant height (94.60, 88.01), number of pods per plant (88.00, 86.01), green pod yield per plant (86.30, 92.89), intermodal length (84.60,64.41),node to first pod set (80.90, 33.37), pod length (76.20, 22.85) and number of primary branches per plant (69.00, 62.56).

Yadav *et al.* (2010) observed that, the heritability was maximum in pea genotypes for plant height (96.70) followed by seed yield per plant (96.20), 100 seed weight (95.90) and seeds per pod (90.60). The genetic advance was

maximum for seed yield per plant (72.00) followed by pods per plant (55.39) and 100 seed weight (47.96). The minimum genetic advance value was recorded for days to maturity (10.41).

Singh *et al*. (2011) observed the high heritability in days to maturity (90.19), plant height (79.09), pod length (66.83) and 100 seed weight (61.96). High genetic advance was recorded in plant height (33.88), number of clusters per plant (21.59), 100 seed weight (20.79) and pod length (20.32) in field pea.

Tiwari and Lavanya (2012) recorded high heritability for days to 50 per cent flowering (94.94) and days to maturity (92.80). Respectively in addition they recorded high genetic advance for seed yield per plant (50.11) and plant height (23.61) in field pea.

Basaiwala *et al.* (2013) reported that, high heritability coupled with high genetic advance were observed for plant height (99.30, 98.58), pods per plant (91.2, 46.08), harvest index (87.30, 34.16) and seed yield plant (87.40, 51.98) in field pea.

Jaiswal *et al.* (2013) reported high heritability was recorded for plant height (99.00), followed by days to 50 per cent flowering (95.00), days to maturity (70.00), number of seeds per pod (65.00), pod length (64.00) and seed index (63.00). Maximum genetic advance as per cent of mean was recorded for plant height (98.42), followed by seed yield per plant (36.29), number of pods per plant (27.23) and number of seeds per pod (27.22).

Pal and Singh (2013) revealed that, the high heritability coupled with high genetic advance recorded in plant height (99.90, 77.14), days to first flowering (98.20, 38.58), days to fifty per cent flowering (99.60, 37.11), number of branches per plant (97.90, 46.52) number of pods per plant (97.10, 27.67) and green pod yield per plant (99.60, 54.25) in garden pea.

Pallavi *et al.* (2013) the results revels that, heritability (broad sense) ranged between 99.97% to 22.50%. Highest heritability was recorded for days of flowering as (99.97%) and lowest in number of seed per pod (22.50%) in

pea. The genetic advance as percent of the mean was height in 100 seed weight (29.28%) followed by number of primary branches per plant (26.94%) and lowest in number of per pod (6.9%).

Siddika *et al.* (2013) studied that, high heritability associated with high genetic advance ware observed for plant height (94.79, 59.76), pod length (90.60, 25.81) and seed yield per plot (63.08, 53.03) in pea.

Ahmad *et al*. (2014) studied on twelve genotypes of garden pea and revealed that high heritability coupled with high genetic advance as percent of mean were recorded for pod per plant (98.00, 64.37) followed by seed yield (94.00, 45.56) and moderate were observed for plant height (35.00, 13.80).

Selvi *et al.* (2014) studied that, the high heritability and high expected genetic advance were observed in pea for number of leaves (71.25, 37.44), number of tendrils per plant (83.90, 106.38), days to first flowering (97.07, 42.64), plant height at flowering stage (69.87, 45.43), number of leaves at flowering stage (66.94, 47.58), days to fifty per-cent flowering (95.18, 39.88), pod length (83.15, 28.58), number of seeds per pod (88.14, 39.42), individual pod weight (94.95, 65.62), individual seed weight (79.92, 47.97), pod coat weight (94.17, 76.81), leaf area (98.29, 93.11), 100 seed weight (94.90, 49.74) and pod yield per plant (99.94, 65.18).

Singh and Lavanya (2014) observed the number of pods per plant (99.00, 59.60), plant height (99.00, 52.16), seed index (95.00, 23.09), seed yield per plant (91.00, 21.88) and seeds per pod (95.00, 21.74) showed high estimates of heritability along with high estimates of genetic advance as per cent of mean in field pea.

Kumar *et al.* (2015) revealed that, high heritability coupled with high to moderate genetic gain observed in garden pea for pod yield per plot (83.20, 67.87), pod yield per hectare (83.20, 67.99), node at which the first flower appear (80.50, 27.34), number of pods per plant (94.40, 42.03) and total Phenols (94.20, 72.46) which indicated that these characters are under the

control of additive genes and offer more scope for reliable and effective selection.

Pandey *et al.* (2015) reported that, high heritability coupled with high genetic advance as percent of mean was observed in garden pea for plant height (99.00, 53.36), total soluble solids (99.00, 53.36) and pod yield per plant (99.00, 51.99).

Georgieva *et al*. (2016) observed the high heritability coupled with high genetic advance for number of seeds per plant (81.00, 23.20), seed weight per plant (77.00, 29.94) and seed yield (61.00, 33.30).

Katoch *et al*. (2016) revealed that, pod yield per plant (78.50, 22.28) and plant height (88.60, 23.82) exhibited high heritability associated with high genetic advance and indicated the additive gene action for their expression and respond better to selection for garden pea.

Khandait *et al.* (2016) observed that, the high heritability estimates for pod length (98.29%), number of pods per plant (92.04%), pod weight (91.98%), number of flower clusters per plant (91.28%) and pod width (91.78%). The highest estimate of genetic advance as percentage of mean was recorded for number of flower clusters per plant (93.63%) followed by number of pods per plant (67.67%), pod length (48.24%), number of pods per cluster (47.84%), pod weight (47.01%), pod width (38.17%), number of flowers per cluster (36.49%), number of branches after 30 days of sowing (21.68%), pod yield per plot (21.55%), pod yield per ha (21.55%) and pod yield per plant (20.86%) in cowpea.

Tambolkar *et al*. (2016) studied the genetic variability, heritability and genetic advance in fifteen pea genotypes. The high heritability estimates with high genetic advances were obtained for plant height, number of pickings, pod yield per plant, pod yield per plot and pod yield per hectare.

Thakur *et al.* (2016) reported that, high heritability coupled with high genetic advance were observed for plant height (98.59, 57.63), pod length

(93.99, 41.74), number of grains per pod (91.42, 41.40), shelling percentage (89.13, 31.80) and number of pods per plant (81.07, 41.26) in garden pea.

Afreen *et al.* (2017) revealed that, high heritability and moderate genetic gain was observed for characters like days to 50 per cent flowering (94.41, 26.74), days to 100 per cent flowering (94.69, 25.69), length of garden pea pods (90.84, 22.42) and width of garden pea pods (94.41, 26.74).

Devi *et al.* (2017) observed that, high heritability coupled with high genetic gain was observed in pea for days to fifty per cent flowering (98.53, 82.31), days to marketable maturity (98.99, 75.32) and 100-pod weight (83.54, 41.96) indicating prominent role of additive gene effect.

Gautam *et al.* (2017) studied that, the heritability and genetic advance in pea were high for first flowering (98.21, 40.86), fifty per cent flowering (98.52, 40.70), days to first pod initiation (98.88, 41.74), plant height (97.83, 68.36) and pod yield per plant (97.26, 49.72).

Gudadinni *et al.* (2017) recorded high heritability for all characters except protein content (53.36) which was medium heritability. High heritability coupled with high genetic advance observed for the traits *viz.*, pod yield per plant (88.75, 40.44), pod yield per plot (88.75, 40.44), plant height (99.23, 39.58) and days to first flowering (98.95, 43.33) in garden pea.

Khan *et al.* (2017) reported that, the hundred seed weight had the highest heritability in pea (95.97). Genetic advance as per cent of mean was highest for hundred seed weight (75.26).

Santhosha *et al.* (2017) reported the high heritability coupled with high genetic advance were observed for number of branches 90 DAS (89.59, 117.32), number of branches 45 DAS (83.93, 0.5.00), green pod yield per plant (88.29, 47.78), green pod yield per plot (75.79, 36.06), green pod yield per hectare (75.79, 36.06) and number of pods per cluster (63.92, 35.13).

Sharma *et al.* (2017) observed moderate heritability were found in seed yield per plant (0.71), primary branches per plant (0.69), seed per pod (0.68)

and pods per plant (0.67). Genetic advance as percentage of mean were found for primary branches per plant (40.07), pods per plant (31.77) and seed yield per plant (30.05) in pea.

Srinivas *et al*. (2017) studies on genetic variability, heritability and genetic advance were carried out with thirty genotype of cowpea [*Vigna unguiculata* (L.) Walp] for 16 traits. High heritability along with high genotypic co-efficient of variation was observed for number of branches per plant, pod yield per plot (kg), total number of pods per plant, number of seeds per pod.

Toppo *et al.* (2017) observed among the quality parameter, high heritability coupled with high genetic advance were not recorded for any quality character i.e. protein content (59.109, 6.591), dal recovery (87.717, 4.165), swelling capacity of seed (48.764, 5.621) and swelling index (49.632, 14.613) in pea.

Ali *et al.* (2018) reported high heritability coupled with high genetic advance as per cent of mean were observed for plant height, days to first flowering, days to fifty per cent flowering, number of branches per plant (during both seasons), pod yield (during *kharif*), pod length, weight of hundred fresh and dry seeds (during *rabi*).

Barcchiya *et al.* (2018) estimated that, the high heritability coupled with high genetic advance as percent of mean has been reported for days to days to fifty per cent flowering (96.37, 43.76), days to maturity (98.07, 24.63), plant height at maturity (99.00, 63.61), pods per plant (87.02, 33.12), green pod yield per plant (96.96, 38.82),shelling percent (95.12, 21.79), weight of hundred seed (98.19, 46.92) and seed yield per plant (97.65, 28.46).

Gupta *et al.* (2018) observed that, the high heritability coupled with high genetic advance as per cent of mean for plant height (99.80, 56.84), number of pods per plant (99.57, 43.73), length of first fruiting node (99.61, 43.44), pod yield per plant (99.57, 38.62), pod yield per hectare (99.56, 38.61), days to 50

per cent flowering (98.00, 33.25) and number of seeds per pod (81.78, 24.28) in pea.

Kaur *et al.* (2018) the heritability estimates were observed very high for number of leaves at 90 DAS (99.00), days to first picking (99.00), days to first flowering (97.00) and plant height at 90DAS (94.00). The genetic advance as per cent of mean ranged from -0.27% for number of pods per plant to 43.3 % for pod weight. The moderate estimate was obtained for pod weight (43.3), pod yield per plant (42.84), total yield per hectare (36.02), days to first picking (35.18) and number of leaves at 90 DAS (31.01) in garden pea.

Thouseem *et al*. (2018) studied genetic parameters in seed yield components of cowpea and observed the high heritability coupled with high genetic advance for days to 50 per cent flowering (86.45, 29.28), length of main stem (73.34, 28.62), number of clusters per plant (63.50, 41.02), number of pods per cluster (95.73, 42.04), pod weight (83.86, 90.05), pod length (98.74, 48.44), pod girth (98.94, 38.43), number of seeds pod (92.83, 24.55) and 100 seed weight (99.41, 49.43).

2.3 Correlation Analysis

The correlation coefficient analysis measures the mutual relationship between various characters and it determines the component traits on which selection can be relied upon the effect of improvement. The genotypic correlation coefficients include hereditary influence and provide real association between two characters and may be useful in selection, whereas the phenotypic correlation coefficients include both hereditary and environmental influences, thus, indicating the extent of relationship between two characters (Johnson *et al.*, 1955). Some of the reviews cited below related to this are given below.

Singh and Singh (2006) reported that, the seed yield per plant had significant and positive association with number of pods per plant (0.821),

plant height (0.495), harvest index (0.481) and number of grains per pod (0.461) in garden pea.

Gupta *et al*. (2007) studied correlation analysis for yield and its components in garden pea were conducted using eighty three genotypes. Green pod yield per plant exhibited significant and positive correlation with pod length (0.435, 0.269), 100-green pod weight (0.424, 0.387), 100- green seed weight (0.275, 0.232), early yield plant (0.266, 0.253), number of green pods per plant (0.792, 0.721) and number of primary branches per plant (0.422, 0.364). Negative significant correlation with days to first flowering (-0.345, -0.317), days to first green pod picking (-0.264, -0.243) and plant height (-0.273, -0.247).

Kaur *et al.* (2007) revealed that, highly significant and positive correlation were observed between green pod yield per plant and number of pods per plant, number of seeds per pod, total phenol content, pod length, crude protein content, days taken to flower initiation, number of branches and shelling percentage, suggesting that these are the major yield contributing characters in pea.

Nawab *et al.* (2008) revealed that, in general, estimates of genotypic correlation coefficient was higher than the corresponding phenotypic correlation coefficient. Green pod yield per plot showed positive and significant correlation with number of seeds per pod (0.485, 0.428) and weight of pods per plant (0.409, 0362) at genotypic and phenotypic levels. A strong association was observed between pod length and number of seeds per pod (0.734, 0.713). The results suggested that these traits could be considered as a major green pod yield contributing characters in garden peas.

Yadav *et al.* (2010) studied correlation and coefficient in pea. The seed yield per plant showed significant and positive correlation with pods per plant (0.505, 0.462), 100-seed weight (0.378, 0.393) and plant height (0.358, 0.384) at genotypic and phenotypic levels.

Singh *et al*. (2011) observed that, the significant positive correlation between plant height (0.68), number of primary branches per plant (0.99), number of pods per plant (0.68), number of clusters per plant (0.33) and 100 seed weight (0.66) with seed yield per plant in field pea.

Pal and Singh (2012) studied correlation coefficient analysis in twenty five genotypes of garden pea carried out in green pod yield per plant had positively and highly significant with plant height (0.369, 0.353), days to first flower emergence (0.452, 0.451), days to 50 per cent flower emergence (0.448, 0.449), days to first pod set (0.460, 0.461), days to maturity of edible green pod (0.457, 0.459) number of primary branches per plant (0.409, 0.103), number of seeds per pod (0.364, 0.353) and number of pods per plant (0.957, 0.607) at phenotypic and genotypic levels.

Sharma and Sharma (2012) studied that, the correlation in thirty six garden pea genotypes and observed the green pod yield per plant had a strong positive true relationship with green pods per hectare (0.918, 0.922), number of green pod pickings (0.718), 100 pod weight (0.922, 0.956), pod length (0.888, 0.890), number of seeds of per pod (0.856, 0.860), number of primary branches (0.831, 0.837), plant height (0.720, 0.727), ascorbic acid content (0.585, 0.593) and shelling percentage (0.432, 0.431) at both phenotypic and genotypic levels.

Tiwari and Lavanya (2012) carried out an experiment to study association among yield traits in field pea crosses in F4 generation and concluded that the characters like number of branches per plant (0.93), pod length (0.77), pods per plant (0.68), number of seeds per pod (0.56) and seed index (0.55) recorded high positive and significant correlation with seed yield.

Basaiwala *et al.* (2013) correlations were estimated to estimate the strength of association between yield and ten other characters. Seed yield plant was positive and significantly correlated with plant height (0.664, 0.622), pod bearing length (0.524, 0.489), pods per plant (0.926, 0.847) and seed setting per cent (0.500, 0.432) at both genotypic and phenotypic levels, while seeds per pod (0.534) and harvest index (0.390) only at genotypic level in field pea.

Siddika *et al.* (2013) studied that, twenty six advanced lines of vegetable pea and observed significant positive genotypic and phenotypic correlation between seed yield per plant and days to fifty per cent harvest (0.588, 0.462), pod length (0.701, 0.551) and pod breadth (0.656, 0.512).

Jaiswal and Lavanya (2014) reported positive and significant correlation was found between grain yield and plant height (0.930). Days to 50 per cent flowering (-596, -427), days to maturity (-0.533. -0.393) and number of seeds per pod (-0.691, -0.481) found negative significant correlation at both genotypic and phenotypic levels.

Rai and Dharmatti (2014) studied the correlation and path analysis for cluster bean vegetable pod yield and reported positive associations of vegetable pod yield per hectare with plant height (0.315, 0.309), pods per cluster (0.322, 0.298), pods per plant (0.443, 0.389) and pod yield per plant (0.905, 0.787) at genotypic and phenotypic levels respectively.

Singh and Lavanya (2014) evaluated fifteen field pea genotypes and observed seed yield per plant recorded positive and significant correlation with number of pods per plant (0.585, 0.561) and plant height (0.427, 0.404) at both genotypic and phenotypic levels.

Kumar *et al.* (2015) observed that, pod yield was positively correlated with number of pods per plant (0.845, 0.931), pod length (0.902, 0.915), number of seeds per pod (0.898, 0.923), shelling percentage (0.894, 0.927) and total sugar (0.922, 0.997) at both genotypic and phenotypic levels.

Pandey *et al.* (2015) reported that, in garden pea significant correlation association of yield per hectare with pod yield per plant (0.84, 0.82), total soluble solids (0.72, 0.70), number of pods per plant (0.74, 0.62) and days to fifty per cent flowering (0.67, 0.65) at genotypic and phenotypic levels respectively.

Tofiq *et al.* (2015) studied that, the simple correlation coefficient among yield and yield contributing characters in pea. It was observed that the

character weight of seeds per plant is positive and significantly correlated with number of pods per plant (0.857), weight of pods per plant (0.839), biological weight per plant (0.694) and harvest index (0.505) respectively.

Georgieva *et al.* (2016) observed that, the seed yield was positively and significantly correlated with 1000 seed weight (0.960) and pod stem (0.945) in forage pea.

Katoch *et al.* (2016) reported that, the pod yield per plant showed a positive and significant correlation with number of pods per plant (0.817), pod length (0.0318) and number of seeds per pod (0.213).

Patel *et al*. (2016) studied correlation and path analysis in cowpea. Association analysis between green pod yield per plant and other eleven quantitative characters revealed that green pod yield per plant was highly significant and positively correlated with pod length (0.456, 0.312) and sugar content (0.269, 0.217) at both genotypic and phenotypic level.

Thakur *et al.* (2016) revealed that, significant positive association of pod yield per plant in garden pea was observed with number of pods per plant (0.604, 0.560), pod length (1.012, 0.530), pod width (0.830, 0.696) and number of grains per pod (0.423, 0.338) at both phenotypic and genotypic levels.

Devi *et al*. (2017) The phenotypic and genotypic correlation coefficients among different characters showed that pod yield per plot had positive association with number of pods per plant (0.764, 0.524), pod length (0.493, 0.397), number of seeds per pod (0.496, 0.400), shelling per cent (0.572, 0.412), days to marketable maturity (0.419, 0.377) and TSS (0.717, 0.542) in pea.

Gautam *et al.* (2017) character association studies revealed that pod yield per plant exhibit positive and highly significant correlation with number of pods per plant (0.760, 0.721), days to first flowering (0.530, 0.520), days to fifty percent flowering (0.511, 0.501) and number of branches per plant (0.473, 0.410) in pea.

Khan *et al.* (2017) studied that, the pod length (0.280, 0.179), hundred seed weight (0.426, 0.306), pods per plant (0.191, 0.562) and seeds per plant (0.330, 0.657) showed significant and positive genotypic as well as phenotypic correlation with seed yield per plant in pea.

Pandey *et al.* (2017) revealed that, number of green pods (0.637, 0628), T.S.S (0.388, 0.458), number of nodes per plant (0.325, 0.363), length of pod (0.241, 0.252) and plant height (0.209, 0.223) significantly and positively correlated with green pod yield per plant at both phenotypic as well as genotypic levels while negatively correlated with width of pod (-0.303, -0.797).

Sharma *et al*. (2017) reported that, the significant and highly positive correlation with seed yield per plant at both genotypic and phenotypic levels for number of pods per plant (0.825, 0.859) and number of seeds per pod (0.478, 0.405).

Srinivas *et al.* (2017) correlation study was under taken on thirty genotypes of cowpea and observed phenotypic and genotypic correlation coefficient for pod yield per plot was significantly and positively correlated with number of branches per plant (0.765), number of nodes (0.552), pod length (0.396), number of seeds per pod (0.281), number of cluster per plant (0.550), number of pods per plant (0.547), number of pods per cluster (0.524), plant height (0.437) and protein content (0.287). However, days for 50 per cent flowering (-0.208) showed significantly and negatively correlated with pod yield per plot.

Toppo *et al.* (2017) studied the correlation analysis in pea and it revealed that seed yield per plant exhibited a significant positive association with protein (0.317) at genotypic level only.

Kumawat *et al*. (2018) studied correlation in twenty genotypes of pea (*Pisum sativum* L.) and observed that the green pod yield per plant was positively and significantly correlated with pod length (0.395), pod weight (0.469) and number of grains per pod (0.393).

Lal *et al.* (2018) studied that, the correlation analysis in field pea and observed seed yield per plant exhibited highly significant and positive correlation with harvest index (0.906), seeds per pod (0.795), pod length (0.724) and 100-seed weight (0.381).

Palve *et al*. (2018) studied characters like number of pods per plant (0.8327, 0.8376), number of pods per cluster (0.6325, 0.6375), primary branches per plant (0.5568, 0.5292), number of cluster per plant (0.5334, 0.5121), pod length (0.5236, 0.5072), pod diameter (0.5016, 0.4831), average pod weight (0.4099, 0.3914) and leaf area (0.3556, 0.3394) highly significant positive correlation with pod yield per plot at both genotypic and phenotypic levels.

Shrivastava *et al.* (2018) observed one hundred and thirteen field pea genotypes including three check varieties. Seed yield per plant exhibited highly significant and positive correlation with 100 seed weight (0.377), number of pods per plant (0.352), harvest index (0.327), number of seeds per pod (0.326) and biological yield (0.282).

Singh *et al.* (2018) studied that, the one hundred and twenty field pea genotypes including forty indigenous and ten exotic collections of pea and four check varieties and recorded strong and positive association of seed yield per plant observed with harvest index (0.463), biological yield per plant (0.942), plant height (0.342), number of seeds per pod (0.255), number of primary branches per plant (0.375) and number of pods per plant (0.320).

Diwaker *et al.* (2019) studied correlation in cowpea and observed that at genotypic and phenotypic level maximum significant and positive correlation was shown by pod yield quintal per hectare (0.999) with pod yield per plant followed by pod length (0.963) and negative significant correlation were observed for plant height at 45 days (-0.280), number of primary branches per plant (-0.276) and days to first picking (-0.244).

Rahman *et al*. (2019) studied correlation in eleven genotypes of garden pea and reported the number of pods per plant (0.987, 0.905), plant height

(0.967, 0.738), number of seeds per pod (0.930, 0.877), pod length (0.869, 0.781), shelling percentage (0.710, 0.394), days to first picking (0.626, 0.545) and days to 50 per cent flowering (0.609, 0.426) had significant and strongly positive correlation with pod yield per plant both at genotypic and phenotypic levels.

2.4 Path Coefficient Analysis

Path coefficient is the measure of direct influence of one variable upon another which permits the separation of correlation coefficient into component of direct and indirect effects. The term path coefficient was coined by Wright (1921) while Dewey and Lu (1959) were the first to introduce this technique in plant breeding. The use of path coefficient analysis requires a cause and effect situation among variables. Path analysis helps in partitioning correlation coefficients into direct and indirect effects of component characters in yield. Wright (1921) provided effective means of finding out direct and indirect causes of association and permits a critical examination of the specific forces acting to produce a given correlation and measures the relative importance of each casual factor through path analysis technique.

Kaur *et al.* (2007) results of path analysis revealed that direct effects were highest for number of pods per plant, node at which first fertile pod develops, number of branches, number of seeds per pod and pod length which can serve as reliable variable for selection.

Nawab *et al.* (2008) revealed that, 100-seed weight (3.16), number of pods per plant (2.99), number of seeds per pod (2.14) and days to 50 per cent flowering (1.48) exhibited maximum positive direct effect on green pod yield per plot. It indicated that these are main contributors towards yield in garden pea.

Yadav *et al.* (2010) path coefficient was calculated taking seed yield per plant as dependent variable and rest of eight characters as independent variables. The direct and indirect effect of yield contributing traits on yield

revealed that the maximum positive direct effect was exhibited by pods per plant (0.702) followed by 100-seed weight (0.459), days to maturity (0.130) and pod length (0.058). While days to flowering (-0.133), number of primary branches (-0.085) and plant height (-0.062) had negative direct effect on pea yield.

Singh *et al*. (2011) studied path analysis in field pea and observed number of pods per plant (1.229) depicted maximum direct effect on seed yield followed by plant height (0.654) and 100 seed weight (0.640). Days to emergence (-0.108), days to flowering (-0.222), days to maturity (-0.357) and number of clusters per plant (-1.030) had negative direct effect on grain yield.

Sharma and Sharma (2012) studied the path analysis in thirty six field pea genotypes and observed that the green pod yield per hector exerted the highest positive direct effect at genotypic level on number of pods per plant (0.528) followed by 100 pod weight (0.433), green pod yield per plant (0.222) and pod length (0.073).

Tiwari and Lavanya (2012) studied path analysis in field pea and observed that the days to maturity (0.46, 0.36), plant height (0.40, 036) and pod length (0.23, 0.13) showed high positive direct effect on seed yield at genotypic and phenotypic levels.

Pal and Singh (2012) studied path analysis in twenty five garden pea genotypes and observed that days to maturity of green pods had highest positive and direct effect (38.052) on green pod yield per plant followed by pod width (6.466), number of primary branches per plant (4.666), days to 1st flower emergence (2.98), shelling percentage (1.433) and number of seeds per pod (0.837).

Basaiwala *et al*. (2013) studied path coefficient analysis in thirty two genotypes of field pea and observed that the plant height (0.611), pods per plant (1.351) and seed setting percent (0.255) had positive direct effect and exhibited significant positive correlation with seed yield.

Siddika *et al.* (2013) studied that, twenty six advanced lines of vegetable pea and observed path coefficient analysis in days to fifty percent flowering (0.289), days to fifty percent harvest (0.289), pod length, pod per plant (0.133), and 100 seed weight (0.128) had positive direct effect on seed yield per plant.

Rai and Dharmatti (2014) genotypic path analysis shows that yield per plant exhibited positive direct effect (1.138) and had strong positive association with yield per hectare (0.905). The positive indirect effects were through days to 50 per cent flowering (0.015), pods per cluster (0.035) and pod breadth (0.046) in cluster bean.

Singh and Lavanya (2014) studied path analysis in field pea. Pods per plant (0.313, 0.345) recorded positive direct effects on seed yield per plant followed by days to 50 per cent flowering (0.392, 0.294) and plant height (0.071, 0.072), while the greater negative direct effects on seed yield per plant were exhibited by pod length (-0.413, -0.361) followed by day to maturity (-0.234, -0.137), number of seeds per pod (-0.086, -0.039) and 100 seed weight (-1.552, -0.048) at genotypic and phenotypic levels.

Kumar *et al.* (2015) the path coefficient analysis in the present studies revealed that the characters under study contributed 99.99 per cent variability of pod yield per hectare. Out of all characters studied, pod yield per plot (1.050) had maximum positive direct effect on pod yield per hectare followed by number of pods per plant (0.318) and number of seeds per pod (0.313), while, in negative direction maximum direct effect of shelling percentage (-0.318).

Tofiq *et al.* (2015) studied that, the path analysis between weight of seeds per plant and other characters in pea. The character biological weight per plant (0.630) and harvest index (0.456) exhibited the maximum positive direct effect on weight of seeds per plant.

Katoch *et al.* (2016) revealed that, the highest positive direct effect of number of pods per plant (0.795) on pod yield per plant followed by pod length (0.234) in garden pea.

Patel *et al*. (2016) studied path analysis in cowpea. path coefficient analysis indicate the highest positive direct effect on green pod yield per plant by pod length (0.716) followed by days to 50 per cent flowering (0.645), shelling percentage (0.398), number of pods per plant (0.289), sugar content (0.219) and plant height at final harvest (0.204).

Devi *et a*l. (2017) reported that, the path coefficient analysis in the present studies indicated that pod length (2.047) had maximum positive direct effect on pod yield per plot followed by number of pods per plant (1.717), number of seeds per pod (1.618), 100-pod weight (0.247), TSS (0.161) and pod width (0.142), while, for days to marketable maturity (-3.739) maximum negative direct effect was recorded.

Gautam *et al.* (2017) studied that, the path coefficient analysis and revealed that maximum positive direct effect was observed through number of pods per plant (0.856, 0.909) followed by days to first flowering (1.018, 0.480), single pod weight (0.588, 0.404) and pod length (0.221, 0.093) towards yield per plant at both genotypic and phenotypic levels in pea.

Khan *et al*. (2017) studied the path analysis in pea. Plant height (0.019), internode length (0.097), hundred seed weight (0.889), number of seeds per pod (0.033) and seeds per plant (0.977) showed positive direct effect on yield.

Pandey *et al*. (2017) studied that, the path coefficient analysis and revealed that maximum positive direct effect was observed through number of pods per plant (0.904, 0.922), pod weight (0.933, 0.869) and internodal length (0.189, 0.129) positive direct effect on green pod yield per plant at both phenotypic and genotypic levels.

Srinivas *et al.* (2017) observed path coefficient analysis of different yield and yield contributing traits on number of branches per plant, number of

nodes per plant, number of cluster per plant, number green pods per plant, number of pods per plant, number of seeds per pod, pod weight (g), pod yield per plot and percentage of protein content exhibited positive direct effects on pod yield per plot in cowpea.

Toppo *et al.* (2017) studied the path coefficient analysis for seed yield and its components in field pea. The study showed that protein content (0.016) had the negligible positive direct effect on seed yield.

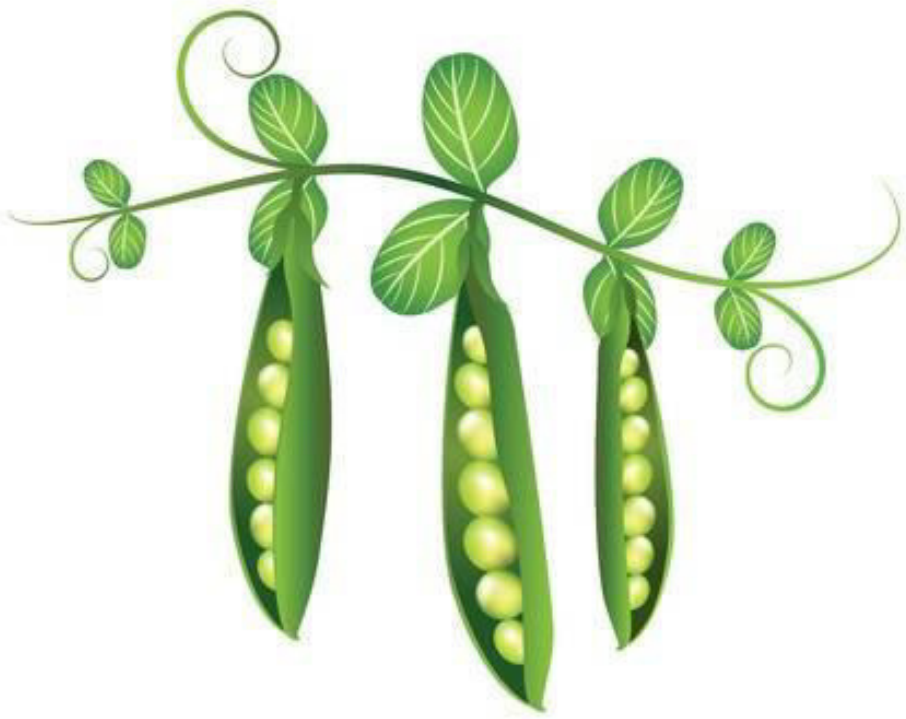
Kumawat *et al*. (2018) path coefficient analysis revealed that traits like number of pods per plant (1.272), pod weight (1.514), number of grains per pod (0.114), number of pickings (0.090) and protein content (0.389).

Lal *et al*. (2018) path analysis observed that the highest positive and direct effect on seed yield per plant was exerted by harvest index (0.5702), biological yield per plant (0.4339) and seeds per pod (0.1360).

Palve *et al*. (2018) studied the path coefficient analysis in cowpea and observed number of pods per plant (1.5256), 100 seed weight (0.0461), primary branches per plant (0.1938), plant height (0.1441), pod length (0.0517), days to first flowering (0.1312) average pod weight (0.3194) and fiber content (0.2955) have positive direct effect on pod yield per plot.

Shrivastava *et al.* (2018) recorded that, the highest positive direct effect on seed yield per plant was exerted by harvest index (0.790) followed by biological yield (0.782), 100 seed weight (0.341), number of seeds per pod (0.279) and number of pods per plant (0.262).

Diwaker *et al.* (2019) studied path analysis in vegetable cowpea and observed positive direct effect on number of primary branches per plant (0.457), number of pickings (0.239), number of clusters per plant (2.578), number of pods per cluster (1.389), number of pods per plant (1.049), TSS (0.999) and nitrogen content in pod (0.604) at genotypic level.



MATERIALS AND METHODS

Chapter - III

MATERIALS AND METHODS

The present investigation on **''Variability studies in pea (*Pisum sativum* L.)"** was carried out at Instructional-Cum-Research Farm, Department of Horticulture, College of Agriculture Latur, Vasantrao Nike Marathwada Krishi Vidyapeeth, during *Rabi* season of 2017-18. The detail of the materials used and techniques adopted during the course of the present investigation are described in this chapter under appropriate headings and sub headings.

3.1 General

3.1.1 Location

The present investigation was conducted at Instructional-Cum-Research Farm, Department of Horticulture, College of Agriculture, Latur. Geographically Latur is situated at 18^{o} 24' North latitude and 77^{o} 36' East longitude. Its height above mean sea level is about 633.85 meter and has a tropical and sub-tropical climate.

3.1.2 Climatic condition

The climate of Marathwada region on annual basis can be classified as semi arid type. The area is having wide fluctuations of temperature. The weekly meteorological data on various weather parameters were recorded at meteorological observatory, of Oilseeds Research Station, Latur during the experimental period of November 2017 to February 2018 is given in annexure I. The minimum and maximum temperatures recorded during crop growth period where as 11.6 ºC and 30.5 ºC, respectively. The average relative humidity was recorded during experimental period is 75.94 AM and 33.75 PM. The total rainfall received during the experimentation was 00.00 mm.

3.2 Materials

3.2.1 Soil

The experiment was conducted on medium black soil with appropriate drainage. The plot was ploughed and harrowed twice to bring the fine tilth of soil.

3.2.2 Genotypes and source of seed

The material under study was constituted of 21 genotypes of pea (*Pisum sativum* L.) which were collected from various places. The genotypes under study are listed with their seed sources. The details are given in Table 1.

Table 1: Name of the genotypes and their source

Sr. No.	Treatment Symbol	Name of genotypes	Source of seed
1	T_1	AP-1	Ahmednagar local market
2	T_2	AP- 3	Ahmednagar local market
3	T_3	DPM-10	KVK Baramati
4	T_4	Pea-M-Gold	Mahabeej Bhavan Akola
5	T_5	Amaravati Local	Shri. Laxmanrao Hiwase At. Nimbhi Tq. Morshi Dist. Amaravati
6	T_6	Yavatmal Local	Shri. Kamleshwar Giri At. Nimbha Tq. Darwha Dist. Yavatmal
7	T_7	Buladhana Local	Shri. Shivaji Kale At. Malkapur Panghra Tq. Sindkhed Raja Dist. Buldhana
8	T_8	Wardha Local	Shri. Dilip Shende At. Hetikundi Tq. Karanja Dist. Wardha
9	T_9	Chandrapur Local	Shri. Tukaram Thikare At. Pathari Tq. Saoli Dist. Chandrapur
10	T_{10}	Nagpur Local	Nagpur local market
11	T_{11}	Washim Local	Shri. Babanrao Bhoyar At. Dudhkheda Tq. Washim Dist. Washim
12	T_{12}	Pune Local	Shri.Shantaram Chive At. Bhalewadi Tq. Haveli Dist. Pune
13	T_{13}	Parabhani Local	Shri. Paemeshwar Ghatul At. Savargon Tq. Manwat Dist. Parbhani

14	T_{14}	Latur Local	Shri. Avinash Magar At. Renapur Tq. Latur Dist. Latur
15	T_{15}	Hingoli Local	Shri. Pralhadrao Samale At. Pimpla Tq. Aundha Dist. Hingoli
16	T_{16}	Kolhapur Local	Kolhapur local market
17	T_{17}	Ahmednagar Local	Shri. Rajabhau Karanjkar At. Ghogargaon Tq. Shrigonda Dist. Ahmednagar
18	T_{18}	Solapur Local	Shri. Rajendra Patil At. Akole Tq. Mhada Dist. Solapur
19	T_{19}	Satara Local	Shri.Ganesh Mane At. Nisare Tq. Patan Dist. Satara
20	T_{20}	Baramati Local	Shri. Bhushan Dhumal At. Shetphal Tq. Baramati Dist. Pune
21	T_{21}	Phule Priya	MPKV, Rahuri

3.2.3 Experiment details

1.	Name of crop	:	Pea
2.	Family	:	Leguminaceace
3.	Experimental design	:	Randomized Block Design
4.	Number of replications	:	02
5.	Number of Genotypes	:	21
6.	Total number of plot	:	42
7.	Spacing.	:	30 x 15 cm
8.	Plot size	:	2.50 m x 2.00 m
9.	Distance between two replications	:	2.00 m
10.	Plant unit per plot	:	111
11.	Total experimental area	:	22 m x 14 m= 308 Sq. m
12.	Season and year of experiment	:	*Rabi*-2017-18

3.3 Methods

3.3.1 Cultivation details

The details of the cultural and other operations carried out in the experimental plot during the period of experimentation are presented in Table 2.

Table 2: Schedule of cultural operations carried out on the experimental field

Sr. No.	Operation	Frequency	Date
1.	Ploughing	1	12.11.2017
2.	Rotavator	1	18.11.2017
3.	FYM application	1	26.11.2017
4.	Cleaning	1	26.11.2017
5.	Layout/marking	1	26.11.2017
6.	Fertilizer application	2	26.11.2017
			25.12.2017
7.	Sowing	1	29.11.2017
8.	Gap filling	1	08.12.2017
9.	Thinning	1	17.12.2017
10.	Weeding	2	30.12.2017
			18.01.2018
12.	Irrigation	10	
13.	Harvestings	7	

3.3.2 Cultural practices

3.3.2.1 Land preparation

The land was brought to a fine tilth by ploughing and clod crushing was done by rotavator.

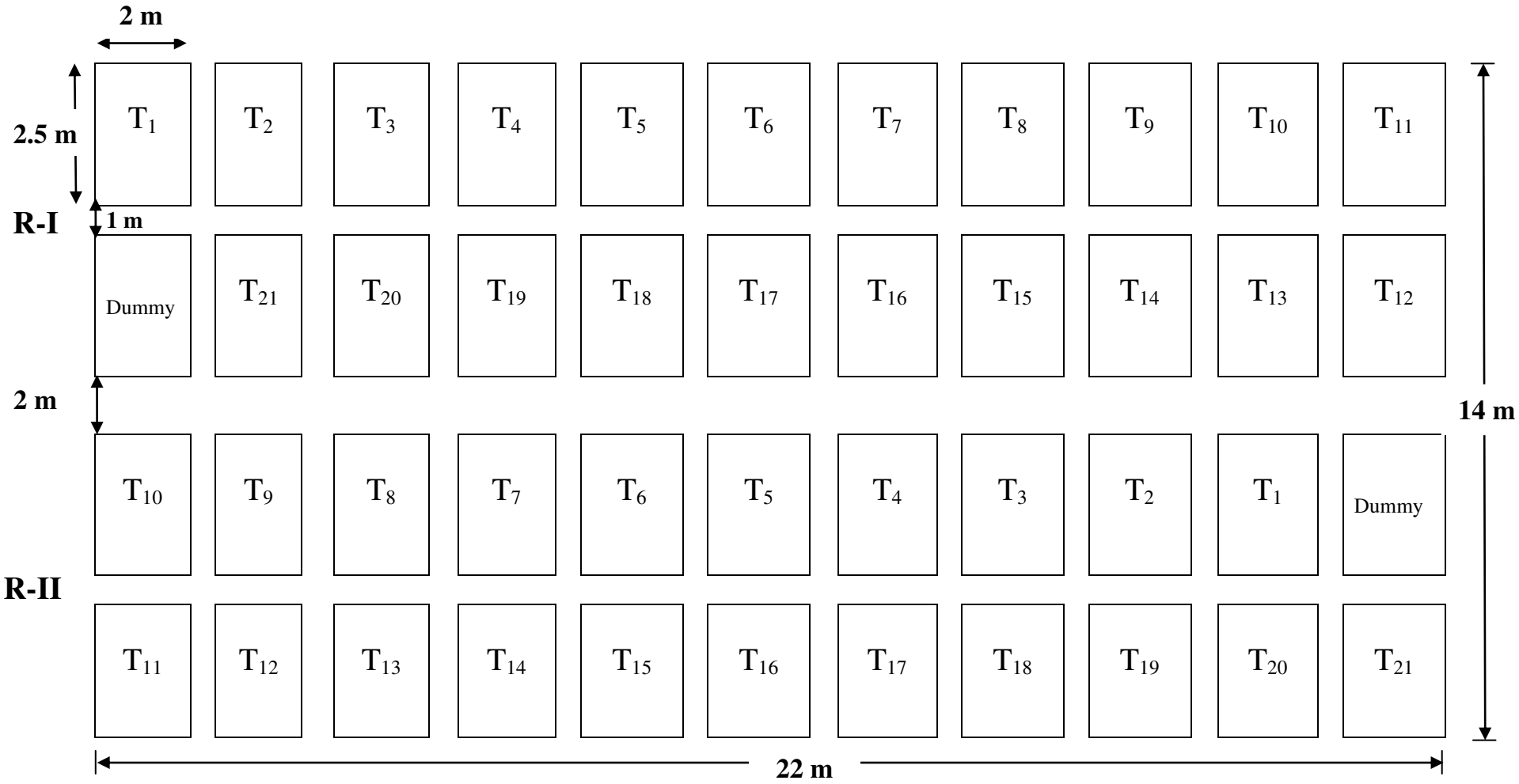


Fig. 1: Layout of experimental plot

Experimental design : RBD

Replication : 02

Treatments : 21

Total number of plots : 42

Plot size : 2.5 m x 2 m = 5 Sq. m

Total area : 22 m x 14 m = 308 Sq. m

Plate 1. General view of experimental plot

3.3.2.2 Layout

Experimental field was laid out as per the plan after preparation of land. The layout consisted of 42 experimental plots each having 2.50 m x 2.00 m size. The randomization of treatment was done in two replications. The distance of 2.00 m between two replications. The flat beds and irrigation channels were prepared for proper irrigation. The layout of experimental plot is shown in fig. 1.

3.3.2.3 Fertilizer application

Farm yard manure (FYM) was applied @ 20 tonnes per hectares before last harrowing which was mixed with the soil. The recommended dose of fertilizer 30:60:60 kg NPK/ha was applied to the crop. Out of this full dose of phosphorus and potassium and half dose of nitrogen was applied at the time of sowing as basal dose. Remaining half dose of nitrogen was applied after one month of sowing.

3.3.2.4 Sowing

The uniform sized and healthy seeds are treated before sowing with Bavistin @ 2.5 g/kg of seed. The sowing of seeds was done on 29th November, 2017 as per layout in the flat bed at 30 cm distance between rows and 15 cm distance between the plants by dibbling method.

3.3.2.5 Irrigation

Immediately after sowing light irrigation was given and followed after three days. Thereafter, irrigations were given to the crop as per requirement.

3.3.2.6 Emergence count and final plant stands

Emergence count was taken at 17th days after sowing and final plant stand from each plot recorded before harvest.

3.3.3 Inter cultural operations

3.3.3.1 Gap filling and thinning

Gap filling was carried out after 9th days of sowing on 8th December, 2017 and plant population of each treatment plot was maintained. Thinning was done by kipping only one healthy seedling at one hill after 18th days of sowing on 17th December, 2017.

3.3.3.2 Weeding and hoeing

Twice hand weeding was undertaken to control the weeds and hoeing was done in order to kept the soil porous and to conserve the soil moisture in experimental plots.

3.3.3.3 Top dressing

Top dressing of half dose of nitrogen was given after one month of sowing to all treatments.

3.3.3.4 Plant protection

The plant protection measures applied as per recommendations.

3.3.3.5 Harvesting

Harvesting of pods was carried out at green pod stage for the table purpose. Regular pickings of the green pods were done at an interval of 7 to 10 days.

3.4 Observations recorded

Observations on various characters were recorded on five plants randomly selected from each treatment of two replications, to study the yield of green pods and quantitative characters. The observations were recorded on the following characters.

3.4.1 Growth characters

The five plants from each plot were selected randomly and labeled for observation purpose. The observations were recorded on the five labeled plants in each plot and the averages were worked out.

3.4.1.1 Plant height (cm)

The height of plant measured from base to growing tip of the plant in centimeters. The observation recorded at the time of last harvesting.

3.4.1.2 Number of branches per plant

The total number of branches per plant was recorded from randomly selected five plants from each treatment and average number of branches per plant was calculated at last harvesting.

3.4.1.3 Pod stringiness

The stringed or string less pods counted at the time of harvesting.

3.4.1.4 Type of tendril

The different types of tendrils were observed at full foliage stage as *afila*/wild type/tendril-less/*afila* tendril-less.

3.4.1.5 Number of tendril per plant

The numbers of tendrils were counted from main stem of plant at the stage of last harvesting. The mean number of tendrils per plant was calculated.

3.4.1.6 Days to initiation of first flowering

The mean days to appearance of first flower from the time of sowing were recorded.

3.4.1.7 Days to 50 per cent flowering

The number of days required for 50 per cent flowering was recorded from date of sowing.

3.4.1.8 Colour of flower

By visually recorded from colour of flower.

3.4.1.9 Crop duration (days)

From the date of sowing to last harvesting the crop duration was recorded.

3.4.2 Yield attributes

3.4.2.1 Days to first picking

The number of days required to first green pod picking were worked out from date of sowing.

3.4.2.2 Number of pickings

In each experimental plot, the date of the each harvesting and number of harvestings were recorded as number of pickings.

3.4.2.3 Number of clusters per plant

The total number of clusters of randomly selected five plants were recorded from each treatment and average number of clusters per plant was calculated.

3.4.2.4 Number of pods in cluster

The total number of pods in a cluster of randomly selected five plants were recorded from each treatment and average number of pods in cluster were calculated.

3.4.2.5 Pod length (cm)

Five green pods from each observational plant were selected randomly during harvesting for recording the length from the base of calyx to the apex of the pod and mean length of pod was calculated in centimeter.

3.4.2.6 Number of seeds per green pod

Five green pods from observational plants of each plot were selected randomly at the time of harvesting for counting the number of grains in a green pod and mean number of grains per pod were calculated.

3.4.2.7 Green pod yield per plant (g)

The weight of the green pods from all the pickings of observational plants in each treatment was recorded and averages were worked out in grams.

3.4.2.8 Green pod yield per plot (kg)

The weight of the green pods of all pickings from each plot was summed and recorded yield per plot in kilograms.

3.4.2.9 Green pod yield per hectare (q)

The total yield per plot was recorded and it was computed on hectare basis in quintals.

3.4.3 Quality parameters

3.4.3.1 Physiological loss of weight (%)

The green pod of each treatment were weighed at the beginning of storage and that weight was recorded as initial weight and store in open condition at room temperature till to the constant weight. Per cent loss in weight was calculated by using the following formula.

$$\text{Physiological loss of weight (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \text{ X } 100$$

3.4.3.2 Total soluble solids (%)

The shelled grains were crushed with the help of mortal and pistil. Crushed grains squeezed out by lime squeezer and drop of grain juice was taken on prism of hand refractometer and estimated in T.S.S. per cent. The observation was repeated tree times for each sample and mean was calculated.

3.5 Statistical analysis

The data obtained in respect of all the character have been subjected to the following statistical analysis.

3.5.1 Analysis of variance

Analysis of variance was carried out in order to partition the total variation showed by different characters under study into its components *viz*., replication, treatment and error. This is carried out as per the standard method suggested by Panse and Sukhatme (1985). The details are given in the following table.

Analysis of variance

Sr. No.	**Source of variation**	***d.f.***	**S.S.**	**M.S.S. of variation**
1.	Replications	(r-1)	RSS	M_1
2.	Treatments (Genotypes)	(n-1)	TrSS	M_2
3.	Error	(r-1) (n-1)	ErSS	M_3
	Total	**r (n-1)**	-	**$M_1+M_2+M_3$**

Where, r = Number of replications

n = Number of genotypes

$$\text{Genotypic variance} = \frac{M_2 - M_3}{r}$$

$$\text{Phenotypic variance} = \frac{M_2 - M_3}{r} + M_3$$

$$\text{Environmental variance} = M_3$$

3.5.2 Genetic parameters

The genetic parameters such as genotypic coefficients of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense and genetic advance for different characters were worked out for all the genotypes under study by following the standard procedures.

3.5.2.1 Genotypic and phenotypic coefficient of variation

Genotypic and phenotypic coefficients of variation were estimated by the formulae as suggested by Burton and DeVane (1953).PCV and GCV values were categorized as low (0-10%), moderate (10.1-20%) and high (>20) values as indicated by Sivasubranian and Menon (1973).

$$\text{GCV (\%)} = \frac{\sqrt{\text{Genotypic variance}}}{\overline{X}}$$

Where, $\overline{X}$= the mean of character

$$\text{PCV (\%)} = \frac{\sqrt{\text{Phenotypic variance}}}{\overline{X}}$$

Where, $\overline{X}$= the mean of character

3.5.2.2 Heritability estimates (h^2)

Heritability in broad sense was calculated by the formula as suggested by Allard (1960). Heritability was classified as suggested Robinson *et al.* (1949) into low (0-30%), moderate (30.1-60%) and high (>60%).

$$h^2 (b) = \frac{\sigma^2 g_i}{\sigma^2 p_i} \text{ X } 100$$

Where, h^2 (b) = Heritability in broad sense.

$\sigma^2 g_i$ = Genotypic variance of character 'i'.

$\sigma^2 p_i$ = Phenotypic variance of character 'i'.

3.5.2.3 Genetic advance (GA)

The Genetic advance (GA) resulting from selection of five per cent superior individuals was worked out as suggested by Allard (1960). The GAM% was categorized into low (0–10%), moderate (10.1–20%) and high (>20%) as suggested by Johnson *et al.* (1955).

$$\text{Genetic advance} = H \times \sigma p \times K$$

Where,

K = 2.06 (Selection differential at 5 per cent selection index)

σ p = Phenotypic standard deviation

H = Heritability in broad sense

Expected genetic advance is expressed in percentage over mean.

$$\text{EGA in \% of mean} = \frac{\text{EGA}}{\bar{X}}$$

Where, $\bar{X}$ = the mean of treatment.

3.5.2.4 Correlation studies

The relationship between two or more quantitative characters is of great interest and carries much practical significance. Correlation is a measure of the degree to which characters are associated with yield or among themselves (Burton, 1952).

To study the extent of association between different traits under study the simple genotypic and phenotypic correlation coefficient were worked out from the respective variance and co-variances as per the formulae.

$$\text{Genotypic } r_{1,2} = \frac{\text{Genotypic covariance 1,2}}{\sqrt{\text{Genotypic variance of 1 X Phenotypic variance of 2}}}$$

$$\text{Phenotypic } r_{1,2} = \frac{\text{Phenotypic covariance 1,2}}{\sqrt{\text{Genotypic variance of 1 X Phenotypic variance of 2}}}$$

Where, r = Correlation coefficient

1 & 2 = Two variable under study.

3.5.2.5 Path coefficient analysis

The genotypic and phenotypic correlation coefficients were used in finding out their direct and indirect contribution towards yield per plot. The direct and indirect paths were obtained by following Dewey and Lu (1959). The path coefficients were obtained by simultaneous selection of the following equations, which expresses the basic relationship between genotypic correlation 'r' and path coefficients (P).

$$r_{14} : P_{14} + P_{24}\, r_{12} + P_{34}\, r_{13}$$

$$r_{24} : P14\, r_{21} + P_{24} + P_{34}\, r_{23}$$

$$r_{34} : P_{14}\, r_{31} + P_{24}\, r_{32} + P_{34}$$

Where,

r_{14}, r_{24} and r_{34} are genotypic correlations of component characters with yield (dependent variable) and r_{12}, r_{13} and r_{23} are the genotypic correlations among component characters (independent variables).

The direct effects were calculated by the following set of equations:

$$P_{14} = C_{11}\, r_{14} + C_{12}\, r_{24} + C_{13}\, r_{34}$$

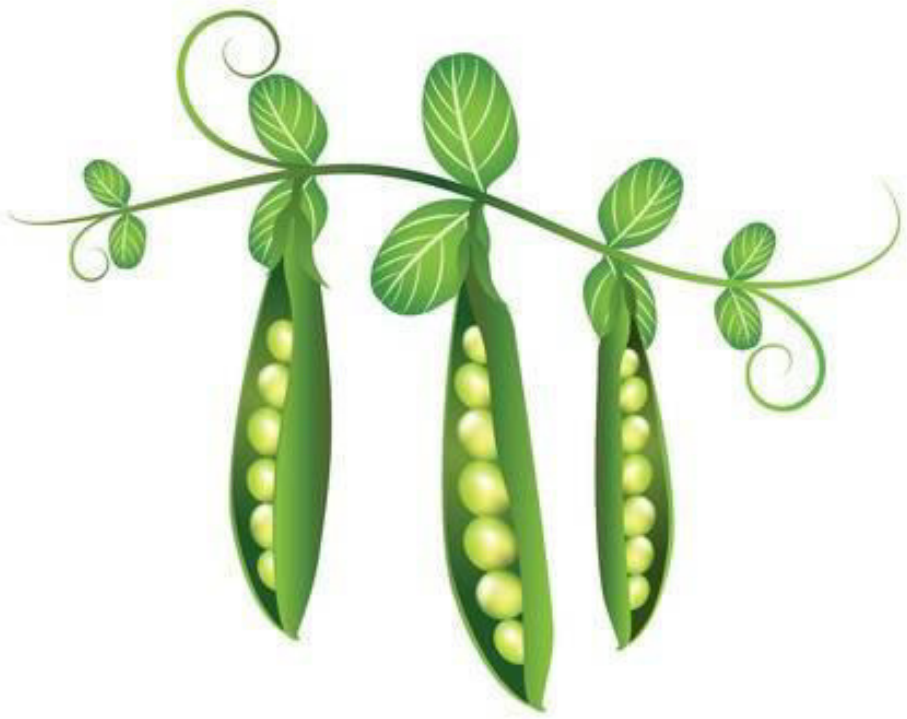
$$P_{24} = C_{21}\, r_{14} + C_{22}\, r_{24} + C_{23}\, r_{34}$$

$$P_{34} = C_{31}\, r_{14} + C_{32}\, r_{24} + C_{33}\, r_{34}$$

Where,

C_{11}, C_{22}, C_{23} and C_{33} are constants derived by using abbreviated Doulittle's technique as explained by Goulden (1959).

$r_{12}\, P_{24}$, $r_{13}\, P_{34}$, $r_{21}\, P_{14}$, $r_{23}\, P_{34}$, $r_{31}\, P_{14}$, $r_{32}\, P_{24}$ are indirect effects.



RESULTS AND DISCUSSION

Chapter-IV

RESULTS AND DISCUSSION

The results of the present investigation entitled "Variability studies in pea (*Pisum sativum* L.)" are presented in this chapter under appropriate headings and sub headings.

4.1 Analysis of variance

4.2 Estimation of mean of characters

4.3 Coefficient of variance

4.4 Heritability

4.5 Genetic advance

4.6 Correlation coefficient analysis

4.7 Path analysis

4.1 Analysis of variance

Analysis of variance for randomized block design was carried out to assess the variation for all the characters. The significance was marked by applying 'F' test. Analysis of variance for seventeen characters consisting of replication mean squares, treatment mean squares and error mean squares is given in Table 3.

The analysis of variance indicated significantly higher amount of variability among the genotypes for all the characters studied *viz*., plant height, primary branches per plant, number of tendrils per plant, days to initiation of first flowering, days to 50 per cent flowering, days to first picking, number of pickings, number of clusters per plant, number of pods per cluster, pod length, number of seeds per pod, crop duration, physiological loss of weight, TSS, green pod yield per plant, green pod yield per plot and green pod yield per hectare are given in Table 3 indicating the presence of genetic variability in the existing material. Similar findings reported by Kaur *et al*., (2007), Nawab *et al*., (2008), Pal and Singh (2013), Selvi *et al.,* (2014), Tambolkar *et al.,* (2016), Gudadinni *et al.,* (2017), Sharma *et al*., (2017), Srinivas *et al*., (2017) and Thouseem *et al.*, (2018).

Table 3: Analysis of variance for different characters studied in the genotypes of pea

Sr. No.	Characters	Mean sum of squares		
		Replication	Treatments	Error
1	Plant Height (cm)	9.315	302.034**	22.588
2	Number of primary branches/plant	0.000	9.836**	0.060
3	Number of tendrils/plant	3.547	997.529**	11.827
4	Days to initiation of first flowering	5.357	77.081**	2.757
5	Days to 50% flowering	2.881	76.229**	1.881
6	Days to first picking	9.524	112.529**	7.524
7	Number of pickings	0.095	2.057**	0.195
8	Number of clusters/plant	0.275	3.635**	0.069
9	Number of pods per cluster	0.004	0.329**	0.010
10	Pod length (cm)	0.005	8.361**	0.046
11	Number of seeds/green pod	0.004	4.748**	0.070
12	Crop duration (days)	120.024	252.164**	95.374
13	Physiological loss of weight (%)	0.149	297.306**	1.223
14	T.S.S. content (%)	0.283	7.998**	0.079
15	Green pod yield/plant (g)	0.457	139.489**	5.616
16	Green pod yield/plot (kg)	0.001	0.508**	0.028
17	Green pod yield/ha (q)	1.907	719.822**	39.396

Table 4: Mean, range and different genetic parameters in pea

Sr. no.	Genetic parameters	Mean	Range	GV	PV	GCV	PCV	Heritability (h^2) %	GA %	GA as % of mean
1	Plant height (cm)	66.54	48.42-96.27	139.72	162.31	17.76	19.15	86.1	22.59	33.95
2	Number of primary branches /plant	2.84	1.00-11.00	4.89	4.95	77.96	78.44	98.8	4.53	159.62
3	Days to initiation of first flowering	46.40	33.00-54.00	37.16	39.92	13.14	13.62	93.3	12.12	26.11
4	Days to 50% flowering	53.21	39.00-60.50	37.17	39.06	11.46	11.74	95.2	12.25	23.03
5	Days to first picking	71.29	48.00-86.00	102.50	110.03	14.20	14.72	93.2	20.13	28.24
6	No. of pickings	6.14	4.00-8.00	0.93	1.13	15.71	17.28	82.7	1.81	29.42
7	No. of clusters/plant	7.01	5.30-9.00	1.78	1.85	19.04	19.40	96.3	2.70	38.47
8	No. of pods per cluster	1.95	1.10-2.70	0.16	0.17	20.47	21.09	94.2	0.80	40.93
9	Pod length (cm)	7.21	3.77-10.09	4.16	4.20	28.26	28.42	98.9	4.18	57.90
10	No. of seeds/ green pod	6.83	4.60-9.60	2.34	2.41	22.40	22.73	97.1	3.11	45.47
11	Crop duration	106.93	88.50-125.00	78.40	173.77	8.28	12.33	45.1	12.25	11.46
12	Green pod yield/ plot	1.52	0.86-2.54	0.24	0.27	32.22	34.04	89.6	0.96	62.81
13	Green pod yield/ ha	57.17	32.36-95.70	340.21	379.61	32.26	34.08	89.6	35.97	62.91
14	Green pod yield/ plant	28.44	17.20-46.03	66.94	72.55	28.77	29.95	92.3	16.19	56.93

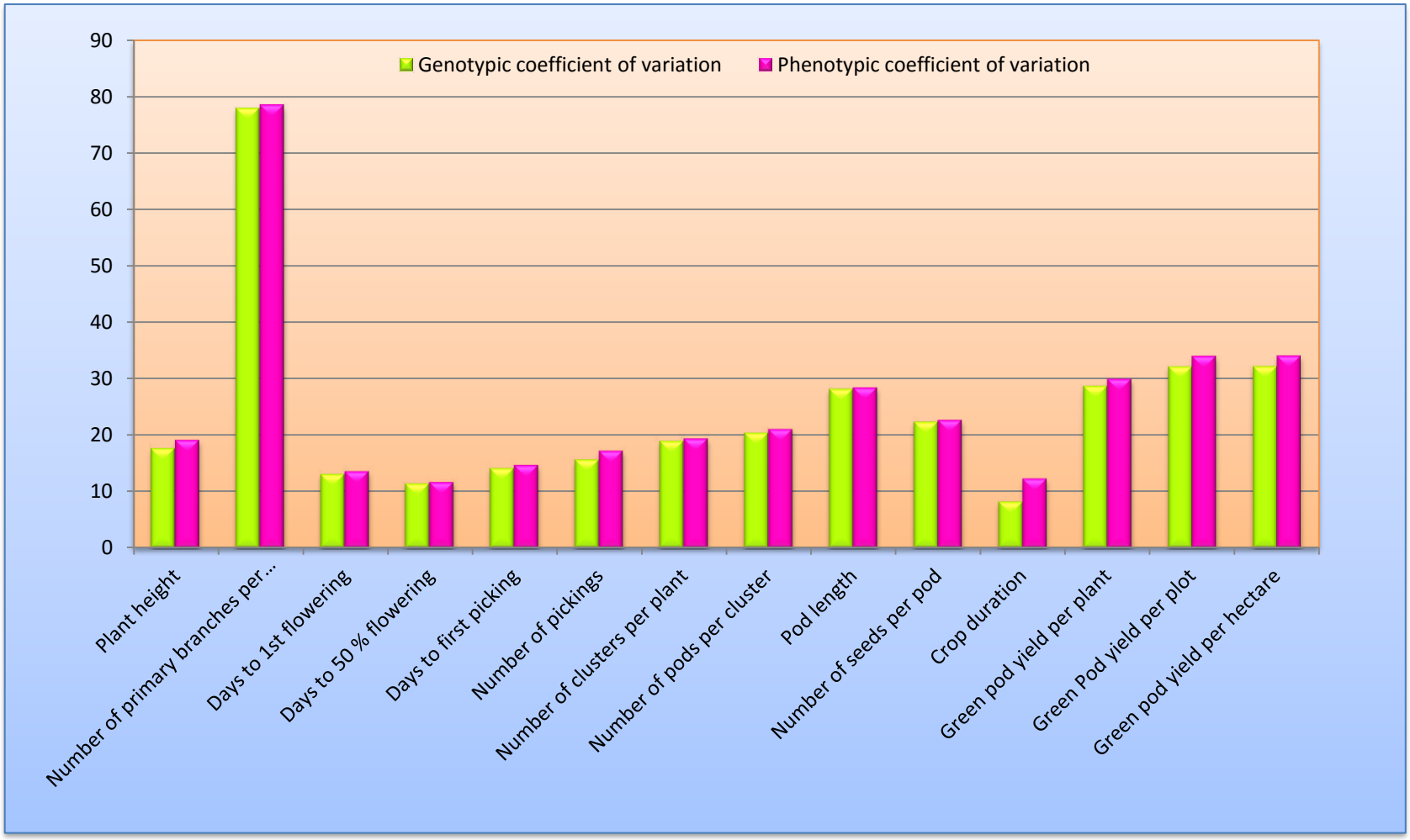


Fig. 2: Genotypic and phenotypic coefficient of variation for 14 characters in pea

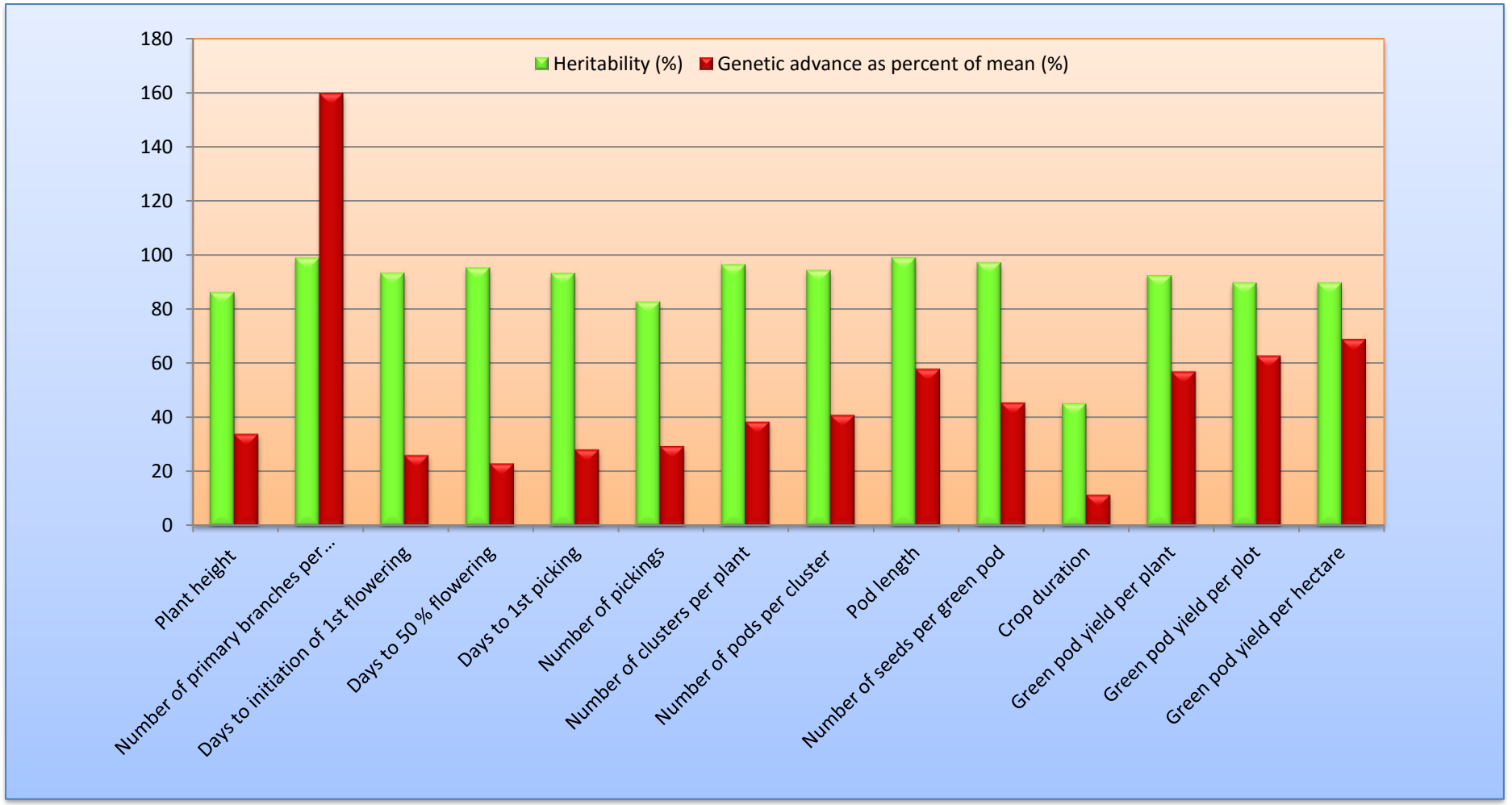


Fig. 3: Heritability (%) and genetic advance as percent of mean (%) for 14 characters of pea

4.2 Estimation of mean of characters

The Mean values of twenty one genotypes of pea for all the characters along with the standard error of mean and critical difference are given in Annexure II.

4.2.1 Growth attributes

Regarding the different growth characters the mean and range are present in Table 4.

4.2.1.1 Plant height (cm)

The range was recorded for plant height from 48.42 to 96.27 cm with an average value of 66.54 cm. The genotype Latur Local was found to be the highest plant height (96.27 cm) followed by Ahemadnagar Local (82.23 cm) and Kolhapur Local (77.58 cm). The genotype AP-3 found to be the lowest plant height (48.42). Similar finding reported by Gudadinni *et al.,* (2017), Georgieva *et al.,* (2016), Pandey *et al.,* (2015) and Singh and Singh (2006).

4.2.1.2 Number of primary branches per plant

The range recorded for number of primary branches per plant was 1.00 to 11.00. The average number of primary branches overall the twenty one genotypes were 2.84. The genotype Latur Local was significantly produced highest branches per plant (11.00) followed by Parbhani Local (4.80) and Washim Local (4.10). The genotype AP-1, AP-3, DPM-10, Pea-M-Gold, Amaravati Local and Satara Local were found to produce lowest number of primary branches per plant (1.00). Similar finding reported by Sharma *et al.,* (2017).

4.2.1.3 Number of tendrils per plant

The number of tendrils per plant was recorded in all the twenty one genotypes ranged from 10.00 to 94.90, with an average of 34.46. The genotype Latur Local recoded maximum number of tendrils per plant (94.90) followed

by genotype Parbhani Local (73.30) and Washim Local (63.50). The genotype Amaravati Local recorded minimum number of tendrils per plant (10.00). Maximum number of tendrils helps for standing and better growth of the plant. Similar finding reported by Selvie *et al.,* (2014).

4.2.1.4 Days to initiation of first flowering

Regarding the character days to initiation of first flowering for all the twenty one genotypes, the range 33.00 to 54.00 days was observed. The average number of days taken to flower was 46.40 days. The genotype AP-3 was found significantly early to flowering (33.00) followed by Phule Priya (37.50) and Amaravati Local (40.00). The genotypes Parbhani Local and Hingoli Local were found late to first flowering (54.00). Similar finding reported by Gudadinni *et al.,* (2017), Pandey *et al.,* (2015), Selvie *et al.,* (2014), Pal and Singh (2013).

4.2.1.5 Days to 50 per cent flowering

Regarding the range recorded for days to 50 per cent flowering in different genotypes from 39.00 to 60.50 days with the average of 53.21 days. The genotype AP-3 recorded significantly minimum days for 50 per cent flowering (39.00) followed by Phule Priya (46.00 days) and Amaravati Local (46.50 days). The genotype Wardha Local was taken maximum days (60.50) for 50 per cent flowering. Similar finding reported by Gudadinni *et al.,* (2017), Pandey *et al.,* (2015), Selvie *et al.,* (2014), Pal and Singh (2013).

4.2.1.6 Crop duration (days)

The range of crop duration was found 88.50 to 125.00 days. The average crop duration 106.93 days was recorded. The genotype Nagpur Local was found minimum crop duration (88.50 days) followed by Parbhani Local (90.50 days) and Pune Local (95.00 Days). The Yavatmal Local was found maximum days of crop duration (125.00 days). Similar finding reported by Tambolkar *et al.,* (2016).

4.2.3 Yield attributes

The different yield attributes of twenty one genotypes are given in Table 4.

4.2.3.1 Days to first picking

Days to first picking of green pods for all the twenty one genotypes ranged from 48.00 days to 86.00 days, with an average of 71.29 days. The genotype AP-3 taken minimum days to first picking of green pod (48.00 days) followed by genotype Chandrapur Local (57.00 days), DPM-10 (61.00). The genotype Buldhana Local was recorded maximum days (86.00 days) to first harvest. Similar finding reported by Gudadinni *et al.,* (2017) and Kaur *et al.,* (2018).

4.2.3.2 Number of pickings

The number of pickings for all the twenty one genotypes ranged from 4.00 to 8.00, with an average of 6.14. The genotype Latur Local recoded maximum number of pickings (8.00) followed by genotype Baramati Local (7.50), AP-3, DPM-10 and Chandrapur Local (7.00). The genotype Washim Local and Ahemednagar Local recorded minimum number of pickings (4.00). Similar finding reported by Tambolkar *et al.,* (2016).

4.2.3.3 Number of clusters per plant

The number of clusters per plant for all the twenty one genotypes ranged from 5.30 to 9.00, with the average of 7.01. The genotypes Hingoli Local and Ahemednagar Local were recorded significantly maximum number of clusters per plant (9.00) followed by genotype Baramati Local (8.90) and Latur Local (8.40). The minimum numbers of clusters per plant (5.30) in genotypes AP-3, DPM-10 and Chandrapur Local.

4.2.3.4 Number of pods per cluster

The number of pods per cluster for all the twenty one genotypes ranged from 1.10 to 2.70, with an average of 1.95. The genotype Hingoli Local taken

maximum number of pods in cluster (2.70) followed by genotype Washim Local, Kolhapur local, Phule Priya (2.40). The genotype Baramati Local taken minimum number of pods per cluster (1.10). Similar finding reported by Gudadinni *et al.,* (2016).

4.2.3.5 Pod length (cm)

The range noted for pod length was from 3.77 to 10.09 cm, with the average of 7.21 cm. Amaravati local was recorded significantly maximum length of pod (10.09 cm) followed by genotype DPM-10 (9.98 cm) and genotype Pea-M Gold (9.93 cm). The genotype Baramati Local was recorded minimum pod length (3.77 cm). Similar finding reported by Selvie *et al.,* (2014), Pal and Singh (2013) and Kaur *et al.,* (2007).

4.2.3.6 Number of seeds per pod

The range noted for number of seeds per pod was 4.60 to 9.60, with the average number of seeds per green pod 6.82. Chandrapur Local was significantly recorded maximum number of seeds per green pod (9.60) followed by genotype Satara local (9.00), DPM-10 and Phule Priya (8.80). The genotype Yavatmal Local was recorded minimum number of seeds per green pod (4.6). Similar finding reported by Selvie *et al.,* (2014), Pal and Singh (2013) and Kaur *et al*., (2007).

4.2.3.7 Green pod yield per plant (g)

Range for the green pod yield per plant was recorded from 17.20 g to 46.03 g. The average yield per plant was found to be 28.44 g. The genotype Phule Priya significantly produced maximum yield per plant (46.03 g) followed by genotype Chandrapur Local (45.03 g) and AP-3 (41.79 g). The genotype Latur Local recorded minimum yield per plant (17.20 g). Similar finding reported by Ali *et al.,* (2018) and Pandey *et al.,* (2015).

4.2.3.8 Green pod yield per plot (kg)

The green pod yield per plot of all the twenty one genotypes were in the range of 0.86 kg to 2.54 kg. The average green pod yield per plot was found 1.52 kg. The genotype Phule Priya was recorded maximum yield per plot (2.54 kg) followed by genotype Chandrapur Local (2.53 kg) and AP-3 (2.35 kg). The genotype Latur Local was recorded minimum green pod yield per plot (0.86 kg). Similar finding reported by Gudadinni *et al.,* (2017).

4.2.3.9 Green pod yield per hectare (q)

The green pod yield per hectare of all the twenty one genotypes ranged from 32.36 q to 95.70 q. The average yield per hectare was found 57.17 q. The genotype Phule Priya produced maximum green pod yield per hectare (95.70 q) followed by genotype Chandrapur Local (95.22 q) and AP-3 (88.56 q). The genotype Latur Local was recorded the minimum yield per hectare (32.36 q). Similar finding reported by Kumar *et al*., (2015).

4.2.3 Morphological & quality attributes

The different morphological and quality characters of different genotypes are given in Table 5.

4.2.3.1 Physiological loss of weight (%)

The data in respect of per cent physiological loss of weight in green pod of different genotypes stored at room temperature up to seven days. The physiological loss of weight in green pods was noted different genotypes from 39.25 to 77.25 per cent, with the average physiological loss of weight in green pods was recorded 61.41 per cent. The minimum physiological loss of weight was recorded in genotype AP-1 (39.25%) followed by Parbhani Local (42.30%). These findings indicated that variety AP-1 and Parbhani Local could be kept in market as fresh even after a week. Similar finding reported by Tambolkar *et al.,* (2016).

Table 5: Morphogical and quality characters of twenty one genotypes of pea

Sr. no.	Treatments	Color of flower	Type of tendrils	Stringed/string less	PLW (%)	TSS (%)
1	AP-1	White	Wild type	Stringed	39.25	14.45
2	AP-3	White	Wild type	Stringed	70.50	16.55
3	DPM-10	White	Wild type	Stringed	60.25	13.70
4	Pea- M Gold	White	Wild type	Stringed	57.15	13.75
5	Amaravati Local	White	Wild type	Stringed	61.10	14.50
6	Yavatmal Local	White	*afila*	Stringed	46.05	12.25
7	Buladhana Local	White	*afila*	Stringed	66.20	12.65
8	Wardha Local	White	*afila*	Stringed	68.55	12.75
9	Chandrapur Local	White	Wild type	Stringed	71.45	16.40
10	Nagpur Local	White	*afila*	Stringed	69.40	11.77
11	Washim Local	White	*afila*	Stringed	65.75	11.60
12	Pune Local	White	Wild type	Stringed	73.55	15.30
13	Parabhani Local	White	*afila*	Stringed	42.30	11.62
14	Latur Local	Pink	Wild type	Stringed	76.60	9.60
15	Hingoli Local	White	*afila*	Stringed	51.95	10.87
16	Kolhapur Local	White	*afila*	Stringed	45.35	10.30
17	Ahemadnagar Local	White	*afila*	Stringed	42.75	11.55
18	Solapur Local	White	*afila*	Stringed	71.35	12.10
19	Satara Local	White	Wild type	Stringed	77.25	14.60
20	Baramati Local	Pink	Wild type	Stringed	71.30	9.80
21	Phule Priya	White	Wild type	Stringed	61.50	11.95

4.2.3.2 T.S.S. (%)

The character T.S.S. percent for all the twenty one genotypes were ranged from 9.60 to 16.55 per cent. The mean for all the twenty one genotypes were found to be 12.76 percent. The genotype AP-3 recorded maximum T.S.S. (16.55%) followed by Chandrapur Local (16.40%) and Pune Local (15.30%). The genotype Latur Local was recorded minimum T.S.S. (9.60%). These findings indicated that variety AP-3, Chandrapur Local and Pune Local were having more sweetness as compare to the remaining genotypes. Similar finding reported by Kumar *et al.,* (2015) and Devi *et al.,* (2017).

4.2.3.3 Type of tendril or leaf

It was visually observed all the twenty one genotypes *viz*., Yavatmal Local, Buldhana Local, Wardha Local, Nagpur Local, Washim Local, Parbhani Local, Hingoli Local, Kolhapur Local, Ahemadnagar Local and Solapur Local observed *afila* type, remaining all genotypes were observed wild type of tendril or leaf. *afila* type of cultivars increased standing ability in pea. Similar finding reported by Mikic *et al.,* (2011).

4.2.3.4 Stringed/string less

It was visually observed all the twenty one genotypes all genotypes ware observed stringed in the pods.

4.2.3.5 Colour of flower

It was visually observed all the twenty one genotypes *viz*., Latur Local and Baramati Local observed pink colour, remaining all genotypes were observed white colored flower. Similar finding reported by Tambolkar *et al*., (2016).

4.3 Coefficient of variance

In the present findings, phenotypic coefficient of variation were higher than the corresponding genotypic coefficient of variation for all the characters studied, (Table 3) However, the differences was narrow which implied less

environmental influences. In other words it seems that genetic factors were predominantly responsible for expression of those attributes and selection could be made effectively on the basis of phenotypic performance Similar finding h reported by Thouseem *et al*., (2018), Gudadinni *et al.,* (2017) Sharma *et al.,* (2017), Srinivas *et al.,* (2017) and Selvi *et al*., (2014).

4.3.1. Phenotypic coefficient of variance (PCV)

The phenotypic coefficient of variation ranged from 11.74% for days to 50 per cent flowering to 78.44% for number of primary branches per plant. The phenotypic coefficient of variations was highest for characters *viz*., number of primary branches per plant (78.44%), number of green pod yield per hectare (34.08%), green pod yield per plot (34.04%), green pod yield per plant (29.95%), pod length (28.42%), number of seeds per green pod (22.73%) and number of pods per cluster (21.09%) are given in Table 4. It indicates that these characters would respond to selection. Similar finding reported by Thouseem *et al*., (2018), Gudadinni *et al.,* (2017), Sharma *et al*., (2017), Tambolkar *et al.,* (2016), Thakur *et al.,* (2016), Kumar *et al*., (2015) and Selvi *et al*., (2014).

The rest of the characters such as number of clusters per plant (19.40%), plant height (19.15%), number of pickings (17.28%), days to first picking (14.71%), days to first flowering (13.61%), crop duration (12.33%) and days to 50 per cent flowering (11.74%) exhibited moderate phenotypic coefficient of variation. Similar finding reported by Kaur *et al*., (2018), Thouseem *et al*., (2018), Gudadinni *et al.,* (2017), Srinivas *et al.,* (2017), Tambolkar *et al*., (2016), Ahmad *et al*., (2014) and Pal and Singh (2013).

4.3.2 Genotypic coefficient of variance (GCV)

The data revealed from the Table 4, the genotypic coefficient of variation varied from 8.28% for crop duration to 77.96% for of number of primary branches per plant. The genotypic coefficient of variations was highest for characters *viz*., number of primary branches per plant (77.96%), green pod yield per hectare (32.26%), green pod yield per plot (32.22%), green pod yield

per plant (28.77%), pod length (28.26%), number of seeds per green pod (22.39%) and number of pods per cluster (20.47%). The high values of GCV suggested greater phenotypic genotypic variability among the genotypes and responsiveness of the attributes for making further improvement by selection. Similar finding reported by Thouseem *et al*., (2018), Gudadinni *et al.,* (2017), Sharma *et al*., (2017), Tambolkar *et al.,* (2016), Thakur *et al.,* (2016), Kumar *et al*., (2015) and Selvi *et al*., (2014).

The moderate variability recorded in the characters, such as number of clusters per plant (19.03%), plant height (17.76%), number of pickings (15.71%), days to first picking (14.20%), days to first flowering (13.14%) and days to 50 per cent flowering (11.46%). This indicated the moderate variability influenceed by environment. Similar finding reported by Kaur *et al*., (2018), Thouseem *et al*., (2018), Gudadinni *et al.,* (2017), Srinivas *et al.,* (2017), Ahmad *et al*., (2014) and Pal and Singh (2013).

The low variability noted only in crop duration (8.28%) characters, which indicated the major influence of environment. Similar finding reported by Tambolkar *et al*., (2016).

4.4 Heritability

Heritability which denotes the proportion of genetically controlled variability expressed by a programme for a particular character or a set of character is very important biometrical tool for guiding plant breeders for adoption of appropriate breeding procedures. High heritability in broad sense is helpful in identifying appropriate character for selection and enables the breeder to select superior genotypes on the basis of phenotypic expression of quantitative characters.

Heritability in broad sense estimates were highest for pod length (98.9%), number of primary branches per plant (98.8%), number of seeds per green pod (97.1%), number of clusters per plant (96.3%), days to 50 per cent flowering (95.2%), number of pods in cluster (94.2%), days to first picking (93.2%), days to initiation of first flowering (93.1%), green pod yield per plant

(92.3%), green pod yield per plot (89.6%), green pod yield per hectare (89.6%), plant height (86.1%) and number of pickings (82.7%). It indicated that characters were less influenced by environmental effect. This variation is due to total genetic variance. It reflected that the phenotypes were the true representative of their genotypes and selection based on phenotypic performance would be reliable. Similar finding reported by Gupta *et al.* (2018), Kaur *et al*. (2018), Thouseem *et al.,* (2018), Gudadinni *et al*., (2017), Santosha *et al.,* (2017), Sharma *et al*., (2017), Srinivas *et al*., (2017), Tambolkar *et al.,* (2016), Ahmad *et al.,* (2014), Selvi *et al*., (2014) and Pal and Singh (2013).

The estimates of heritability was moderate only for crop duration (45.1%) It indicated that character was moderately influenced by environmental effect. This indicated that selection based on phenotypic performance would be effective. Similar finding reported by Tambolkar *et al.,* (2016).

4.5 Genetic advance

Genetic advance as percent of mean ranged between 11.46% for crop duration to 159.62% for number of primary branches per plant. The highest estimate of genetic advance as percent of mean was recorded for number of primary branches per plant (159.62%), green pod yield per hectare (62.91%), green pod yield per plot (62.81%), pod length (57.90%), green pod yield per plant (56.93%), number of seeds per green pod (45.47%), number of pods in cluster (40.93%), number of clusters per plant (38.47%), plant height (33.95%), number of pickings (29.42%), days to first picking (28.24%), days to initiation of first flowering (26.11%) and days to 50 per cent flowering (23.03%). %). This indicated that these characters were governed by additive genes and selection of this trait is more effective. Similar finding reported by Gupta *et al.* (2018), Kaur *et al*., (2018), Thouseem *et al.,* (2018), Gudadinni *et al*., (2017), Santosha *et al.,* (2017), Sharma *et al*., (2017), Srinivas *et al*., (2017), Tambolkar *et al.,* (2016), Ahmad *et al.* (2014), Selvi *et al*., (2014) and Pal and Singh (2013).

Whereas, moderate genetic advance estimates was observed only for crop duration (11.46%) character. It indicated that, this character governed by additive gene action and selection of this trait is more effective. Similar finding reported by Thouseem *et al.,* (2018) and Tambolkar *et al.,* (2016).

Heritability however indicates only the effectiveness with which selection of a genotype can be based on phenotypic performance, but fails to indicate the genetic progress. Heritability estimates along with genetic advance are more effective and reliable in predicting the improvement through selection (Johnson *et al.,* 1955).

High heritability coupled with high genetic advance were observed for plant height, number of primary branches per plant, days to initiation of first flowering, days to 50 per cent flowering, days to first picking, number of pickings, number of clusters per plant, number of pods per cluster, pod length, number of seeds per green pod, green pod yield per plant, green pod yield per plot and green pod yield per hectare (Tables 4). The results suggested the importance of additive gene action for the inheritance of these characters and improvement could be brought about by phenotypic selection. Similar finding reported by Gupta *et al.,* (2018), Thouseem *et al.,* (2018), Gudadinni *et al*., (2017), Sharma *et al*., (2017), Tambolkar *et al.,* (2016), Pal and Singh (2013) and Ahmad *et al.,* (2014).

Moderate heritability coupled with moderate genetic advance was observed for crop duration. The result suggested the importance of additive gene action for the inheritance of this character and improvement could be brought about by phenotypic selection. Similar finding reported by Tambolkar *et al.,* (2016).

Table 6: Genotypic and phenotypic coefficients of correlation among different traits of pea

		PH	PBP	1st F	50% F	1st Pick	No Pick	Clu/Plant	Pods/Clu	PL	Seeds/pod	Crop Dur	Y/Plot	Y/ha	Y/Plant
PH	rg	**1.000**	0.762**	0.568**	0.615**	0.622**	-0.118	0.804**	0.066	-0.857**	-0.736**	0.139	-0.807**	-0.807**	-0.769**
	rp	**1.000**	0.701**	0.482**	0.544**	0.571**	-0.088	0.735**	0.057	-0.793**	-0.688**	0.121	-0.681**	-0.681**	-0.653**
PBP	rg		**1.000**	0.187	0.219	0.305*	0.303	0.578**	-0.231	-0.674**	-0.393**	-0.243	-0.492**	-0.492**	-0.517**
	rp		**1.000**	0.188	0.207	0.292	0.275	0.568**	-0.221	-0.664**	-0.385*	-0.172	-0.457**	-0.457**	-0.487**
1st F	rg			**1.000**	1.026**	0.929**	-0.445**	0.544**	0.498**	-0.598**	-0.716**	0.537**	-0.635**	-0.636**	-0.607**
	rp			**1.000**	0.959**	0.851**	-0.399**	0.510**	0.500**	-0.566**	-0.682**	0.295	-0.558**	-0.558**	-0.554**
50% F	rg				**1.000**	0.955**	-0.462**	0.586**	0.502**	-0.631**	-0.747**	0.548**	-0.651**	-0.651**	-0.627**
	rp				**1.000**	0.877**	-0.399**	0.555**	0.468**	-0.616**	-0.703**	0.326*	-0.621**	-0.622**	-0.601**
1st Pick	rg					**1.000**	-0.324*	0.627**	0.436**	-0.755**	-0.697**	0.578**	-0.673**	-0.674**	-0.647**
	rp					**1.000**	-0.285	0.592**	0.417**	-0.722**	-0.672**	0.374*	-0.612**	-0.614**	-0.612**
No Pick	rg						**1.000**	-0.262	-0.590**	0.108	0.420**	-0.276	0.336*	0.335*	0.247
	rp						**1.000**	-0.198	-0.545**	0.116	0.377*	-0.191	0.314*	0.313*	0.248
Clu/Plant	rg							**1.000**	0.091	-0.689**	-0.632**	-0.068	-0.685**	-0.685**	-0.655**
	rp							**1.000**	0.087	-0.670**	-0.620**	-0.050	-0.642**	-0.642**	-0.617**
Pods/Clu	rg								**1.000**	-0.069	-0.304	0.545**	0.075	0.074	0.133
	rp								**1.000**	-0.072	-0.303	0.364*	0.043	0.042	0.106
PL	rg									**1.000**	0.751**	-0.248	0.675**	0.676**	0.684**
	rp									**1.000**	0.738**	-0.154	0.652**	0.653**	0.664**
Seeds/Pod	rg										**1.000**	-0.461**	0.738**	0.739**	0.707**
	rp										**1.000**	-0.275	0.682**	0.683**	0.662**
Crop Dur	rg											**1.000**	-0.177	-0.179	-0.131
	rp											**1.000**	-0.198	-0.198	-0.119
Y/Plot	rg												**1.000**	1.000**	0.996**
	rp												**1.000**	1.000**	0.976**
Y/ha	rg													**1.000**	0.996**
	rp													**1.000**	0.977**
Y/Plant	rg														**1.000**
	rp														**1.000**

*-significant at 5% level and **-significant at 1% level **PH-** Plant Height, **PBP-**Primary branches per plant, **1st F-** Days to first flowering, **50% F-** Days to 50% flowering, **1st Pick-** Days to first picking, **No Pick-** Number of pickings, **Clu/Plant-** Number of clusters per plant, **Pods/Clu-** Number of pods per cluster, **PL-** Pod length, **Seeds/pod-**Number of seeds per pod, **Crop Dur-** Crop duration, **Y/Plot-**Green pod yield per plot, **Y/ha-** Green pod yield per hector, **Y/Plant-** Green pod yield per plant, **G-** Genotypic correlation, **P-** Phenotypic correlation.

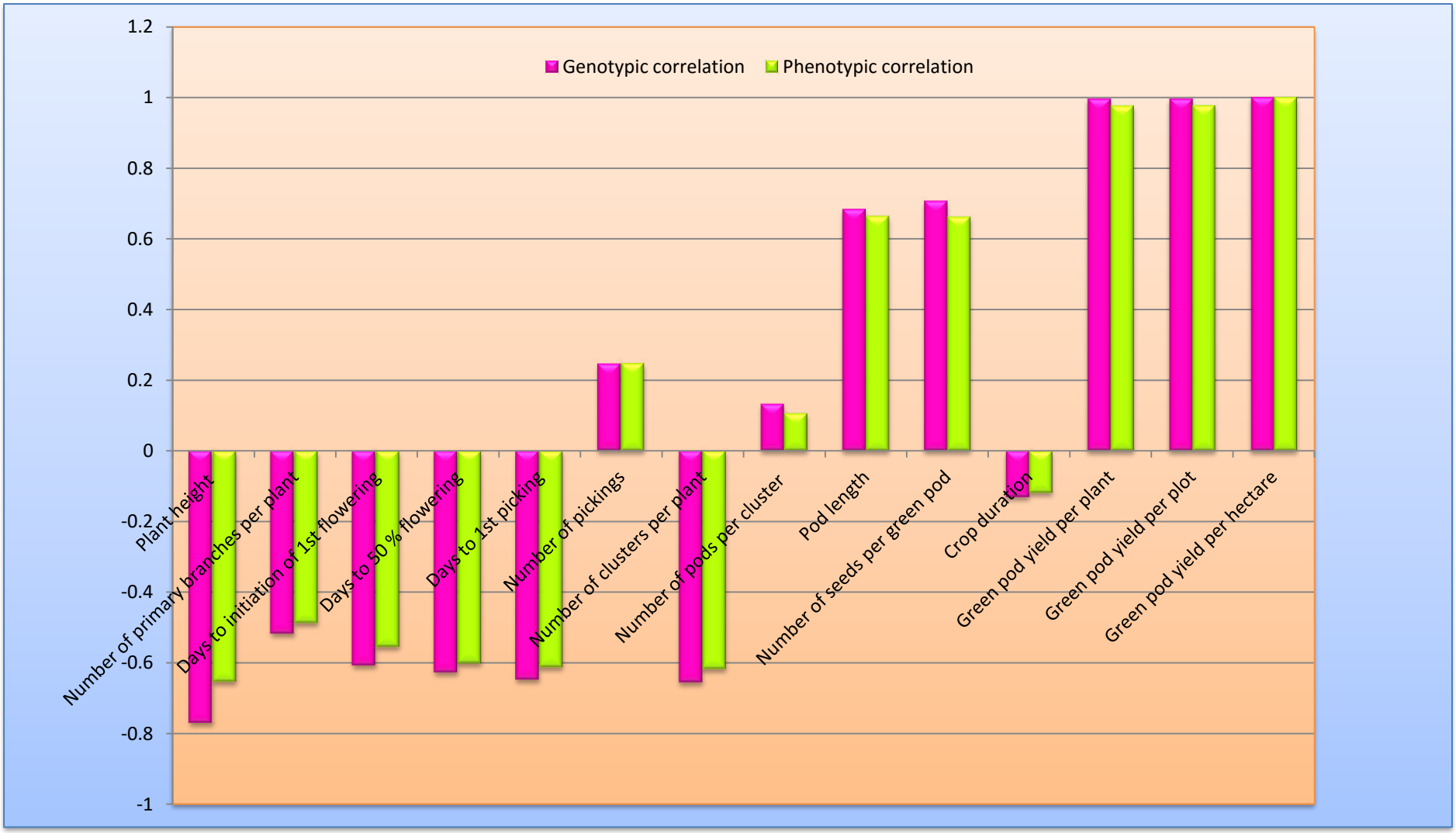


Fig.4: Genotypic and phenotypic correlation coefficient for 14 characters in pea

4.6 Correlation coefficient analysis

A wide range of variation in quantitative characters provides the basis for selection in plant breeding programme. The knowledge of association among the characters is useful to the breeder for improving the efficiency of selection. Correlation coefficient analysis measures the mutual relationship between plant characters and determines the component character on which selection can be made for genetic improvement of yield. Investigation regarding the presence of component and nature of association among themselves is essential and prerequisite for improvement in yield. Correlation coefficient provides a clear picture of the extent of association between a pair of traits and indicates whether simultaneous improvement of the correlated traits may be possible or not. The knowledge of genetic association between yield and its component characters help in improving the efficiency of selection for yield by making proper choice and balancing one component with another.

The magnitude of genotypic correlation was higher than the phenotypic correlation for all the traits that indicated inherent association between various characters.

Correlation coefficient of green pod yield per plant was recorded highly significant and positive with green pod yield per plot (rg=0.996, rp=0.976), green pod yield per hectare (rg=0.996, rp=0.976), number of seeds per green pod (rg=0.707, rp=0.662) and pod length (rg=0.684, rp=0.664). Green pod yield per plant was recorded highly significant and negative correlation with plant height (rg=-0.769, rp=-0.653), number of clusters per plant (rg=-0.655, rp=-0.617), days to first picking (rg=-0.647, rp=-0.612), days to 50 per cent flowering (rg=-0.627, rp=-0.601), days to first flowering (rg=-0.607, rp=-0.554) and number of primary branches per plant (rg=-0.517, rp=-0.487) at both genotypic and phenotypic levels. These characters are responsible for increasing green pod yield per plant. Characters like days to first flowering, days to 50 per cent flowering and days to first picking were recorded negative and significant correlation with green pod yield per plant these characters showing earliness in pea crop. Similar finding reported by Diwaker *et al.,*

(2018), Kumar *et al*., (2015), Kumawat *et al.,* (2018), Basaiwala *et al.,* (2013) and Gupta *et al*., (2007).

4.6.1 Plant height

Plant height showed significant and positive correlation with number of primary branches per plant (rg=0.762, rp=0.701), days to first flowering (rg=0.568, rp=0.482), days to 50 per cent flowering (rg=0.615, rp=0.544), days to first picking (rg=0.622, rp=0.571) and number of clusters per plant (rg=0.804, rp=0.735) at both genotypic and phenotypic levels. Similar finding reported by Kumawat *et al.,* (2018), Singh *et al*., (2011) and Gupta *et al*., (2007).

However, it showed negative but significant correlation with pod length (rg=-0.857, rp=-0.793), number of seeds per pod (rg=-0.736, rp=-0.688), green pod yield per plot (rg=-0.807, rp=-0.681), green pod yield per hectare (rg=-0.807, rp=-0.681) and green pod yield per plant (rg=-0.769, rp=-0.653) at both genotypic and phenotypic levels. Similar finding reported by Pandey *et al.,* (2017), Kumar *et al.,* (2015) and Gupta *et al*., (2007).

4.6.2 Number of primary branches per plant

Number of primary branches per plant showed significant and positive correlation with number of clusters per plant (rg=578, rp=568) at both genotypic and phenotypic level and days to first picking (rg= 0.305) positive and significant only at genotypic level. Similar finding reported by Singh *et al*., (2011) and Gupta *et al*., (2007).

However, it showed negative and significant genotypic and phenotypic correlation with pod length (rg=-0.674, rp=-0.664), number of seeds per pod (rg=-0.393, rp=-0.385), green pod yield per plot (rg=-0.492, rp=-0.457), green pod yield per hector (rg=-0.492, rp=-0.457) and green pod yield per plant (rg=-0.517, rp=-0.487) at both genotypic and phenotypic levels. Similar finding reported by Diwaker *et al.,* (2018) and Rai and Dharmatti (2014).

4.6.3 Days to first flowering

Days to first flowering showed significant and positive correlation with days to 50 per cent flowering (rg=1.026, rp=0.959), days to first picking (rg=0.929, rp=0.851), number of clusters per plant (rg=0.544, rp=0.510) and number of pods per cluster (rg=0.498, rp=0.500) at both genotypic as well as phenotypic level and crop duration (rg= 0.537) is positive and significant only at genotypic level. Similar finding reported by Kumawat *et al*. (2018), Gupta *et al*., (2007) and Srinivas *et al.,* (2017).

However, negative but significant correlations with number of pickings (rg=-0.445, rp=-0.399), pod length (rg=-0.598, rp=-0.566), number of seeds per pod (rg=-0.716, rp=-0.682), green pod yield per plot (rg=-0.635, rp=-0.558), green pod yield per hector rg=-0.635, rp=-0.558) and green pod yield per plant (rg=-0.607, rp=-0.554) at both genotypic and phenotypic levels. Similar finding reported by Kumawat *et al*., (2018), Gupta *et al*., (2007), Palve *et al*., (2018) and Srinivas *et al.,* (2017).

4.6.4 Days to 50 per cent flowering

Days to 50 per cent flowering showed significant and positive correlation with days to first picking (rg=0.955, rp=0.877), number of clusters per plant (rg=0.586, rp=0.555) number of pods per cluster (rg=0.502, rp=0.468) and crop duration (rg=0.548, rp=0.326) at both genotypic and phenotypic levels. Similar finding reported by Rahman *et al*., (2019), Pandey *et al*., (2017) and Patel *et al*., (2016).

However, it showed negative but significant correlations with number of pickings (rg=-0.462, rp=-0.399), pod length (rg=-0.631, rp=-0.616), number of seeds per pod (rg=-0.747, rp=-0.703), green pod yield per plot (rg=-0.651, rp=-0.621), green pod yield per hectare (rg=-0.651, rp=-0.622) and green pod yield per plant (rg=-0.627, rp=-0.601) at both genotypic and phenotypic levels. Similar finding reported by Kumawat *et al.,* (2018), Pandey *et al*., (2017) and Basaiwala *et al.,* (2013).

4.6.5 Days to first picking

Days to first picking showed significant and positive correlation with number of clusters per plant (rg=0.627, rp=0.592), number of pods per cluster (rg=0.436, rp=0.417) and crop duration (rg=0.578, rp=0.374) at both genotypic and phenotypic levels.

However, it showed negative but significant correlations with pod length (rg=-0.755, rp=-0.722), number of seeds per pod (rg=-0.697, rp=-0.672), green pod yield per plot (rg=-0.673, rp=-0.612), green pod yield per hectare (rg=-0.674, rp=-0.614) and green pod yield per plant (rg=-0.647, rp=-0.612) at both genotypic and phenotypic levels and number of pickings (rg=-0.324) negative and significant only at genotypic level. Similar finding reported by Diwaker *et al.,* (2018) and Gupta *et al.,* (2007).

4.6.6 Number of pickings

Number of pickings showed significant and positive correlation with number of seeds per pod (rg=0.420, rp=0.377), green pod yield per plot (rg=0.336, rp=314) and green pod yield per hectare (rg=0.335, rp=0.313) at both genotypic and phenotypic levels. Similar finding reported by Sharma *et al.*, (2012).

However, it showed negative but significant correlations with number of pods per cluster (rg=-0.590, rp=-0.545) at both genotypic and phenotypic levels.

4.6.7 Number of clusters per plant

Number of clusters per plant showed significant and negative correlation with pod length (rg=-0.689, rp=-0.670), number of seeds per pod (rg=-0.632, rp=-0.620), green pod yield per plot (rg=-0.685, rp=-0.642), green pod yield per hectare (rg=-0.685, rp=-0.642) and green pod yield per plant (rg=-0.655, rp=-0.617) at both genotypic and phenotypic levels. Similar finding reported by Srinivas *et al.,* (2017), Patel *et al.,* (2016) and Singh *et al.,* (2011).

4.6.8 Number of pods per cluster

Number of pods per cluster showed significant and positive correlation with crop duration (rg=0.545, rp=0.364) at both genotypic and phenotypic levels.

4.6.9 Pod length

Pod length showed significant and positive correlation with number of seeds per pod (rg=0.751, rp=0.738), green pod yield per plot (rg=0.675, rp=0.652), green pod yield per hectare (rg=0.676, rp=0.653) and green pod yield per plant (rg=0.684, rp=0.664) at both genotypic and phenotypic levels. Similar finding reported by Kumawat *et al.* (2018), Devi *et al.,* (2017) and Gupta *et al*., (2007).

4.6.10 Number of seeds per pod

Number of seeds per pod showed significant and positive correlation with green pod yield per plot (rg=0.738, rp=0.682), green pod yield per hectare (rg=0.739, rp=0.683) and green pod yield per plant (rg=0.707, rp=0.662) at both genotypic and phenotypic levels. Similar finding reported by Kumawat *et al.,* (2018) and Devi *et al*., (2017).

However, it showed negative but significant correlations with crop duration (rg=-0.461) at only genotypic level.

4.6.11 Crop duration

Crop duration showed negative but non-significant correlation with green pod yield per plant (rg=-0.131, rp=-0.119), green pod yield per plot (rg=-0.177, rp=-0.198) and green pod yield per hectare (rg=-0.179, rp=-0.198) at both genotypic and phenotypic levels.

4.6.12 Green pod yield per plot

Green pod yield per plot showed significant and positive correlation

with green pod yield per hectare (rg=1.00, rp=1.00) and green pod yield per plant (rg=0.996, rp=0.976) at both genotypic and phenotypic levels.

4.6.13 Green pod yield per hectare

Green pod yield per hectare showed significant and positive correlation with green pod yield per plant (rg=0.996, rp=0.977) at both genotypic and phenotypic levels. Similar finding reported by Kumawat *et al*., (2018).

4.7 Path analysis

Correlation coefficients, which measure the association between any two characters, may not give a true or comprehensive picture of a rather complex situation. Path coefficient analysis provides an efficient means of measuring the direct and indirect effects of one variable through the other variables on the end product. The path coefficient analysis was carried out at genotypic level. The direct and indirect effect of various traits on green pod yield per plant is presented in Table 7.

4.7.1 Plant height

Plant height had negative direct effect (-0.061) on green pod yield per plant. However, positive indirect effect through number of pickings (0.007), pod length (0.052), number of seeds per green pod (0.045), green pod yield per plot (0.049), green pod yield per hectare (0.049) and negative indirect effect *via.*, number of primary branches per plant (-0.046), days to initiation of first flower (-0.345), days to 50 per cent flowering (-0.037), days to first picking (-0.038), number of clusters per plant (-0.049), number of pods in cluster (-0.004), crop duration (-0.008). Similar finding reported by Kumawat *et al*., (2018), Srivastava *et al.,* (2018), Pandey *et al*., (2017), Katoch *et al.,* (2016), Katoch *et al.,* (2016), Kumar *et al*., (2015), Siddika *et al*., (2013), Sharma *et al.,* (2012) and Yadav *et al*., (2010).

Table 7: Genotypic path estimates of direct and indirect effects of different traits on green pod yield per plant in pea

	PH	PBP	1st F	50% F	1st Pick	No Pick	Clu/ Plant	Pods /Clu	PL	Seeds/ Pod	Crop Dur	Y/Plot	Y/ha	Y/Plant	Partial R^2
PH	**-0.061**	-0.046	-0.035	-0.038	-0.038	0.007	-0.049	-0.004	0.052	0.045	-0.009	0.049	0.049	-0.769	0.047
PBP	0.261	**0.342**	0.064	0.075	0.104	0.104	0.198	-0.079	-0.230	-0.135	-0.083	-0.168	-0.168	-0.517	-0.177
1st F	-0.008	-0.003	**-0.013**	-0.014	-0.012	0.006	-0.007	-0.007	0.008	0.010	-0.007	0.009	0.009	-0.607	0.008
50% F	0.154	0.055	0.258	**0.251**	0.240	-0.116	0.147	0.126	-0.159	-0.188	0.138	-0.164	-0.164	-0.627	-0.157
1st Pick	-0.187	-0.092	-0.280	-0.287	**-0.301**	0.098	-0.189	-0.131	0.227	0.210	-0.174	0.203	0.203	-0.647	0.195
No Pick	0.011	-0.029	0.042	0.044	0.031	**-0.094**	0.025	0.056	-0.010	-0.040	0.026	-0.032	-0.032	0.247	-0.023
Clu/Plant	0.100	0.072	0.067	0.073	0.078	-0.033	**0.124**	0.011	-0.085	-0.078	-0.008	-0.085	-0.085	-0.655	-0.081
Pods/Clu	0.005	-0.017	0.037	0.038	0.033	-0.044	0.007	**0.075**	-0.005	-0.023	0.041	0.006	0.006	0.133	0.010
PL	0.131	0.103	0.091	0.096	0.115	-0.016	0.105	0.011	**-0.152**	-0.114	0.038	-0.103	-0.103	0.684	-0.104
Seeds/Pod	-0.100	-0.054	-0.098	-0.102	-0.095	0.057	-0.086	-0.041	0.102	**0.136**	-0.063	0.101	0.101	0.707	0.096
Crop Dur	-0.009	0.015	-0.034	-0.035	-0.037	0.017	0.004	-0.034	0.016	0.029	**-0.063**	0.011	0.011	-0.131	0.008
Y/Plot	10.318	6.296	8.123	8.323	8.608	-4.296	8.758	-0.956	-8.628	-9.440	2.262	**-12.786**	-12.786	0.996	-12.739
Y/ha	-11.068	-6.754	-8.723	-8.933	-9.251	4.596	-9.401	1.012	9.267	10.134	-2.449	13.717	**13.717**	0.996	13.666

R SQUARE = 0.9986 RESIDUAL EFFECT = 0.0372

PH- Plant Height, **PBP-**Primary branches per plant, **1st F-** Days to first flowering, **50% F-** Days to 50%flowering, **1st Pick-** Days to first picking, **No Pick-** Number of pickings, **Clu/Plant-** Number of clusters per plant, **Pods/Clu-** Number of pods per cluster, **PL-** Pod length, **Seeds/pod-**Number of seeds per pod, **Crop Dur-** Crop duration, **Y/Plot-**Green pod yield per plot, **Y/ha-** Green pod yield per hectare, **Y/Plant-** Green pod yield per plant

4.7.2 Number of primary branches per plant

Number of primary branches per plant had positive direct effect (0.342) on green pod yield per plant. However, positive indirect effect through plant height(0.260, days to initiation of first flowering (0.064), days to 50 per cent flowering (0.075), days to first picking (0.104), number of pickings (0.104), number of clusters per plant (0.198) and negative indirect effect *via*., number of pods in cluster (-0.079), pod length (-0.230), number of seeds per green pod (-0.134), crop duration (-0.0830), green pod yield per plot (-0.168), green pod yield per hectare (-0.168). Similar finding reported by Srivastava *et al*., (2018), Pandey *et al.,* (2017) and Singh *et al.,* (2011).

4.7.3 Days to initiation of first flowering

Days to initiation of first flowering had negative direct effect (-0.013) on green pod yield per plant. However, positive indirect effect through number of pickings (0.006), pod length (0.008), number of seeds per green pod (0.010), green pod yield per plot (0.008), green pod yield per hectare (0.068). Indirect negative effect through plant height (-0.008), number of primary branches per plant (-0.002), days to fifty percent flowering (-0.014), days to first picking (-0.012), number of clusters per plant (-0.007), number of pods in cluster (-0.007) and crop duration (0.007). Similar finding reported by Kumawat *et al*., (2018), Khan *et al.,* (2017) and Yadav *et al.,* (2010).

4.7.4 Days to 50 per cent flowering

Days to 50 per cent flowering had positive direct effect (0.251) on green pod yield per plant. However, positive indirect effect through plant height (0.154), number of primary branches per plant (0.055), days to initiation of first flowering (0.258), days to first picking (0.240), number of clusters per plant (0.147), number of pods in cluster (0.126), crop duration (0.138) However, negative indirect effect *via*, number of pickings (-0.116), pod length (-0.158), number of seeds per green pod (-0.188), green pod yield per plot (-0.163), green pod yield per hectare (-0.163). Similar finding reported by Kumawat *et*

al., (2018), Lal *et al*., (2018), Srivastava *et al.,* (2018), Pandey *et al.,* (2017), Katoch *et al*., (2016), Singh and Lavanya (2014), Basaiwala *et al.,* (2013), Suddika *et al.*, (2013), Sharma *et al*., (2012) and Tiwari and Lavanya (2012).

4.7.5 Days to first picking

Days to first picking had negative direct effect (-0.301) on green pod yield per plant. Whereas, positive indirect effect *via,* number of pickings (0.098), pod length (0.227), number of seeds per green pod (0.210), green pod yield per plot (0.203), green pod yield per hectare (0.203) and negative indirect effect *via.*, plant height (-0.187), number of primary branches per plant (-0.092), days to initiation of first flowering (-0.280), days to 50 per cent flowering (-0.287), number of clusters per plant (-0.189), number of pods in cluster (-0.131), crop duration (-0.174). Similar finding reported by Katoch *et al.,* (2016) and Sharma *et al*., (2012).

4.7.6 Number of pickings

Number of pickings had negative direct effect (-0.094) on green pod yield per plant. However, positive indirect effect through plant height (0.011), days to initiation of first flowering (0.042), days to 50 per cent flowering (0.044), days to first picking (0.031), number clusters per plant (0.025), number of pods in cluster (0.056), crop duration (0.026). However, negative indirect effect *via*, number of primary branches per plant (-0.029), pod length (-0.010), number of seeds per green pod (-0.040), green pod yield per plot (-0.032), green pod yield per hectare (0.032). Similar finding reported by Sharma *et al*., (2012).

4.7.7 Number clusters per plant

Number clusters per plant had positive direct effect (0.124) on green pod yield per plant. However, positive indirect effect through plant height (0.100), number of primary branches per plant (0.072), days to initiation of first flowering (0.067), days to 50 per cent flowering (0.073), days to first picking

(0.078), number of pods in cluster (0.011), However, negative indirect effect *via*, number of pickings (-0.032), pod length (-0.085), number of seeds per green pod (-0.078), crop duration (-0.008), green pod yield per plot (-0.085), green pod yield per hectare (-0.085). Similar finding reported by Srinivas *et al.*, (2017).

4.7.8 Number of pods per cluster

Number of pods in cluster had positive direct effect (0.075) on green pod yield per plant. However, positive indirect effect through plant height (0.005), days to initiation of first flowering (0.037), days to 50 per cent flowering (0.038), days to first picking (0.033), number of clusters per plant (0.007), crop duration (0.041), green pod yield per plot (0.006), green pod yield per hectare (0.005) and negative indirect effect *via*., number of primary branches per plant (-0.017), number of pickings (-0.044), pod length (-0.005), number of seeds per green pod (-0.023). Similar finding reported by Srinivas *et al.,* (2017).

4.7.9 Pod length

Pod length had negative direct effect (-0.152) on green pod yield per plant. However, positive indirect effect through plant height (0.130), no of primary branches per plant (0.103), days to initiation of first flowering (0.091), days to 50 per cent flowering (0.096), days to first picking (0.0115), number of clusters per plant (0.105), number of pods in cluster (0.010), crop duration (0.038), However, negative indirect effect *via*, number of pickings (-0.016), number of seeds per green pod (-0.114), green pod yield per plot (-0.103) and green pod yield per hectare (-0.103). Similar finding reported by Lal *et al*., (2018), Khan *et al.,* (2017), Pandey *et al*., (2017), Tofiq *et al.,* (2015), Singh and Lavanya (2014) and Siddika *et al.,* (2013).

4.7.10 Number of seeds per green pod

Number of seeds per green pod had positive direct effect (0.136) on

green pod yield per plant. However, positive indirect effect through number of pickings (0.057), pod length (0.102), green pod yield per plot (0.101), green pod yield per hectare (0.101) and negative indirect effect *via*, plant height (-0.100), number of primary branches per plant (-0.054), days to initiation of first flowering (-0.098), days to 50 per cent flowering (-0.110), days to first picking (-0.095), number of clusters per plant (-0.086), number of pods in cluster (-0.041), crop duration (-0.063). Similar finding reported by Kumawat *et al.,* (2018), Lal *et al*., (2018), Srivastava *et al.,* (2018), Khan *et al*., (2017), Katoch *et al.,* (2016), Kumar *et al*., (2015) and Tofiq *et al*., (2015).

4.7.11 Crop duration

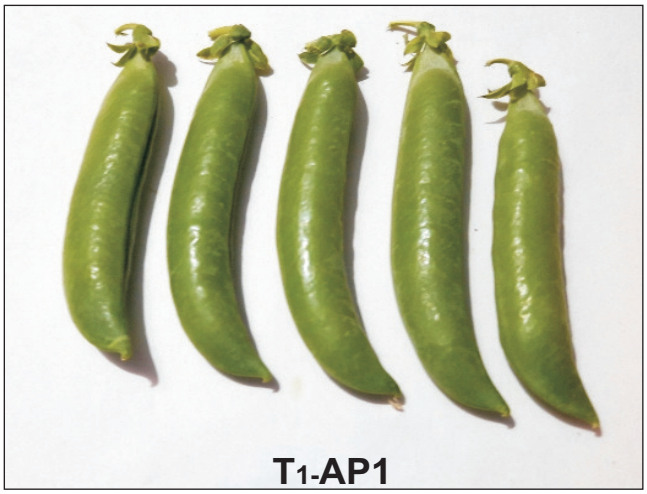
Crop duration had negative direct effect (-0.063) on green pod yield per plant. However, positive indirect effect *via*, number of primary branches per plant (0.015), number of pickings (0.017), number of clusters per plant (0.004), pod length (0.016), number of seeds per green pod (0.029), green pod yield per plot (0.011) and green pod yield per hectare (0.011). However, negative indirect effect *via*, plant height (-0.009), days to initiation of first flower (-0.034), days to 50 per cent flowering (-0.035), days to first picking (-0.036), number of pods in cluster (-0.034). Similar finding reported by Patel *et al.,* (2016).

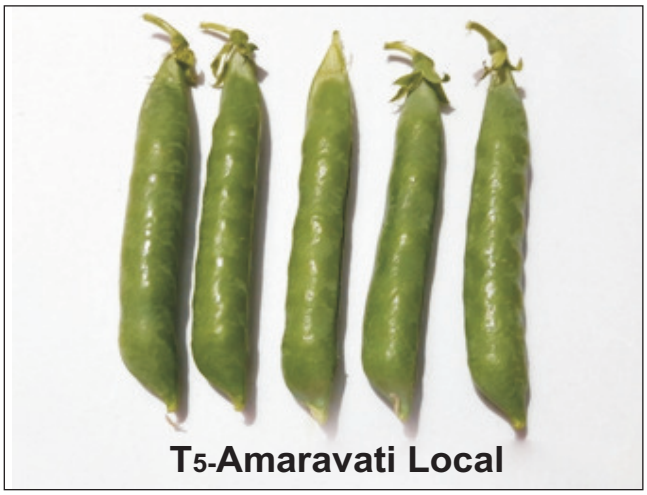
4.7.12 Green pod yield per plot

Green pod yield per plot had negative direct effect (-12.785) on green pod yield per plant. However, positive indirect effect through plant height (10.318), number of primary branches per plant (6.295), days to initiation of first flowering (8.123), days to 50 per cent flowering (8.323), days to first picking (8.607), number of clusters per plant (8.758) and crop duration (2.262), However, negative indirect effect *via,* number of pickings (-4.295), number of pods per cluster (-0.956), pod length (-8.6280) number of seeds per green pod (-9.439), green pod yield per hectare (-12.785). Similar finding reported by Srivastava *et al.,* (2018).

4.7.13 Green pod yield per hectare

Green pod yield per hectare recorded positive direct effect (13.717) on green pod yield per plant. However positive indirect effect *via.*, number of pickings (4.596), number of pods per cluster (1.012), pod length (9.267), number of seeds per green pod (10.134) and green pod yield per plot (13.717) However, negative indirect effect *via*., plant height (-11.068), number of primary branches per plant (-6.754), days to initiation of first flower (-8.723), days to 50 per cent flowering (-8.933), days to first picking (-9.251), number of clusters per plant (-9.401) and crop duration (-2.448). Similar finding reported by Sharma *et al*., (2012).





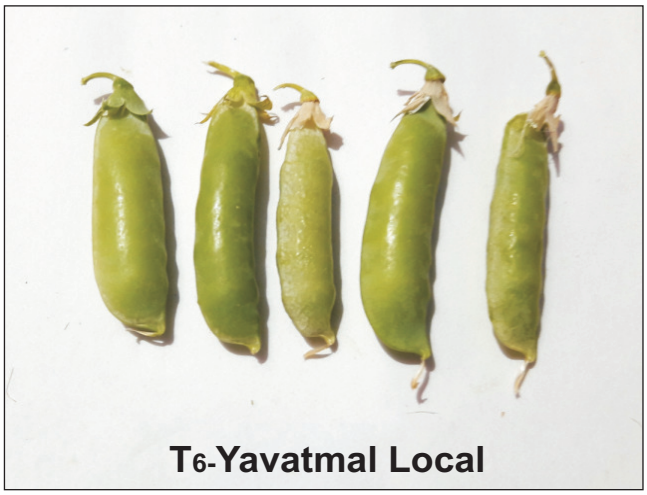
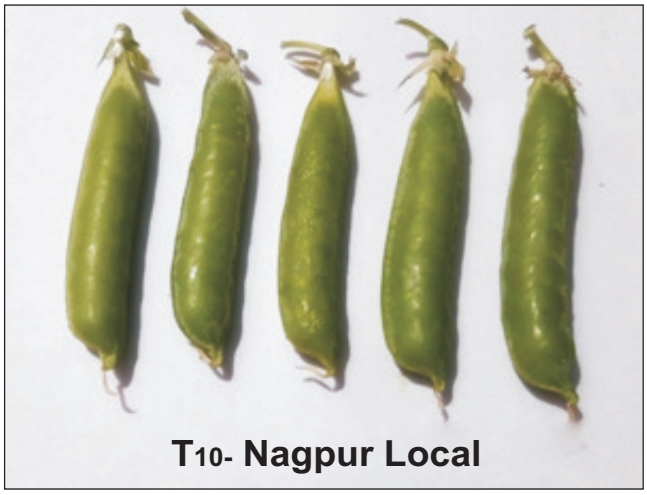


Plate No.2 Variability for pod characters in pea

T8- Wardha Local

T9- Chandrapur Local

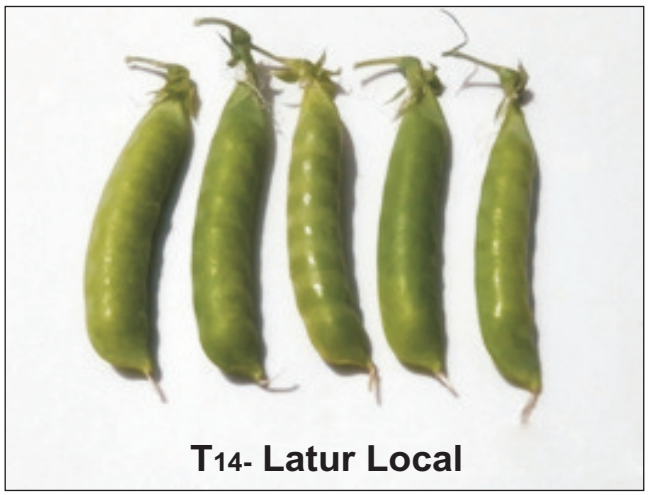


T10- Nagpur Local

T11- Washim Local

T12- Pune Local

T13- Parbhani Local

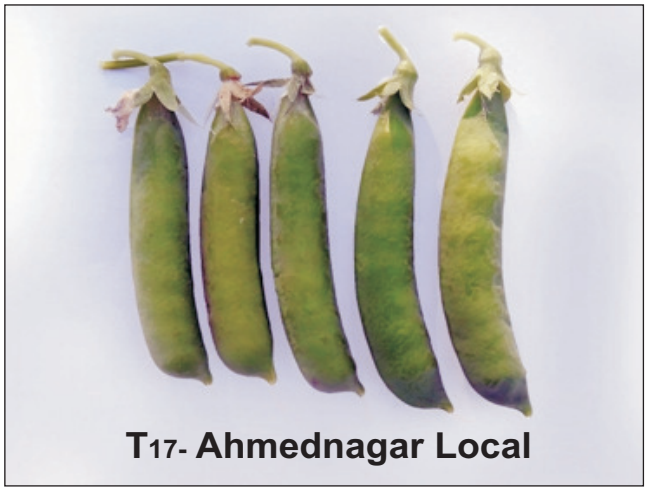


T14- Latur Local

Plate No.3 Variability for pod characters in pea

T_{15}- Hingoli Local

T_{16}- Kolhapur Local



T_{17}- Ahmednagar Local

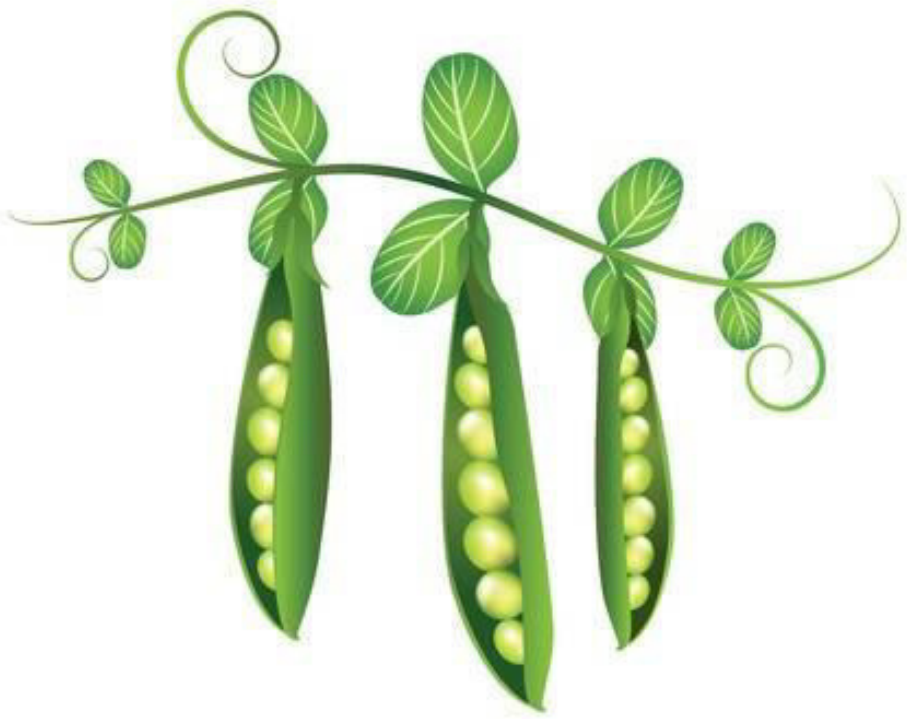
T_{18}- Solapur Local

T_{19}- Satara Local

T_{20}- Baramati Local

T_{21}- Phule Priya

Plate No.4 Variability for pod characters in pea



SUMMARY AND CONCLUSION

Chapter-V

SUMMARY AND CONCLUSION

The present investigation entitled "Variability studies in pea (*Pisum Sativum* L.)" was carried out during *Rabi* season of 2017-18 at Instructional-Cum-Research Farm, Department of Horticulture, College of Agriculture, Latur. The statistical design adapted was Randomized Block Design (RBD) with twenty one treatments replicated twice.

The observation were recorded on plant height (cm), number of primary branches per plant, days to initiation of first flowering, days to 50 per cent flowering, days to first picking, number of pickings, number of clusters per plant, number of pods per cluster, pod length (cm), number of seeds per green pod, crop duration (days), physiological loss of weight (%), T.S.S. content (%), green pod yield per plant (g), green pod yield per plot (kg) and green pod yield per hectare (q).

A wide range of variability was observed for quantitative characters. The estimates of genotypic coefficients of variation were lower than that of phenotypic coefficient of variation. Genotypic as well as phenotypic coefficients of variation were highest observed in number of primary branches per plant, number of pods per cluster, pod length, number of seeds per green pod, green pod yield per plant, green pod yield per plot and green pod yield per hectare. Moderate PCV and GCV were recorded for characters plant height, days to initiation of first flowering, days to 50 per cent flowering, days to first picking, number of pickings and number of clusters per plant. However, moderate PCV and low GCV were recorded only for crop duration.

Heritability estimates (broad sense) were found high degree to moderate. High heritability was observed in plant height, number of primary branches per plant, days to initiation of first flowering, days to 50 per cent flowering, days to first picking, number of pickings, number of clusters per plant, number of pods in cluster, pod length, number of seeds per green pod, green pod yield per

plant, green pod yield per plot and green pod yield per hectare. While, moderate heritability was observed only in crop duration.

High values of genetic advance were recorded for number of primary branches per plant, green pod yield per hectare, green pod yield per plot, pod length, green pod yield per plant, number of seeds per green pod, number of pods in cluster, number of clusters per plant, plant height, number of pickings, days to first picking, days to initiation of first flowering and days to 50 per cent flowering. Whereas, moderate estimates were observed only for crop duration indicated that, these characters have scope for improvement through selection.

The genotypic and phenotypic correlation coefficient studied between yield and its contributing characters indicating that, the green pod yield per plant exhibited positive and significant correlation with pod length, number of seed per green pod, green pod yield per plot and green pod yield per hectare at both levels. Whereas, significant negative correlation were recorded for plant height, number of primary branches per plant, days to first flowering, days to first 50 per cent flowering, days to first picking and number of clusters per plant at both genotypic as well as phenotypic levels. Positive but non-significant correlation with number of pickings and number of pods per clusters at both genotypic as well as phenotypic levels. While, only crop duration was negatively non significant correlated with green pod yield per plant at both genotypic and phenotypic level.

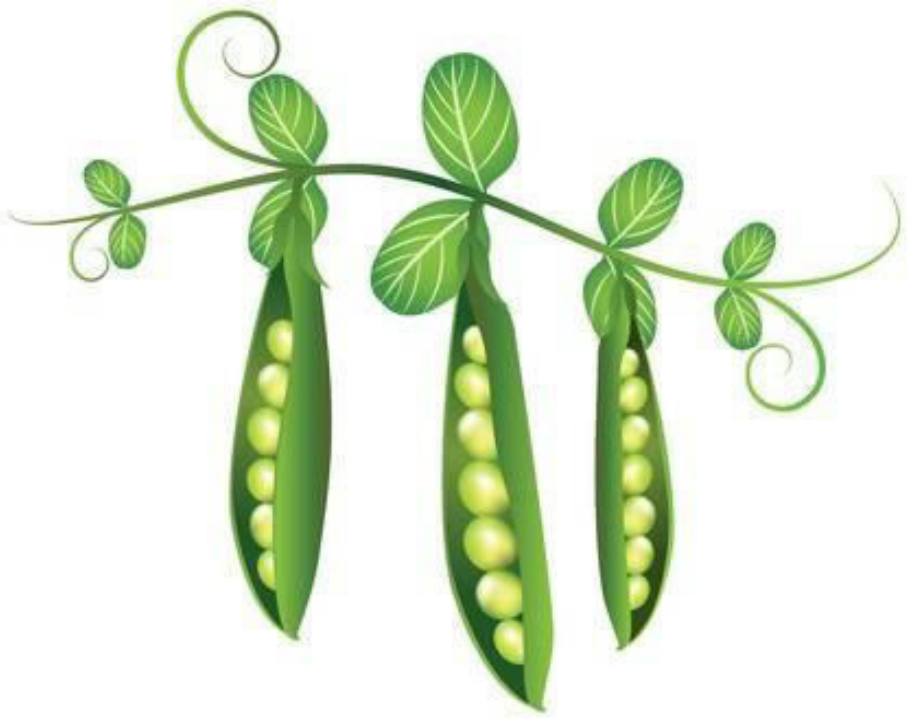
Path analysis indicated that, the importance of yield contributing characters like number of primary branches per plant, days to 50 per cent flowering, number of seeds per pod, number of clusters per plant, number of pods per cluster and pod yield per hectare which were positively directly influenced by correlations of green pod yield per plant with its components.

The studies also revealed that, the ineffectiveness of other characters *viz*. days to first picking, pod length, number of pickings, crop duration, plant height, days to first flowering and pod yield per plot in correlations with yield.

Conclusion

The range and mean performance of yield, yield contributing components and quality traits revealed that, Phule Priya, Chandrapur Local and AP-3 was found superior than the rest of the genotypes. The genotype 'AP-3' was found early observed from the characters, days to first flowering, days to 50 per cent flowering and days to first picking. For the quality character, the genotype AP-3 and Chandrapur Local were found to be superior for T.S.S. AP-1 and Parbhani Local was found for minimum physiological loss of weight.

Thus, it can be concluded that, from the present investigation, the genotype Phule Priya, Chandrapur Local and AP-3 were superior for yield and yield contributing characters. While, for the quality characters AP-3, Chandrapur Local, AP-1 and Parbhani Local were found superior than the rest of genotypes. The genotypes Phule Priya, Chandrapur Local, AP-3, AP-1 and Parbhani Local were found superior in yield and quality contributing characters in the Marathwada region for commercial cultivation and for further improvement of pea through breeding programme.



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ANNEXURE

ANNEXURE I: Meteorological data recorded at Latur for the period of experiment during *rabi* 2017-18.

Month and year	Standard Week	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	Rainy Days
		Max.	Min.	AM	PM		
November 2017	44	29.3	15.9	85	33	0.0	-
	45	29.3	15.7	79	35	0.0	-
	46	29.7	16.0	73	37	0.0	-
	47	30.5	19.7	86	46	0.0	-
December 2017	48	29.2	14.3	75	30	0.0	-
	49	28.9	16.8	88	47	0.0	-
	50	29.6	15.5	80	35	0.0	-
	51	27.8	11.7	80	30	0.0	-
January 2018	52	27.9	11.6	76	29	0.0	-
	1	27.8	12.7	76	33	0.0	-
	2	28.6	14.8	72	36	0.0	-
	3	28.9	14.7	67	30	0.0	-
February 2018	4	28.0	12.6	68	30	0.0	-
	5	30.5	13.5	61	22	0.0	-
	6	29.9	16.0	62	28	0.0	-
	7	30.0	16.3	87	39	0.0	-

AM- Anti meridian, PM- Post meridian

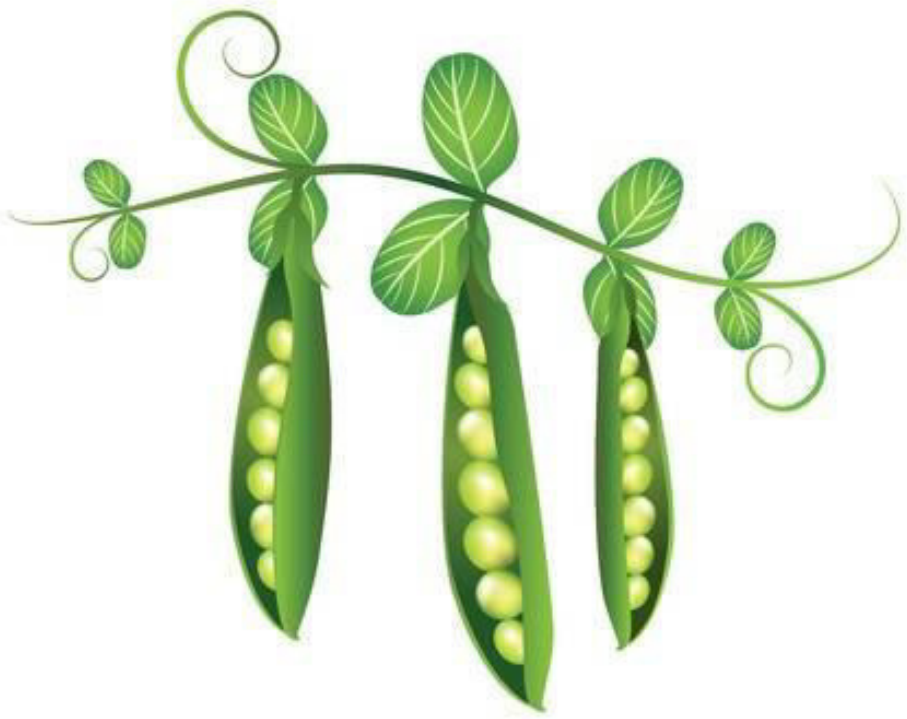
Annexure II: Mean performance of twenty one genotypes

Sr. no.	Treatments	Plant height (cm)	Number of primary branches per plant	No. of Tendrils/plant	Days to Initiation of 1st Flowering	Days to 50% Flowering	Days to First Picking	No. of Pickings	No. of Clusters/ plant	No. of Pods in Cluster
1	AP-1	54.11	1.00	14.90	50.50	56.50	73.50	6.50	5.60	2.00
2	AP-3	48.42	1.00	10.80	33.00	39.00	48.00	7.00	5.30	1.50
3	DPM-10	53.96	1.00	12.80	41.50	47.50	61.00	7.00	5.30	1.70
4	Pea- M Gold	55.34	1.00	11.50	41.50	48.00	63.00	6.50	5.50	1.80
5	Amaravati Local	52.23	1.00	10.00	40.00	46.50	63.50	5.50	5.70	1.70
6	Yavatmal Local	73.27	2.40	22.10	51.00	58.50	80.00	6.00	5.60	2.20
7	Buladhana Local	64.75	2.90	32.10	53.50	59.50	86.00	6.00	7.20	2.20
8	Wardha Local	69.62	2.40	37.80	53.00	60.50	82.50	5.00	7.30	1.90
9	Chandrapur Local	58.87	1.90	22.70	42.00	48.00	57.00	7.00	5.30	1.80
10	Nagpur Local	74.76	2.70	49.20	52.50	59.50	74.50	5.00	8.30	1.80
11	Washim Local	67.02	4.10	63.50	48.50	54.50	72.50	4.00	7.20	2.40
12	Pune Local	51.38	3.30	31.00	42.00	49.00	61.50	6.50	7.60	1.70
13	Parabhani Local	72.16	4.80	73.30	54.00	60.00	84.50	6.50	8.10	2.30
14	Latur Local	96.27	11.00	94.90	42.50	50.00	68.50	8.00	8.40	1.20
15	Hingoli Local	76.76	3.80	42.30	54.00	60.00	84.00	6.00	9.00	2.70
16	Kolhapur Local	77.58	3.00	46.80	52.50	59.50	79.00	6.00	7.60	2.40
17	Ahemadnagar Local	82.23	1.70	32.80	47.00	55.00	73.50	4.00	9.00	2.30
18	Solapur Local	73.83	3.30	44.50	51.00	58.00	73.50	6.00	8.00	1.90
19	Satara Local	62.53	1.00	15.80	42.00	49.00	62.50	6.50	6.50	2.00
20	Baramati Local	75.56	4.10	35.50	45.00	53.00	81.50	7.50	8.90	1.10
21	Phule Priya	56.74	2.15	19.30	37.50	46.00	67.00	6.50	5.90	2.40
	Mean	**66.54**	**2.84**	**34.46**	**46.40**	**53.21**	**71.29**	**6.14**	**7.01**	**1.95**
	S.E. ±	3.36	0.17	2.43	1.17	0.97	1.94	0.31	0.19	0.07
	C.D. 5%	9.91	0.51	7.17	3.46	2.86	5.72	0.92	0.55	0.21

Conti...

Conti...

Sr. no.	Treatments	Pod length	No. of seeds/ green pod	Crop duration	Physiological loss of weight	TSS	Green pod yield/ plot (kg)	Green pod yield/ ha (q)	Green pod yield/ plant (g)
1	AP-1	8.55	7.10	121.00	39.25	14.45	2.04	76.92	36.77
2	AP-3	8.62	7.60	101.50	70.50	16.55	2.35	88.56	41.79
3	DPM-10	9.98	8.80	97.00	60.25	13.70	1.74	65.62	31.30
4	Pea- M Gold	9.93	8.10	106.00	57.15	13.75	1.78	67.04	33.13
5	Amaravati Local	10.09	8.20	106.50	61.10	14.50	1.56	58.70	28.96
6	Yavatmal Local	5.01	4.60	125.00	46.05	12.25	1.14	42.76	21.35
7	Buladhana Local	6.04	6.30	122.50	66.20	12.65	1.15	43.36	22.08
8	Wardha Local	5.86	7.00	120.00	68.55	12.75	0.96	36.12	21.43
9	Chandrapur Local	8.97	9.60	98.00	71.45	16.40	2.53	95.22	45.13
10	Nagpur Local	6.37	5.80	88.50	69.40	11.77	1.17	44.22	21.24
11	Washim Local	5.35	5.90	98.00	65.75	11.60	1.25	47.21	22.80
12	Pune Local	9.77	7.80	95.00	73.55	15.30	1.72	64.65	30.97
13	Parabhani Local	5.58	5.40	90.50	42.30	11.62	1.52	57.17	28.64
14	Latur Local	4.13	6.10	99.50	76.60	9.60	0.86	32.36	17.20
15	Hingoli Local	5.72	6.20	117.00	51.95	10.87	1.59	59.72	29.66
16	Kolhapur Local	6.53	4.70	121.00	45.35	10.30	1.17	44.04	22.81
17	Ahemadnagar Local	6.56	4.80	115.00	42.75	11.55	1.10	41.55	26.18
18	Solapur Local	6.74	5.00	112.50	71.35	12.10	1.13	42.63	22.60
19	Satara Local	9.72	9.00	100.00	77.25	14.60	1.52	57.33	28.64
20	Baramati Local	3.77	6.60	101.00	71.30	9.80	1.06	39.72	18.42
21	Phule Priya	8.21	8.80	110.00	61.50	11.95	2.54	95.70	46.03
	Mean	**7.21**	**6.83**	**106.93**	**61.41**	**12.77**	**1.52**	**57.17**	**28.44**
	S.E. ±	0.15	0.19	6.91	0.78	0.20	0.12	4.44	1.68
	C.D. 5%	0.45	0.55	20.37	2.31	0.59	0.35	13.09	4.94



VITA

VITA

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A candidate of the degree of

MASTER OF SCIENCE (HORTICULTURE)

In

VEGETABLE SCIENCE

2019

Title of Thesis : **Variability studies in pea (*Pisum sativum* L.)**

Major Field : Horticulture (Vegetable Science)

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