

**Studies on genetic parameters, correlation and
path coefficient analysis of yield and its
components in garden pea (*Pisum sativum*. L)**

THESIS

Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

**In partial fulfilment of the requirements
for the Degree of**

MASTER OF SCIENCE

In

AGRICULTURE

(HORTICULTURE- VEGETABLE SCIENCE)

By

GEETHA RAVI

**Department of Horticulture
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur
College of Agriculture
Jabalpur (M.P.)**

2013

CERTIFICATE - I

This is to certify that the thesis entitled “**Studies on genetic parameters, correlation and path coefficient analysis of yield and its components in garden pea (*Pisum sativum. L*)**” submitted in partial fulfilment of the requirement for the degree of **Master of Science in Agriculture (Horticulture)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Ms. Geetha Ravi** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma (Certificate awarded etc.) or has been published / published part has been fully acknowledged.

All the assistance and help received during the course of the investigation have been fully acknowledged by her.

Place : Jabalpur
Dated :/...../.....

(Dr. S.K. Sengupta)
Chairman of the Advisory Committee

THESIS APPROVED BY THE STUDENT’S ADVISORY COMMITTEE

Chairman **Dr. S. K Sengupta**

Member **Dr. P. K. Jain**

Member **Mr. B. K. Verma**

Member **Dr. H.L. Sharma**

CERTIFICATE - II

This is to certify that the thesis entitled “**Studies on genetic parameters, correlation and path coefficient analysis of yield and its components in garden pea (*Pisum sativum. L*)** submitted by **Ms. Geetha Ravi** to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of “**Master of Science in Agriculture (Horticulture)**” in the Department of Horticulture has been, after evaluation, approved by the External Examiner and by the Student’s Advisory Committee after an oral examination on the same.

Place: Jabalpur

Date...../...../.....

Dr. S. K. Sengupta

(Chairman of the Advisory
Committee)

MEMBERS OF THE ADVISORY COMMITTEE

Chairman **Dr. S.K. Sengupta**

University Professor &
Head of the Department **Dr. P.K. Jain**

Director of Instruction **Dr. P. K. Mishra**

ACKNOWLEDGEMENT

Space doesn't allow to my desired extent and words fail to express adequately my feelings of deep sense of gratitude from the care of my heart which I own to my Honorable Guide and Chairman of my advisory committee Dr. S. K. Sengupta, Senior Scientist, Department of Horticulture, JNKVV, Jabalpur, for his helpful and illuminating guidance, constant encouragement and kind help throughout the course of this investigation.

No words can fully express my sincere thanks and obligations to Members of my Advisory Committee Dr. P. K. Jain, University Professor & Head of the Department, Department of Horticulture, Shri B. K. Verma, Department of Horticulture, Dr. H. L. Sharma, Professor, Department of Mathematics and Agricultural Statistics, for their fruitful suggestions and valuable guidance during the course of investigation.

I sincerely express my thanks to Dr. G. Kalloo Vice –Chancellor, JNKVV Jabalpur, Dr. O. P. Veda Director of Instruction, Dr. S. S. Tomar, Director of Research Services, Dr. D. K. Mishra Dean of College of Agriculture Jabalpur and Dr. P. K. Bisen Dean of Student Welfare JNKVV, Jabalpur for providing all necessary facilities during the research work.

With deepest sense of humility and gratefulness, I fell myself duly bound to express my heartfelt and sincere thanks to my teachers Dr. S.K. Pandey, Dr. R. K. Shrivastava, Dr. S.K. Mitra, Dr. T.R. Sharma, Dr. B.P. Bisen, Dr. A. K. Tiwari, Dr. C.S. Pandey and all staff members of department of Horticulture, JNKVV, Jabalpur, for their unflinching co-operation during the course of investigation.

I express my sincere thanks to all my teachers for their encouragement and constant help throughout my studies and I extend my thanks to non-teaching staff of Department of horticulture who helped me a lot during office and field work.

I wish to express my appreciation and thanks to my Colleagues and friends Ashwini Dadiga, Monica Mishra, Rajani Singh, Kavita Jataw, Deepshikha, Shikha Gond, Ranvijay, Satish, Yogesh, Om Veer and my seniors Maya, Saraswati patel, Meenakshi, Beena Nair and Ankita who helped me directly or indirectly.

In the last but not least, words are too less to express my gratitude to my parents Shri R. Malleswara Rao and Smt Lilly Grace, younger brother and sister Manoj and Priyanka whose filial affection, sacrifice, sincere prayers, blessings, affectionate encouragement, love, support and faith in my activities have always been the most vital source of inspiration which helped me to set higher.

Lastly I would like to convey my cordial thanks to all those unmentioned persons who helped me to fulfill my dream, come true.

Date:

Place:

Geetha Ravi

LIST OF CONTENTS

| Chapter | Title | Page No. |
|----------------|---|-----------------|
| 1 | Introduction | 1-3 |
| 2 | Review of Literature | 4-24 |
| 3 | Materials and Methods | 25-40 |
| 4 | Results | 41-65 |
| 5 | Discussion | 66-81 |
| 6 | Summary, Conclusion & Suggestions for Further Research Work | 82-89 |
| 6.1 | (i) Summary | 82-86 |
| 6.2 | (ii) Conclusions | 87-88 |
| 6.3 | (iii) Suggestions for Further Research Work | 88-89 |
| | References | 90-96 |
| | Vita | |

LIST OF TABLES

| Table No. | Title | Page No. |
|-----------|---|----------|
| 3.1 | Meteorological information (week wise) during entire crop season of the year 2012-13 at Jabalpur | |
| 3.2 | Details of genotypes and checks used in the study | |
| 3.3 | Experimental details | |
| 4.1 | Analysis of variance for various characters in Pea (mean sum of squares). | |
| 4.2a | Mean performance in twenty two Pea genotypes for the characters viz. plant height at 30, 60 & 90 DAS (cm), number of primary branches per plant 30, 60 & 90 at DAS. | |
| 4.2b | Mean performance in twenty two Pea Pea genotypes for the characters viz. leaves per plant at 30, 60 & 90DAS, days to first & 50% flowering and days to first picking. | |
| 4.2c | Mean performance in twenty two Pea genotypes for the characters viz. Number of seeds per pod, number of pods per plant and yield per plant (g) etc. | |
| 4.3 | Genetic parameters in twenty characters in pea | 42 |
| 4.4 | Estimates of phenotypic and genotypic correlation coefficients among yield and its contributing traits in Pea. | 46 |
| 4.5 | Estimates of phenotypic path coefficient showing direct and indirect effect on pod yield per plant | 50 |

| Table No. | Title | Page No. |
|------------------|---|-----------------|
| 4.6 | Estimates of Genotypic path coefficient showing direct and indirect effect on pod yield per plant | |
| 4.7 | Qualitative characters in garden pea genotypes | |
| 4.8 | Mean performance of incidence of disease and pest of garden pea | |

LIST OF FIGURES

| Figure No. | Title | Page No. (in between) |
|-------------------|--|----------------------------------|
| 1 | Weekly meteorological data during the investigation from November 2012 to March 2013 | |
| 2 | Plan of the layout of experimental plot | |
| 3 | Genetic parameters in twenty characters in garden pea | |
| 4 | Phenotypical path diagram for Yield/ plant(gm) | |

| Figure No. | Title | Page No. (in between) |
|-------------------|---|----------------------------------|
| 5 | Genotypical path diagram for Yield/ plant(gm) | |

LIST OF PLATES

| Plate No. | Title | Page No. (in between) |
|------------------|--|----------------------------------|
| 1 | Showing pods of different genotypes under investigation. | |

LIST OF ABBREVIATIONS

| | | |
|-------------------------------|---|-------------------------------------|
| % | : | Per cent |
| ANOVA | : | Analysis of variance |
| CD | : | Critical difference |
| cm | : | centimetre |
| d.f. | : | Degree of freedom |
| <i>et al.</i> | : | Et alli (and other) |
| gm | : | gram |
| G.C.V | : | Genotypic coefficient of variation |
| GA | : | Genetic advance |
| h^2 | : | Heritability estimate |
| ha. | : | hectare |
| Kg | : | Kilogram |
| P.C.V | : | Phenotypic coefficient of variation |
| q | : | Quintal |
| SEm \pm | : | Standard error of mean |
| viz., | : | Videlicet (namely) |
| sq.mt | : | Square metre |
| i.e | : | that is |
| DAS | : | Days after sowing |
| Fig | : | Figure |
| MT | : | Metric tonnes |
| No. | : | Number |
| °C | : | Degree centigrade |
| N | : | Nitrogen |
| P ₂ O ₅ | : | Phosphorous |
| K ₂ O | : | Potassium |

INTRODUCTION

Garden pea (*Pisum sativum* L.) is an important vegetable crop cultivated on a large scale for green pods and seeds. It is native of Ethiopia. In India, it is gaining an industrial importance, since its green immature seeds can be canned or dehydrated for off-season consumption. Crop also has important value in agricultural economy of the country and importance as pulse and vegetable crop in human diet need no emphasis.

The nutritive value of pea is very high having high percentage of digestible proteins and good content of vitamins, minerals and carbohydrates. Pea seeds contains protein 7.20g, moisture 72.0g, carbohydrates 15.80g, mineral matter 0.80g, fiber 4.00g, fat 0.10g, calcium 20.0 mg, sulphur 95.0 mg, sodium 7.80 mg, magnesium 34.0 mg, phosphorous 139 mg, potassium 79.0 mg, iron 1.50 mg, thiamin 25.0 mg, vitamin 'A' 139.0 IU, vitamin 'C' 9.0 mg and calories 93.0. Hence, peas are considered as valuable vegetable for vegetarians. Seeds contain trypsin and chymotrypsin which could be used for contraceptive and fungistatic. There are no significant amounts of toxicity or antimetabolites in peas.

In India, it is grown mainly as a winter vegetable in the plains of north India and as summer vegetable in the hills in other states. In India pea occupies an area of 408.0 thousand hectare with production of 3745.0 thousand metric tonnes and productivity of 9.17 metric tonnes per hectare (HNB data based 2011-12). Major pea growing states in India are Uttar

Pradesh, Bihar, Haryana, Punjab, Himachal Pradesh, Orissa and Karnataka. In Madhya Pradesh, it is grown in 47.30 thousand hectare of land with the annual production of 452.21 thousand metric tonnes and productivity of 9.56 metric tonnes per hectare (HNB data based 2011-12).

It can be grown in wide range of agro-climatic zones which provides a tremendous scope and potential for cultivation of this crop. However, low productivity of this crop has created the necessity to breed new high yielding varieties, which may fulfill the needs of the growers and enhance the productivity.

Planning and execution of a breeding programme for the improvement of the various quantitative attributes depend to a great extent, upon the magnitude of genetic variability existing in the population. Hence, studies on genetic variability with the help of suitable biometrical tools such as coefficient of variability, heritability, and genetic advance become indispensable in breeding programmes for tangible results of desired values. The genetic variability forms the basis of the entire breeding programme. Selection cannot be effective in population without variability. In terms of variability, it is the genetic fraction of the observed variation that provides a measure of transmissibility of the variation under study and responds to selection.

To give a better insight of ancillary characters under selection, correlation and path coefficient analysis are the tools, which are being effectively used for determining the rate of various yield components in

different crops, leading to the selection of superior genotypes. Therefore, for a rational approach to the improvement of vegetable yield, it is imperative to have information on the association among different yield components and their relative contribution to the yield and its component. Knowledge of relationship is essential for the simultaneous improvement of yield and its component.

In view of the above facts, the present studies in garden pea entitled “Studies on genetic parameters, correlation and path coefficient analysis of yield and its components in garden pea (*Pisum sativum* L.)” has been carried out with the following objectives:

Objectives:

- (1) To estimate the genetic parameters for yield and its components in pea.
- (2) To assess the correlation coefficient between yield and its contributing characters.
- (3) To determine the direct and indirect effects of yield components on pod yield per plant.

REVIEW OF LITERATURE

The success of any plant improvement programme depends on right selection of material and its skillful management. It is only possible when we possess knowledge of previous work done in the field concerned. In pea substantial contribution has been made to the literature regarding its genetics and breeding in the recent years. The literature pertaining to the various aspects of the present study has been reviewed under the following heads: -

- 2.1 Genetic variability
- 2.2 Heritability and Genetic Advance
- 2.3 Correlation Coefficient Analysis
- 2.4 Path Coefficient Analysis

2.1 Genetic variability

For the development of new superior varieties, which are far better than the existing ones, we should choose the material that possesses genetic variability having high GCV along with high mean.

Sureja and Sharma (2000) reported that the considerable genetic variability for pod yield and its component characters were observed.

Shinde (2000) reported that the seventy-three pea cultivars belonging to different eco-geographical regions of India were evaluated for genetic variability, heritability and genetic advance with respect to 13 quantitative and 2 qualitative traits. Significant differences were observed for all the characters among the genotypes.

Mahanta *et al.* (2001) revealed that the DPFDP 8 was the highest yielder followed by KFPD 59 having moderately susceptibility to powdery mildew [*Erysiphe pisi*]. Similarity in phenotypic coefficient of variation and genotypic coefficient of variation of all traits showed low environmental influence.

Pathak and Jamwal (2002) reported that the high genotypic coefficient of variation (GCV) was recorded for pod yield per plant, moderate to high GCV were recorded for number of days to 50% flowering and plant height. Low GCV

for number of days to first picking, pod length and average pod weight and high GCV for ascorbic acid content and number of plants per plant may be attributed to non-additive gene actions.

Ramesh *et al.* (2002) reported that a considerable amount of phenotypic coefficient of variation(PCV) and genotypic coefficient of variation(GCV) was observed for most of the characters such as number of pods per plant, weight of pods per plant, internode length, plant height, mean pod weight and weight of grains per pod, while the variation was low for the other characters tested.

Tyagi and Srivastava (2002) reported that the wide range of variability was evidenced for plant height, pods per plant, and biological yield per plant. The F_1 hybrids showed higher range of variation than the parents for almost all the characters. The phenotypic and genotypic coefficients of variability were higher for pods per plant, biological yield per plant, and seed yield per plant in parents.

Sharma and Kalia (2002) he observed that sufficient genetic variation was present among the parents. Genotype x environment interactions were significant suggesting that the genotypic performance was influenced by varying environmental conditions.

Singh *et al.* (2003) revealed that the magnitude of variability was higher for pod length and number of pods per plant in the F_1 population.

Sharma *et al.* (2003) revealed that the all characters (seed yield per plant, biological yield per plant, harvest index, plant height, 100-seed weight, seeds per pod, pods per plant, days to 50% flowering, pod length and days to maturity) exhibited significant variability. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were highest for seed yield per plant, followed by pods per plant and biological yield per plant.

Singh and Dhillon (2004) reported that the analysis of variance showed significant mean square estimates for all the characters. The pod yield per plant ranged from 9.12 to 101.45 g, whereas the number of pods per plant ranged from 4.36 to 38.60. The pod weight, number of grains per pod, plant height and number of primary shoots varied from 1.03 to 5.02 g, 3.62 to 6.84, 38.35 to

256.76 cm and 1.04 to 8.92, respectively. Internodal length and days to flower initiation ranged from 2.47 to 11.53 cm and 32.93 to 63.07 days, respectively. The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) in all the characters. The highest GCV (64.07) was observed for the number of primary shoots. The lowest variability (GCV11.70) was observed for the number of grains per pod. The pod yield also exhibited GCV (53.78).

Mehta *et al.* (2005) revealed that the analysis of variance for all traits indicated significant differences among the genotypes. A wide range of variability for pod yield per plant (42.99-100.78 g) and plant height (42.83-131.23 cm) along with high estimates of phenotypic and genotypic coefficients of variation respectively indicated that these characters would respond to selection. However, low PCV and GCV were recorded for pod length and total soluble solids. A small difference between PCV and GCV was observed for node at which the first flower appear followed by the number of grains per pod and pod width, which indicated that these characters were least influenced by the environment.

Singh and Mir (2005) reported that the out of the 18 genotypes, VL-7 recorded highest seed yield (17.59 q/ha) followed by Arkel (16.33 q/ha), Azad-P-3 (16.33 q/ha) and Azad-P-1 (15.72 q/ha). High genotypic coefficient of variation and phenotypic coefficient of variation were observed for the number of branches per plant, number of pods per plant, seed yield (q/ha) and average seed yield per plot.

Seema *et al.* (2006) revealed that the genotypes differed significantly for all traits except the number of branches per plant. Seed yield expressed high GCV, indicating the preponderance of additive gene effects for this trait.

Gupta *et al.* (2006) revealed that the analysis of variance revealed highly significant differences for all characters studied. Coefficient of variation ranged from 2.44% (days to seed maturity) to 16.93% (number of green pods per plant). Both phenotypic and genotypic coefficients of variation were highest for green pod yield.

Singh and Singh (2006) reported that the variability was greatest for seed yield per plant, followed by number of pods per plant, plant height, number of branches per plant, and 100-seed weight.

Sharma *et al.* (2007) revealed that the highest pod yield per plant was recorded in Palam Priya followed by Kukumseri Sel. 6 and DPP 9418-06. Phenotypic and genotypic coefficients of variation were of high magnitude for plant height and moderate for pods per plant and pod yield per plant.

Sardana *et al.* (2007) revealed that the high variability was observed for qualitative as well as quantitative traits. Based on agro-morphological traits, 33 diverse germplasm accessions were selected for earliness, dwarf plants, afile type, long pods, high pods per plant, high number of seeds per pod, and high seed yield per plant. Analysis of variance revealed that the differences among 33 accessions were significant for all the characters except seeds per pod. Moderate to high levels of genotypic coefficient of variability were observed for plant height, 100-seed weight, pod length, seed yield per plant, and pods per plant which suggested that these traits would respond to selection owing to their high genetic variability and transmissibility.

Rakesh Kumar *et al.* (2007) revealed that the High magnitude of variability was observed for plant height, 100-seed weight, yield per plant and fat (%).

Nawab *et al.* (2008) revealed that highly significant differences among genotypes for days to emergence, days to 50 percent flowering, number of pods per plant, weight of pods per plant (g), pod length (cm), number of seeds per pod, 100-seed weight (g) and green pod yield (kg/plot). Green pod yield per plot, 100-seed weight, number of pods per plant and weight of pods per plant showed high genetic coefficient of variation (GCV) indicating good scope for selection.

Sanjay *et al.* (2008) revealed that sufficient genetic variation was observed for marketable pod yield, number of pods per plant, durations of availability of pods and grains per pod. The magnitude of phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the traits. The marketable pod yield ranged from 17.88 q (Lincoln) to 42.64 q/ha (Kukumseri Selection).

Bhupendra Kumar (2008) reported that the wide range of variation exhibited for plant height, days to flowering, number of pods per plant, grain yield per plant, days to maturity and harvest index. Significant differences for all the characters except number of primary branches and highest GCV and PCV was recorded for grain yield per plant followed by number of pods per plant, number of seeds per pod and 100-grain weight.

Nisar et al. (2008) reported that the genetic diversity of 246 accessions of *Pisum sativum* L. collected from various localities of the world was evaluated at vegetative stages to ascertain the extent of genetic diversity and assess geographical heterogeneity among the germplasm. It was concluded that, high degree of allelic variation was present in seed coat color and seed shape.

Bora et al. (2009) revealed that a good amount of genetic variation in the experimental materials under investigation.

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, green pod yield per plant and plant height exhibited higher values of genotypic and phenotypic coefficient of variation.

Sharma et al. (2010) revealed that the eight different varieties of peas were evaluated for earliness, yield and quality attributes in 2007 and 2008 under the intermediate agro-climatic conditions of Poonch (J & K). All the genotypes differed significantly for all the characters. The studies revealed that the highest pod yield of 521 q/ha was recorded from variety Palam priya followed by variety E-6 which gave a yield of 494 q/ha. These varieties were light green in color with preferred shape and size of pods. The varieties Bonneville, E-6 and AP-3 were early to mature because days taken to harvest recorded were 44.9, 45.0 and 48.4 respectively in these cultivars. The cvs VL-8, AP-1 and Palam priya were late to mature which took 67.3, 67.00 and 64.6 days to harvest. It is suggested that these varieties of peas can be successfully grown for general cultivation under intermediate conditions of Poonch.

Lal et al. (2011) reported that the analysis of variance revealed that the differences among 30 genotypes were significant for all the characters. Moderate

to high levels of genotypic coefficient of variability (GCV) were observed for plant height, number of primary branches per plant, pods per plant, seeds per pod, cluster per plant, 100 seed weight, harvest index, biological yield per plant and grain yield per plant. Among all traits plant height exhibited high estimates of GCV and PCV (38.8 and 38.82) followed by biological yield (36.88 and 37.1) and harvest index (32.13 and 33.78).

Singh (2010) he found that highest phenotypic coefficient of variability was observed for branches per plant (25.76%), while lowest for plant height (6.95%). The higher differences between these two were observed for number of seeds per pod, pods per plant and branches per plant.

Singh *et al.* (2011) reported that the significant differences were observed among all the F₂ plants for all the characters studied, except for days to emergence.

Million (2012) reported that the mean squares due to genotypes were highly significant for all the characters. The genotypic coefficient of variation ranged from 11.19% for days to mature to 25.72% for number of seeds per plant.

Singh *et al.* (2012) reported that the phenotypic coefficient of variation and genotypic coefficient of variation were high (>25%) for plant height, productive branches per plant, pods per plant, biological yield per plant and seed yield per plant.

2.2 Heritability and Genetic advance

It is well known that right selection of the material is one of the important causes for the success of any improvement programme. The proper selection will depend on the knowledge of heritability. Estimate of genetic advance is an important parameter to evaluate effectiveness of selection.

Sureja and Sharma (2000) reported that the high heritability in association with high genetic advance observed for plant height, length of internode, pod yield per plant, number of pods per plant, seed yield per plant, number of primary branches and 100-seed weight, indicating additive gene effects and emphasized the effectiveness of selection for these traits to improve economic yield.

Shinde (2000) reported that the characters crude protein percentage, weight of pod, yield per ha and yield per plant had high heritability values coupled with high percentage of genetic advance indicating additive gene effects and greater scope for selection.

Mahanta *et al.* (2001) revealed that the high heritability estimates were recorded for all characters. High heritability coupled with high genetic advance observed for yield per plant, pods per plant, plant height, seeds per pod and 100 seed weight indicate additive gene effect.

Ramesh *et al.* (2002) reported that the high estimates of broad sense heritability and genetic advance were observed for plant height, internode length, node of the first fruit and number of pods per plant. High heritability with moderate genetic advance was observed for mean pod weight.

Tyagi and Srivastava (2002) reported that the high broad sense heritability was observed for seed yield per plant, seeds per pod, and harvest index. High genetic advance was recorded for plant height and pods per plant.

Pathak and Jamwal (2002) reported that the high heritability, coupled with high genetic advance (GA) was recorded for pod yield per plant. Moderate GA was recorded for number of days to 50% flowering and plant height, indicating the role of additive gene action for the inheritance of these characters. High heritability with low GA was observed for number of days to first picking, pod length and average pod weight.

Sharma *et al.* (2003) revealed that the high heritability was observed for all characters, except for days to maturity. High genetic advance along with high heritability and GCV was observed for seed yield per plant, biological yield per plant and pods per plant. This indicates that selection for these characters would be effective for further improvement.

Singh *et al.* (2003) revealed that the high heritability and low genetic advance were recorded for harvest index, pod length, number of seeds per pod, protein content and 100-grain weight in both generations. These traits were moderately influenced by non-additive gene action. Thus, these traits should be considered during selection for higher yields in pea.

Singh and Singh (2004) reported that the number of days to flowering, number of days to maturity, plant height, pod length and protein content recorded high estimates of heritability in both generations. High estimates of heritability were also recorded for number of pods per plant and 100-seed weight only in the F_2 and F_1 generations, respectively. The heritability estimates for these traits indicated a high contribution by the additive genetic component; thus, these traits may be improved by mass, progeny or family selection. The estimates of heritability for number of branches and grain yield per plant in both generations, and for number of pods per plant, number of seeds per pod and 100-seed weight for either of the generations indicated the contribution of both additive and non-additive gene components. As such, biparental mating followed by pedigree selection would be appropriate for the improvement of these traits. Harvest index in both generations and number of seeds per pod in the F_1 generation had moderate values of heritability with low genetic gain, suggesting that biparental mating, followed by progeny selection would be suitable for the selection of transgressive segregates and good recombinants. Heritability estimates were higher in the F_2 for number of days to maturity, plant height, number of branches per plant, pod length, number of pods per plant and protein content. The estimates of genetic advance were low for all characters except plant height in both generations.

Singh and Dhillon (2004) reported that the highest heritability of 94.25, resulting in a fare amount of expected genetic gain of 128.13 as a percent of mean, was observed for the number of primary shoots. The moderate heritability (42.64%) and lowest genetic advance as percent of mean (15.74) was observed for the number of grains per pod. The pod yield also exhibited a high heritability (98.76%) with genetic advance of 110.09 as percent of mean.

Mehta *et al.* (2005) revealed that the high heritability along with high genetic gain for node at which first flower appear and the number of grains per pod indicated an additive gene action, which suggested that selection may be effective for these traits.

Singh and Mir (2005) reported that the high heritability was observed for seed yield (q/ha), average seed yield per plot, number of pods per plant and days to 50% flowering. When heritability and genetic gain were considered together, seed yield (q/ha), average seed yield per plot and number of pods per plant recorded the highest values; however, the number of branches per plant, pod length, plant height and pod diameter recorded moderate heritability with higher genetic gain.

Seema *et al.* (2006) revealed that the most of the yield components showed high heritability values. Seed yield expressed high genetic advance, moderate heritability indicating the preponderance of additive gene effects for this trait. The 100-seed weight also showed high heritability coupled with high genetic advance, suggesting the suitability of direct selection for this trait.

Gupta *et al.* (2006) revealed that the heritability ranged from 36.05% for total soluble solids to 99.16% for early yield per plant. Genetic advance was highest for green pod yield per plant. High heritability coupled with high genetic advance was observed for days to first flowering nodes, plant height, number of first flowering nodes, dry matter weight per plant, green pod yield per plant and number of primary branches per plant, indicating the preponderance of additive gene effects and the potential of selection for these characters to improve garden pea yield.

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 and pod length. High expected genetic advance coupled with high heritability estimates were predicted for seed yield per plant, number of pods per plant, and plant height, indicating the low variation due to the environment.

Sardana *et al.* (2007) revealed that the moderate to high heritability, and genetic advance were observed for plant height, 100-seed weight, pod length, seed yield per plant, and pods per plant which suggested that these traits would respond to selection owing to their high genetic variability and transmissibility.

Rakesh Kumar *et al.* (2007) revealed that the high to moderate heritability coupled with high to moderate genetic advance was observed for 100 seed

weight, yield per plant and biological yield, which indicated the predominance of additive gene action which suggested that selection may be effective for these traits.

Sharma *et al.* (2007) revealed that the heritability and genetic advance were high for plant height and moderate for pods per plant and pod yield per plant indicating the additive and non-additive gene action for their expression, respectively.

Nawab *et al.* (2008) revealed that green pod yield per plot, 100-seed weight, number of pods per plant and weight of pods per plant showed high heritability and genetic advance, indicating good scope for selection.

Bhupendra Kumar (2008) reported that the heritability coupled with genetic advance was highest for grain yield per plant followed by number of seeds per pod, number of pods per plant, 100-grain weight and harvest index while genetic advance was maximum for grain yield per plant.

Sanjay *et al.* (2008) revealed that marketable pod yield exhibited high heritability associated with high genetic advance as percent of mean, whereas the number of pods per plant, grains per pod and duration of marketable pods had high heritability with moderate genetic advance. The marketable pod yield ranged from 17.88 q (Lincoln) to 42.64 q/ha (Kukumseri Selection) and it exhibited 96.56% heritability with high genetic advance of 50.91 as percentage of mean.

Nair and Khare (2009) reported that the high estimate of heritability and genetic advance for green pod weight, pod wall weight, seed weight per pod and pod thickness, whereas low estimate for seed pod ratio, pod water content and seed water content. Genotypes 'Arkel', 'Pusa Pragati' and 'VRP 6' had high total sugar (>10%) with 80% part as reducing sugar.

Bora *et al.* (2009) observed that characters like plant height, days to first picking, 100 green pod weight, green pod yield and days to 50 per cent flowering revealed higher values of heritability in broad sense and genetic gain indicating that the additive gene actions are important in determining these characters.

Choudhary *et al.* (2010) revealed that the high estimates of heritability, genotypic coefficient of variation and genetic advance were observed for plant height, number of pods per plant and green pod yield per plant. These characters can be effectively improved through selection.

Lal *et al.* (2011) reported that the moderate to high levels of heritability and genetic advance were observed for plant height, number of primary branches per plant, pods per plant, seeds per pod, cluster per plant, 100 seed weight, harvest index, biological yield per plant and grain yield per plant. Broad sense heritability was high for plant height (99%) and biological yield (99%) followed by number of pods per plant (97) and cluster per plant (97), which suggested that these traits would respond to selection owing to their high genetic variability and transmissibility.

Singh (2010) he found that highest broad sense heritability estimates were observed for all the traits. Genetic advance was high for green pod yield (37.19 g) followed by days to flowering and plant height and low for pod width, branches per plant, number of seeds per pod and pod length. The genetic advance in percent over mean revealed that branches per plant followed by days to flowering, green pod yield and pods per plant were most important characters for improving the yield of pea genotypes as these characters showed maximum genetic gain.

Singh *et al.* (2011) reported that the moderate to high heritability (broad sense) coupled with moderate genetic advance as percent of mean was recorded for the characters plant height, pod length and 100 seed weight indicating role of additive gene action in the expression of these traits.

Million (2012) reported that the estimated broad sense heritability ranged from 19.24% for stand count to 50.81% for days to flowering. Genetic gains that could be expected from selecting the top 5% of the genotypes varied from 11.45% for stand count to 33.08% for number of seeds per plant.

Singh *et al.* (2012) reported that the high heritability (in narrow sense) estimates were recorded for pods per plant, seed yield per plant and biological yield per plant. High genetic advance was recorded for plant height, pods per

plant, productive branches per plant, seeds per pod, biological yield per plant and seed yield per plant.

2.3 Correlation

The study of correlation coefficient between various economic traits of crop plant is very important to display the degree of union between characters. In plant breeding programme, these studies have important.

Mahanta *et al.* (2001) revealed that the yield per plant exhibited positive correlations with branches per plant, pods per plant, seeds per pod and 100-seed weight.

Tiwari *et al.* (2001) revealed that the seed yield per plant exhibited a significant and positive correlation with plant height, number of pods per plant, 1000-seed weight, number of grains per pod and harvest index.

Singh and Mishra (2002) reported that the seed yield per plant was positively and significantly associated with pods per plant, harvest index and primary branches per plant.

Ramesh and Tewatia (2002) reported that the pod weight per plant had strong positive association with number of pods per plant, number of grains per pod, mean pod weight, pod length, plant height and grain weight per pod.

Tyagi and Srivastava (2002) reported that the seed yield per plant was strongly associated with biological yield per plant, pods per plant, plant height, days to maturity, and seeds per pod.

Pathak and Jamwal (2002) reported that the genotypic correlation coefficients were generally higher than the corresponding phenotypic correlation coefficients. At the phenotypic level, pod yield per plant was positively correlated with number of pods per plant, plant height and average pod weight. Positive associations were also observed between number of days to 50% flowering and number of days to first picking, number of pods per plant and plant height, pod length and number of seeds per pod and average pod weight, and number of seeds per pod and average pod weight. Thus, high-yielding cultivars may be

developed via selection for greater number of pods per plant, plant height, average pod weight, pod length and number of seeds per pod.

Sharma *et al.* (2003) reported that the positive and significant association of seed yield per plant with biological yield per plant, pods per plant and pod length. Significant negative correlation of harvest index was observed with plant height. It can be predicted that selection for pods per plant, pod length and biological yield per plant would improve seed yield per plant.

Chaudhary and Sharma (2003) reported that the genotypic correlation coefficients were higher than the phenotypic correlation coefficients. Pod yield per plant showed positive phenotypic correlation with pod length, number of grains per pod, number of pods per plant and shelling percentage.

Kumar *et al.* (2003) observed that the estimates of genotypic correlation coefficients were higher than those of phenotypic correlation coefficients. Pod yield per plant exhibited a significant and positive correlation with number of pods per plant, mean pod weight, weight of edible grains per pod, number of days to first picking, number of edible grains per pod, pod length, internode length, shelling percentage, and number of branches per plant.

Arya *et al.* (2004) revealed that the grain yield was significantly and positively correlated with number of nodes, height at which the first pod appears, plant height, number of primary branches per plant, pod length, and 100-seed weight. These characters were also positively correlated with each other.

Mehta *et al.* (2005) revealed that the green pod yield had significant and positive association with number of green pods per plant, number of grains per pod, shelling percentage and pod length.

Singh and Yadav (2005) revealed that the seed yield had strong positive genotypic and phenotypic correlation with number of pods per plant, number of branches per plant, number of seeds per pod, pod length and pod diameter. The number of days to 50% flowering exhibited significant negative genotypic and phenotypic correlation with seed yield, number of pods per plant, and number of branches per plant.

Singh *et al.* (2005) revealed that the fruit yield per plant was positively correlated with number of pods per plant, number of seeds per pod, shelling percentage and number of days taken from sowing to marketable maturity.

Singh and Singh (2005) observed that in general, the magnitude of genotypic correlation coefficients was higher than the phenotypic correlation coefficients, suggesting the existence of inherent association among the traits studied. Grain yield per plant showed positive and significant correlation with pods per plant, branches per plant, plant height, pod length and seeds per pod, but it showed negative and non-significant association with days to flower.

Singh and Singh (2006) reported that the seed yield per plant had significant and positive association with number of pods per plant, plant height, harvest index, and number of grains per pod.

Sirohi *et al.* (2006) revealed that the seed yield showed positive and significant association with protein percentage (0.458), while the biological yield per plant showed highest and significant association with harvest index (0.628) at phenotypic level. Among the days to flowering with days to maturity (0.591), number of pods per plant (0.426), pod length (0.405) and number of primary branches with plant height (0.446) number of pods per plant (0.457), pod length (0.519) and plant height with pod length (0.521) harvest index (0.445) and plant height with number of pods per plant (0.420) showed positive and significant associations at phenotypic level.

Sharma *et al.* (2007) revealed that the positive association of pod yield per plant with pods per plant, pod length, seeds per pod and total soluble solids.

Singh *et al.* (2007) revealed that the biological yield per plant, harvest index, pods per plant, branches per plant and grains per pod were significantly correlated with seed yield per plant.

Usmani and Dubey (2007) revealed that the seed yield was positively and significantly correlated with harvest index, biological yield, pod bearing length, plant height, number of effective nodes, number of nodes and number of pods.

Kaur *et al.* (2007) revealed that highly significant and positive correlation was 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.

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

Togay *et al.* (2008) revealed that the positive and significant relationship was found among seed yield and pods per plant and biological yield in both years.

Singh *et al.* (2008) revealed that the plant height, length and width of pod and 100-seed weight were associated positively and significantly with grain yield.

Guleria *et al.* (2009) correlation studies indicate that characters like flower number, pod number and seeds per pod not only contributed positively to the grain yield but also had strong correlation coefficient with yield. Thus, the results of character association studies showed that genotypes with higher number of flowers, pods and seeds per pod should be selected to increase the grain yield.

Sharma *et al.* (2009) reported that the highly significant and positive correlation was observed between green pod yield per plant and plant height, pods per plant, node at which first flower appears and total phenols. Significant and positive association between green pod yield per plant and node at which first flower appears indicated that selection for higher yield can be practiced as soon as the first pod develops.

Jitendra Kumar *et al.* (2010) reported that the seed yield per plant exhibited significant and positive correlation with number of pods per plant, number of branches per plant and 100 green seed weight.

Dhama *et al.* (2010) reported that the genotypic correlations were higher than phenotypic correlations for all the characters in all the environments.

Number of pods per plant exhibited significant and positive association with seed yield per plant in all the environments. Seed yield was significantly and positively associated with protein content at genotypic level in E5. Protein content exhibited negative and significant correlation with pod length and number of nodules in E2 and E4 and with number of seed and 100 seed weight in E6.

Singh *et al.* (2011) reported that the numbers of pods per plant, plant height, number of primary branches per plant, 100 seed weight and number of clusters per plant were the major characters contributing to grain yield as these traits were significantly and positively associated with grain yield per plant.

Kosev and Mikic (2012) reported that the strongest positive phenotypic correlations were observed between number of fertile nodes per plant and numbers of pods (0.97) and number of seeds per plant (0.97) and between number of seeds and pods per plant (0.94); between seed weight per plant and number of seeds (0.83) and fertile nodes per plant (0.77). High genetic correlations were found between plant height and first pod height (0.89), between number of pods per plant and seed weight per plant (0.91) and number of seeds per plant (0.96) and between seed weight per plant and number of branches per plant (0.92) and number of fertile nodes per plant (0.89).

2.4 Path coefficient analysis

As numbers of factors are involved in correlation studies, their association becomes more complex and confusing. Under such circumstances, the path coefficient analysis help in removing the complication by measuring the direct and indirect influence of one variable upon the other by partitioning the correlation coefficient into the components of direct and indirect effects. This has also an advantage to point out the true yield determinants for genetic improvement of crop.

Tiwari *et al.* (2001) revealed that the pods per plant, pod length, 1000-seed weight and number of grains per pod had moderate to high positive direct effects on seed yield per plant.

Singh and Mishra (2002) reported that the pods per plant had the highest direct effect followed by harvest index on seed yield. The selection criteria based

on pods per plant, harvest index and primary branches per plant will give fruitful results for yield improvement in pea.

Ramesh and Tewatia (2002) reported that the number of pods per plant had maximum direct genotypic effect on pod weight per plant, followed by mean pod weight, total sugars in edible grain, number of nodes on main stem per plant, days to first picking and grain weight per pod. These traits should be considered important in any selection programme for the yield improvement in garden pea.

Chaudhary and Sharma (2003) reported in path coefficient analysis, the number of grains per pod, pod length, number of pods per plant, and 1000-seed weight had the greatest direct effect on pod yield per plant. The greatest negative direct effects on pod yield were exhibited by number of days to 50% flowering. The number of pods per plant and number of grains per pod appeared to be the most important selection indices for green pod yield.

Kumar *et al.* (2003) revealed that the number of pods per plant had the greatest positive direct effect on pod yield per plant, followed by mean pod weight and number of edible grains per pod. The number of pods per plant had an indirect effect on pod yield per plant through internode length, plant height, number of days to 50% flowering, number of branches per plant, number of days to first picking, shelling percentage and node at which the first pod appears. Plant height had the greatest negative direct effect on pod yield per plant, followed by number of days to first picking and number of days to 50% flowering. The number of pods per plant, mean pod weight and number of edible grains per pod were the major components of pod yield per plant in pea.

Arya *et al.* (2004) observed that path analysis confirmed the major yield components were number of nodes and height at which the first pod appears, number of primary branches per plant, and 100-seed weight, although the direct effect of 100-seed weight was negative. The number of pods per plant had the greatest direct effect on seed yield, followed by height at which the first pod appears, plant height, node number at which the first pod appears, and number of primary branches per plant.

Singh and Yadav (2005) revealed that the number of pods per plant had the greatest direct genotypic and phenotypic effects on seed yield, followed by pod length. These traits should be considered important in any selection programme for the improvement of pea yield.

Mehta *et al.* (2005) revealed that the number of pods per plant and pod length exerted high direct effect on pod yield per plant.

Singh *et al.* (2005) revealed that the number of pods per plant and shelling percentage had the maximum direct effect on green pod yield. Thus, due importance should be given to these characters for improvement of yield.

Singh and Singh (2005) revealed that the number of pods per plant had the maximum positive direct effect on grain yield, followed by number of seeds per pod, 100-seed weight and pod length. Plant height, branches per plant, seeds per pod, pod length and harvest index had the highest indirect effects on grain yield per plant via pods per plant.

Sirohi *et al.* (2006) revealed that the number of seeds per pod exhibited highest (3.558) direct effects towards seed yield at genotypic level. Hence, maximum weight age should be given to number of seeds per pod during selection programme for yield improvement in pea.

Kumar and Sharma (2006) revealed that number of pods per plant had the highest positive direct effect towards pod yield per plant in both years. This was followed by other characters like green grain yield per plant, days to first green pod harvest, number of grains per pod and leaf area index. Number of pods per plant exerted the highest positive indirect effect through leaf area index while highest negative indirect effect was through 1000-seed weight. Shelling percentage followed by characters like biomass weight of plant and harvest index, also exerted direct negative effect. Shelling percentage had highest indirect negative effect through days to first green pod harvest. The study revealed that greater emphasis should be given to characters like number of pod per plant, green grain yield per plant, days to first green pod harvest, number of grains per pod, leaf area index and plant height for green pod yield improvement.

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.

Usmani and Dubey (2007) revealed that the harvest index (%) showed the highest positive direct effect followed by biological yield on seed yield at genotypic level. The indirect effects of biological yield and harvest index via other yield contributing characters under study were high and positive.

Sharma *et al.* (2007) revealed that the highly positive direct effects through pods per plant, plant height and pod length. Therefore, these traits may be considered as the most reliable selection indices for effective improvement in green pod yield in garden pea.

Sardana *et al.* (2007) revealed that the primary branches and 100- seed weight were the most important yield components that could be used as selection indices for further improvement in pea germplasm.

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

Togay *et al.* (2008) revealed that the biological yield (0.6500) and numbers of pods per plant (0.3137) recorded the highest positive and direct effects on seed yield, followed by first pod height (0.2398) and number of seeds per pod (0.2227).

Singh *et al.* (2008) revealed that the 100-seed weight followed by number of primary branches and pods per plant had high direct effect on grain yield. Most of the yield contributing traits affected yield indirectly through seed weight. A compromise must be considered during selection to avoid masking effect of characters among each others.

Sharma *et al.* (2009) path analysis exhibited that pods per plant recorded highest positive direct effect on pod yield per plant followed by node at which first

flower appears and plant height. Direct contribution of these traits indicated that by making selection for these traits, the yield can be substantially improved.

Dhama *et al.* (2010) reported that the plant height had the positive values of direct effects from 0.104 to 0.008 in E3 and E2, respectively. The direct effect of number of seeds per plant on grain yield was observed to be low and positive under E7 and E8 and negative under E1, E2, E3, E4, E5 and E6. The characters like biological yield at phenotypic level had positive correlation with seed yield and its direct effect was positive would be attributed by the direct effects of others yield contributing characters.

Lal *et al.* (2011) in path coefficient analysis revealed that pod per plant, harvest index and biological yield but pod per plant and harvest index were the most important yield components that could be used as selection indices for further improvement in pea.

Singh *et al.* (2011) reported that the number of pods per plant recorded highest positive direct effect on grain yield per plant via positive indirect effects of plant height and number of primary branches per plant.

Million (2012) observed in path analysis at genotypic level revealed that harvest index and biomass yield contributed major positive direct effects on seed yield.

Kosev and Mikic (2012) reported that the strongest and direct positive effect on seed yield was found in branch length (17.70), 1000-seed weight (5.92) and number of seeds per pod (4.93). The highest positive indirect contribution was in branch length to number of seeds per pod (2214.8), number of fertile nodes per plant (1258.0) and number of seeds per plant (708.70). Based on the trait association and the path coefficients for seed yield and its components, it can be concluded that pea breeders should pay attention to traits such as branch length, 1000-seed weight and number of seeds per pod when selecting high-yielding genotypes in pea.

MATERIAL AND METHODS

The materials used and methods employed during the course of investigation on “Studies on genetic parameters, correlation and path coefficient analysis of yield and its components in garden pea (*Pisum sativum* L.)” are as follows: -

3.1 Experimental site

The present investigation was conducted at Horticulture complex, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during the year 2012-13.

3.1.1 Soil

The soil of the experimental field was medium black with good drainage and uniform texture with medium NPK status.

3.1.2 Climate and Weather

Jabalpur is situated in “Kymore Plateau and Satpura Hills” agro climatic region of M.P. It falls on 23.9⁰ N latitude and 79.58⁰E longitudes with an altitude of 411.8 m above the mean sea level. Jabalpur is situated in the semi-arid region having sub-tropical climate with hot dry summer and cold winter. The average rainfall of about 1375 mm, which is mainly distributed from mid June to September. The average maximum and minimum temperature ranges between 46.6⁰C and 21⁰C. The mean relative humidity reaches up to 78% during winter (November- February) with occasional frost.

The data related to weekly maximum and minimum temperature, relative humidity, rainfall (mm), sunshine hours and wind velocity (km/hr) recorded at Meteorological Observatory Krishi Nagar, J.N.K.V.V, Jabalpur are presented in the Table 3.1 and Fig. 1.

Table 1: Weekly meteorological data during the cropping season (2012-2013)

| Month/ Dates | Weeks | Temperature (°C) | | Rainfall (mm) | No. of | | Relative Humidity | |
|-----------------|-------|------------------|------|---------------|------------|----------------|-------------------|------|
| | | Min. | Max. | | Rainy Days | Sunshine Hours | Mor. | Evn. |
| Nov. 5-11 | 45 | 14.6 | 28.2 | 0.0 | 00 | 7.7 | 88 | 30 |
| Nov. 12-18 | 46 | 10.0 | 28.6 | 0.0 | 00 | 8.4 | 85 | 28 |
| 19-25 | 47 | 10.6 | 27.9 | 0.0 | 00 | 7.6 | 88 | 29 |
| Nov. 26-Dec.02 | 48 | 11.5 | 28.4 | 0.0 | 00 | 8.4 | 83 | 33 |
| Dec. 03-09 | 49 | 10.6 | 28.7 | 0.0 | 00 | 9.0 | 85 | 26 |
| 10-16 | 50 | 14.0 | 29.0 | 3.3 | 01 | 7.2 | 92 | 41 |
| 17-23 | 51 | 7.1 | 25.3 | 0.0 | 00 | 8.6 | 88 | 29 |
| 24-31 | 52 | 5.0 | 23.8 | 0.0 | 00 | 9.1 | 90 | 30 |
| Jan. 01-07 | 01 | 7.2 | 23.3 | 0.0 | 00 | 5.9 | 87 | 42 |
| 08-14 | 02 | 5.2 | 23.0 | 0.0 | 00 | 9.2 | 87 | 32 |
| 15-21 | 03 | 10.1 | 26.7 | 0.0 | 00 | 8.1 | 84 | 36 |
| 22-28 | 04 | 5.0 | 21.4 | 0.0 | 00 | 7.6 | 86 | 36 |
| Jan. 29-Feb. 04 | 05 | 7.4 | 24.6 | 0.0 | 00 | 7.4 | 91 | 36 |
| Feb. 05-11 | 06 | 11.3 | 25.9 | 0.0 | 00 | 6.2 | 88 | 49 |
| 12-18 | 07 | 13.0 | 25.2 | 55.4 | 03 | 4.1 | 91 | 60 |
| 19-25 | 08 | 11.0 | 25.0 | 4.8 | 01 | 9.3 | 93 | 49 |
| Feb. 26-Mar.04 | 09 | 9.2 | 28.0 | 0.0 | 00 | 9.8 | 87 | 37 |
| Mar. 05-11 | 10 | 9.9 | 30.7 | 0.0 | 00 | 9.6 | 83 | 28 |

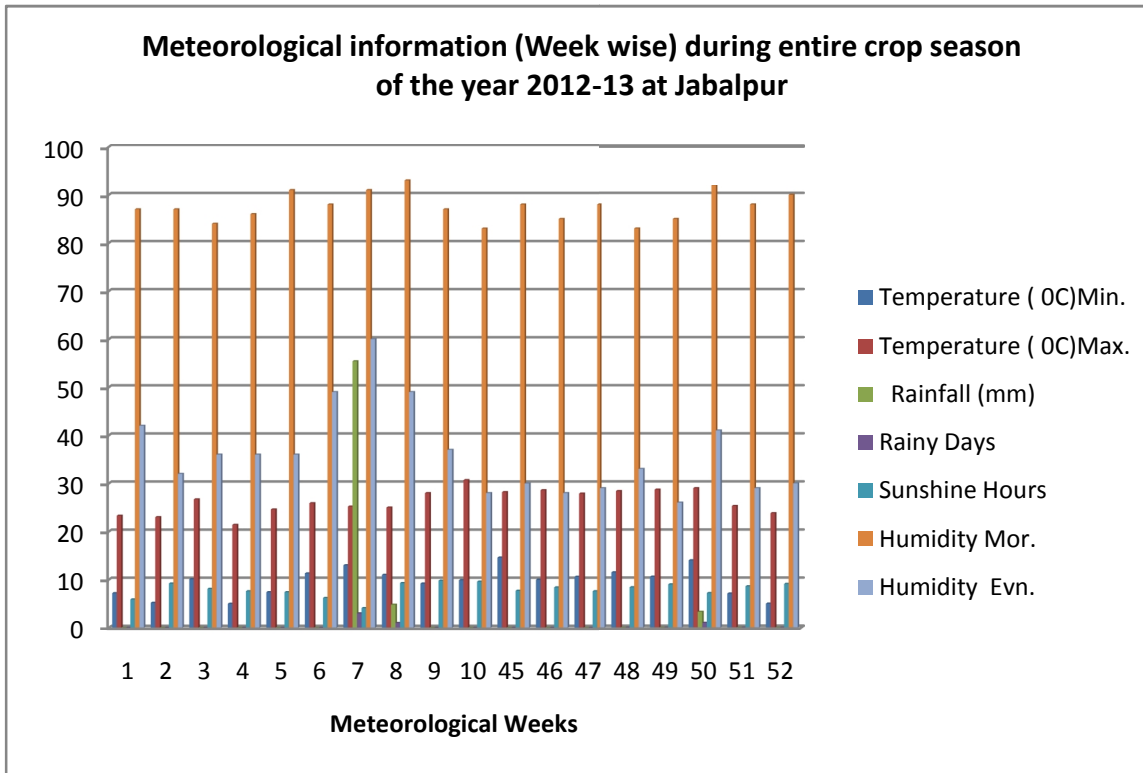


Fig 1: Meteorological information (week wise) during entire crop season of the year 2012-13 at Jabalpur

3.2 Experimental material

The experimental material includes 20 genotypes and two checks of the garden pea collected from different states of India. Genotypes are presented in Table 3.2.

Table 3.2: Details of genotypes and checks used in the study

| S. No. | Genotypes | S. No. | Genotypes |
|--------|-----------------|--------|---------------|
| 1. | 2012/ PMVAR – 1 | 12. | PSM –3 |
| 2. | 2012/ PMVAR – 2 | 13. | AP –1 |
| 3. | 2012/ PMVAR – 3 | 14. | AP –3 |
| 4. | 2012/ PMVAR – 4 | 15. | BE –06 |
| 5. | 2012/ PMVAR – 5 | 16. | Pusa Pragati |
| 6. | VRP – 5 | 17. | Arkel |
| 7. | VRP – 6 | 18. | Akra Sampurna |
| 8. | VRP – 8 | 19. | Arka Ajit |
| 9. | VRP – 16 | 20. | GS –10 |
| 10. | VRP – 22 | 21. | VRP –7 (C) |
| 11. | IIVR –5 | 22. | PC –531 (C) |

3.3 Experimental details

3.3.1 Design of experiment

The experiment was laid out in Randomized Complete Block Design with three replications and each replication consisted of twenty two genotypes. All the genotypes were randomized separately in each replication. The plan of layout is given in Fig. 2 and other details are given as below:-

Table 3.3: Experimental details

| | | |
|-----|---------------------------------|---------------------------------------|
| 1. | Crop | Garden pea (<i>Pisum sativum</i> L.) |
| 2. | Design of experiment | Randomized Complete Block Design |
| 3. | Number of replications | 3 |
| 4. | Number of genotypes | 22 |
| 5. | Total number of plots | 66 |
| 6. | Plot size | 3.0m x 3.0m |
| 7. | Spacing | 30cm x 10cm |
| 8. | Number of rows per plot | 10 |
| 9. | Number of plants per row | 30 |
| 10. | Total number of plants per plot | 300 |
| 11. | Gross experimental area | 874.0 m ² |
| 12. | Net experimental area | 594.0 m ² |
| 13. | Plot to plot distance | 0.50 m |
| 14. | Distance between replication | 1.0 m |
| 15. | Date of sowing | 07.11.2012 |
| 16. | Manure and fertilizers applied | FYM 20tones, NPK 50:60:60 kg/ha |

3.4 Agronomical Operations

3.4.1 Field preparation and sowing

In order to get good tilth of the soil for sowing, one cross cultivation was done by tractor drawn cultivator followed by two harrowing and one planking before sowing of seed.

In the beginning of the experiment, seeds were dibbled. After two weeks of sowing, thinning was carried out to maintain plant to plant distance. All the recommended package of practices was followed to raise healthy crop.

3.4.2 Irrigation

The first light irrigation was given immediately after sowing to ensure proper germination. Subsequent irrigation was given at 15 days interval.

3.4.3 Intercultural operations

The experimental plots were kept weed free. Three hand weedings was done.

3.4.4 Fertilizer Application

Nitrogen, phosphorus and potassium were applied, as per the treatments through urea, single super phosphate and murate of potash respectively. A uniform dose of 50 kg N/ha, 60 kg P/ha, and 60 kg K/ha was applied to all the treatments. Full quantity of phosphorus and potassium fertilizer along with one-third of nitrogen was applied before sowing of seeds. While, the rest of the nitrogen was applied in two equal splits 25 and 50 days after sowing.

3.4.5 Plant protection measures:

The crop was sprayed with imidachlorpid 0.005% or thiomethoxan 0.025% for control of Aphids and Jassid, alternate to keep the crop free from pest during crop growth period.

3.5 Sampling

Sampling was done at 30 days up to till harvest for growth analysis. Five plants were randomly selected from each genotype and replication for the study.

3.6 Observations recorded

The data recorded on various parameters were subdivided into four categories during the period of experimentation. The data were recorded as per standard procedure.

(A) Morphological Parameters

3.6.1 Plant height (cm):

The height of the main stem from the ground level to the apical bud (leaf apex) was measured with the meter scale at 30 days interval (i.e. 30, 60, 90 DAS).

3.6.2 Number of primary branches per plant:

The numbers of primary branches arising from the main stem of each tagged plant was counted at 30 days interval (i.e. 30, 60, 90 DAS).

3.6.3 Number of leaves per plant:

The numbers of leaves of the each tagged plant in all the genotypes were counted at 30 days interval (i.e. 30, 60, 90 DAS).

(B) Phenological Parameters

3.6.4 Days to first flowering:

Number of days taken beginning from the sowing to the appearance of first flower on the five randomly selected plants in each plot was noted and average was calculated.

3.6.5 Days to 50% flowering:

Number of days beginning from the sowing to the date when 50 percent of the plants flowered in a plot was recorded.

3.6.6 Days to first picking:

The number of days beginning from sowing to the day when first picking (fruits attained proper size and colour) was counted for each genotype.

3.6.7 Fruiting span:

The number of days beginning from first pod harvest till the final picking was counted as the duration of the fruiting or fruiting span.

(C) Yield Parameters

3.6.8 Number of pods per plant:

The number of pods harvested from five randomly selected plants in each genotype was collected during each picking counted and totaled together and average pods per plant were calculated.

3.6.9 Pod length (cm):

The length of pods was measured in centimeter for five randomly selected pods at peak fruiting stage.

3.6.10 Pod width (cm):

The width of pod was measured with the help of Verneire caliper and then average was recorded.

3.6.11 Average Pod weight (gm):

The weight of five pods was recorded separately with the help of weighing balance and average was worked out for each genotypes.

3.6.12 Number of seeds per pod:

The number of seeds per pod was counted at the time of harvest to represent this character.

3.6.13 Pod yield per plant (gm):

The weight of the pods of the tagged plants was recorded at each picking and the average weight of the pods per plant was calculated in gm.

3.6.14 Shelling percentage:

Shelling percentage was calculated by the following formula:

$$\text{Shelling percentage} = \frac{\text{Seed weight}}{\text{Mature pod weight}} \times 100$$

3.6.15 Pod yield per hectare (q/ha):

Total pod yield (kg) per plot was converted in quintal per hectare by multiplying with factor.

(D) Other Parameters

3.6.16 Pod colour:

Colour of ten randomly selected pods at marketable stage was observed visually as

- Dark green
- Light green
- Green

3.6.17 Pod shape:

Shapes of ten randomly selected pods were observed visually and were categorized as

- Straight
- Slightly curved

3.6.18 Presence of tendrils:

Presence of tendrils of ten randomly selected plants was observed visually.

- Present
- Absent

3.6.19 Incidence of pod borer:

Incidences of pest like pod borer was recorded at every picking.

$$\text{Percentage of pod borer incidence} = \frac{\text{Number of pod borer infested pod}}{\text{Total number of pod}} \times 100$$

3.6.20 Incidence of Powdery Mildew

An incidence of disease like powdery mildew was recorded at ten days interval. The incidence of above mentioned disease was calculated as follows:

$$\text{Percentage disease incidence} = \frac{\text{Number of disease affected plants}}{\text{Total number of plants per plot}} \times 100$$

3.6.21 Protein content (%)

The nitrogen content of dry seeds was estimated at maturity stage by micro kjeldhal digestion and distillation method as given by (AOAC, 1980) as follows:

0.1gm of sample was digested with concentrate sulphuric acid (10ml) in a kjeldhal flask with 2gm catalyst mixture (80gm of K_2SO_4 , 20gm of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ and 0.34gm of sodium selenate). After digestion for about 3 hours till liquid becomes colourless the flask was allowed to cool and the contents carefully dilute to 100ml with distilled water. The solution is transferred quantitatively to a distillation apparatus. 15ml of 40 percent of sodium hydroxide was added and the liberating ammonia was collected with two drops of mixed indicator (bromocresol green + methyl red) distillation was continued for 5 minutes, appearance of green colour to ensure the complete evaluation of ammonia. After distillation solution was titrated with 0.1N H_2SO_4 . Nitrogen and protein was calculated by following formula.

$$\text{Nitrogen(\%)} = \frac{\text{Normality of H}_2\text{SO}_4 \times \text{Volume of H}_2\text{SO}_4 \times 1.4}{\text{Wt of sample}}$$

Protein percent in the seed was estimated multiplying percentage of seed by factor 6.25

$$\text{Protein(\%)} = \text{Nitrogen \%} \times 6.25$$

3.7 Statistical methodology

The data obtained in respect of all the characters has been subjected to the following statistical analyses.

3.7.1 Mean: It was calculated by using following formula.

$$\text{Mean} = \frac{\sum x}{n}$$

Where,

x = The sum of all the observation

n = Number of observation

3.7.2 Analysis of variance

The data based on the mean of individual plants selected for observation were statistically analysed to find out overall total variability present in the material under study for each character and for all the populations. The first and foremost step is to carry out analysis of variance to test the significance of differences among the populations. The analysis of variance was carried out as per methods suggested by Panse and Sukhatme (1967). The skeleton of analysis of variance used was as follows:

Table 3.4: ANOVA for Randomized Completely Block Design

| Source of variation | d.f. | Sum of square | Mean sum of square | F value | F _t 5% or 1% table value |
|---------------------|-------------|---------------|--------------------|---------|-------------------------------------|
| Replication | r-1 | RSS | RMS | RMS/EMS | - |
| Genotypes | g-1 | GSS | GMS | GMS/EMS | - |
| Error | (r-1)(g-1) | ESS | EMS | - | - |
| Total | rg-1 | TSS | - | - | - |

Where,

r = Number of replications

g = Number of genotypes

D.F. = Degree of freedom

RSS = Replication sum of square

GSS = Genotype sum of square

ESS = Error sum of square

TSS = Total sum of square

RMS = Replication mean sum of square

GMS = Genotype mean sum of square

EMS = Error mean sum of square

A significant value of F test indicates that the test entries differ significantly among themselves, which requires computing C.D.

$$C.V. = \frac{\sqrt{EMS}}{GM} \times 100$$

$$SE\ m \pm = \sqrt{\frac{EMS}{r}}$$

$$SE_{diff} = \sqrt{\frac{2 EMS}{r}}$$

CD at 5% prob. Level = SE diff x $t_{5\%}$ table value

Where,

- C.V. % = Coefficient of variation
- SE m_{\pm} = Standard error of means
- S E diff = Standard error of difference
- GM = Grand mean
- C.D. = Critical difference
- $t_{5\%}$ = t , table value 5% probability level at error d.f.

Estimation of mean, components of variance, phenotypic, genotypic and environmental coefficient of variation, heritability, genetic advance and genetic advance as percentage of mean:

The mean of different characters were calculated by conventional method:-

$$\text{Mean} = \frac{\sum x_i}{n}$$

Where,

- x_i = The sum of all the observation for i^{th} character.
- n = Number of observations.

Range was recorded by observing the lowest and the highest mean values for each character.

The component of variance was calculated as follows:-

| S. No. | Source | M.S.S. | Expected M.S.S. |
|--------|--------------|--------|------------------------|
| 1. | Replications | - | - |
| 2. | Genotypes | M_i | $t^2 e_i + r. t^2 g_i$ |
| 3. | Error | E_i | $t^2 e_i$ |

$$t^2 g_i = M_i - E_i$$

$$t^2 e_i = E_i$$

$$t^2 p_i = t^2 g_i + t^2 e_i$$

Where,

$t^2 g_i$ = Genotypic variance for i^{th} character.

$t^2 e_i$ = Environmental variance for i^{th} character.

$t^2 p_i$ = Phenotypic variance for i^{th} character.

Phenotypic and genotypic coefficient of variation (expressed in %) were calculated by using the formula given by Burton (1952). Genotypic coefficient of variation (GCV) was calculated as below:

$$\text{GCV}\% = \frac{\sqrt{\sigma^2 g_i}}{\bar{X}_i} \times 100$$

Phenotypic coefficient of variation (PCV)

$$\text{PCV}\% = \frac{\sqrt{\sigma^2 p_i}}{\bar{X}_i} \times 100$$

Where,

\bar{x}_i = General mean of the i^{th} character under consideration.

$t^2 g_i$ and $t^2 p_i$ = Genotypic and phenotypic standard deviation of the i^{th} character respectively.

Heritability and genetic advance

Heritability (broad sense) which is ratio of genotypic variance to the total phenotypic variance is symbolized as h^2 (BS) and expressed in percentage. Estimation of heritability was done as per the formula given by Hanson *et al.* (1956).

$$h^2 \text{ (BS)} = \frac{\sigma^2_{g_i}}{\sigma^2_{p_i}} \times 100$$

or

$$= \frac{\text{Genotypic variance of the } i^{\text{th}} \text{ character}}{\text{Phenotypic variance of the } i^{\text{th}} \text{ character}}$$

Expected genetic advance was calculated by using the method suggested by Johnson *et al.* (1955) at 5% selection intensity.

$$\text{Genetic advance (GA)} = K \cdot P_i \cdot h^2_i$$

Genetic advance as percentage of mean was calculated as follows:

$$\frac{\text{Genetic advance}}{\bar{X}_i}$$

Where,

K= Selection intensity its value at 5% selection level is 2.06.

P_i = Phenotypic standard deviation of the i^{th} character.

h^2_i = Broad sense heritability (fraction) of the i^{th} character.

\bar{X}_i = General mean of the i^{th} character under consideration.

Correlation coefficients

Correlation coefficients were calculated in all possible combinations taking all the characters into consideration at genotypic, phenotypic and environmental levels by using the formula as proposed by Miller *et al.* (1958).

$$r = \frac{\sum xy - \frac{\sum x \times \sum y}{n}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right) \left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}}$$

Where,

- r = Correlation coefficient
- n = Number of treatments
- X and Y = Character under study

Genotypic, phenotypic and environmental correlations were computed by substituting corresponding variance and covariance in the above formula, e.g.

$$r_G (X_i X_j) = \frac{G \text{ Cov } (X_i X_j)}{\sqrt{V_G (X_i) \cdot V_G (X_j)}}$$

$$r_P (X_i X_j) = \frac{P \text{ Cov } (X_i X_j)}{\sqrt{V_P (X_i) \cdot V_P (X_j)}}$$

$$r_E (X_i X_j) = \frac{E \text{ Cov } (X_i X_j)}{\sqrt{V_E (X_i) \cdot V_E (X_j)}}$$

Testing of correlations:

The phenotypic correlations are tested for their significance by following formula based on “t” test:

$$T_e = r \sqrt{\frac{n-2}{1-R^2}} \quad \text{at } (n-2) \text{ d.f.}$$

Where,

N= Number of treatments.

R= phenotypic correlations coefficient.

The calculated value of “t” is compared with table of “t” at (n-2) d.f. If the calculated value is equal to or greater than table value, it is significant at given probability level. If $t_c < t_T$, it is non significant.

Path coefficients analysis:

Path coefficients analysis was worked out to show the cause and effect relationship between yield and various yield components and to partition the total correlation coefficient into direct and indirect effects. This procedure was developed by Wright (1921) and as per consent used by Li (1956) and followed by Dewey and Lu (1959).

Path coefficients are the standardized partial regression coefficients and as such measure the direct influence of one variable upon another variable and permits partition of correlation coefficient into components of direct and indirect effects. The sum of the direct and all possible indirect effects via all other traits must be equal to correlation coefficient of dependent traits with independent characters under consideration.

Path coefficients were obtained by setting simultaneous equations which express basic relationship between correlation and path coefficient analysis.

1. $r_{1, y} = P_{1,y} + r_{1, 2} P_{2,y} + r_{1, 2} P_{3yt} + \dots + r_{1, 10} P_{10,y}$
2. $r_{2, y} = P_{2,y} + r_{2, 1} P_{1,y} + r_{2, 2} P_{3yt} + \dots + r_{2, 10} P_{10,y}$
10. $r_{10, y} = P_{10,y} + r_{10, 1} P_{1,y} + r_{10, 2} P_{3yt} + \dots + r_{10, 9} P_{9,y}$

Where,

1, 2, 10 are the component characters and y is dependent upon which direct and indirect effects are studied.

Unexplained variation of the residual effect was obtained from the following equation:

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

Where,

R = Residual effect.

di = Direct effect of the i^{th} character.

r_{ij} = Correlation coefficient between the i^{th} character and j^{th} dependent character.

Direct and indirect effects of bulb yield per plant were calculated at both genotypic and phenotypic levels.

Results

The results obtained from the present investigation “Studies on genetic parameters, correlation and path coefficient analysis of yield and its components in garden pea (*Pisum sativum* L.)” are presented under the following heads

4.1 Analysis of variance

4.2 Genetic variability

4.2.1 Range and mean performance

4.2.2 Coefficient of variation

4.2.3 Heritability

4.2.4 Genetic advance

4.3 Correlation coefficient analysis

4.4 Path coefficient analysis

4.5 Quality parameters

4.6 Incidence of pest and diseases

4.1 Analysis of variance

The analysis of variances for all the characters studied has been presented in Table 4.1. Mean square due to genotypes were highly significant for all the characters except for number of primary branches per plant at 30 DAS, indicating that the presence of genetic diversity in the existing material.

Eight traits viz., pod yield per plant, plant height at 90 DAS, number of pods per plant, plant height at 60 DAS, shelling per cent, days to 50 per cent flowering, days to first flowering and days to first picking exhibited the value of higher magnitude.

Table 4.1: Analysis of variance for various characters in Pea (mean sum of squares).

| Source of variance | D.F. | Plant height (cm) | | | Primary branches per plant | | |
|--------------------|------|-------------------|-----------|-----------|----------------------------|---------|---------|
| | | 30DAS | 60DAS | 90DAS | 30DAS | 60DAS | 90DAS |
| Replications | 2 | 9.592 | 114.658 | 46.045 | 0.029 | 7.782 | 4.513 |
| Genotypes | 21 | 19.393** | 147.615** | 482.993** | 0.026 | 0.920** | 0.471** |
| Error | 42 | 5.371 | 43.131 | 37.542 | 0.039 | 0.213 | 0.089 |

| Source of variance | D.F. | Leaves per plant | | | Days to first flowering | Days to 50% flowering | Days to first picking |
|--------------------|------|------------------|----------|----------|-------------------------|-----------------------|-----------------------|
| | | 30DAS | 60DAS | 90DAS | | | |
| Replications | 2 | 2.576 | 9.977 | 206.431 | 14.378 | 39.560 | 2.469 |
| Genotypes | 21 | 16.378** | 21.156** | 35.528** | 114.774** | 134.531** | 104.188** |
| Error | 42 | 2.071 | 5.783 | 14.860 | 2.220 | 8.576 | 9.564 |

| Source of variance | D.F. | Fruiting span | Number of pods /plant | Pod length (cm) | Pod width (cm) | Pod weight (g) | Number of seeds /pod |
|--------------------|------|---------------|-----------------------|-----------------|----------------|----------------|----------------------|
| Replications | 2 | 3.469 | 218.947 | 0.142 | 0.0071 | 7.088 | 1.575 |
| Genotypes | 21 | 37.448** | 214.03** | 3.643** | 0.0149** | 2.350** | 4.535** |
| Error | 42 | 13.390 | 2.818 | 0.384 | 0.0053 | 0.556 | 0.717 |

| Source of variance | D.F. | Shelling % | Pod yield/ plant (g) | Protein % | Incidence of pod borer (%) | Incidence of powdery mildew (%) |
|--------------------|------|------------|----------------------|-----------|----------------------------|---------------------------------|
| Replications | 2 | 38.786 | 2762.958 | 6.633 | 1.200 | 10.227 |
| Genotypes | 21 | 136.055** | 5766.597** | 18.640** | 7.177 | 72.799 |
| Error | 42 | 41.862 | 105.932 | 0.104 | 9.168 | 49.909 |

4.2 Genetic Variability

4.2.1 Range and mean performance of the genotypes

Range and mean performance (maximum and minimum) of the twenty two genotypes of garden pea for twenty characters are presented in Table 4.2a, b and c.

4.2.1.1 Plant height (cm)

Plant height varied from 11.80 to 20.07 cm, 30.19 to 53.78 cm and 40.03 to 103.95 cm with an overall mean performance of 16.34, 38.23 and 50.72 at 30, 60 and 90 DAS respectively. Genotype Arka Ajit was recorded the maximum plant height 20.07, 53.78 and 103.95 cm and genotype PC - 531 was exhibited the minimum 11.80, 30.19 and 40.03 cm plant height at 30, 60 and 90 DAS respectively.

4.2.1.2 Number of primary branches per plant

Number of primary branches per plant ranged between 0.00 to 0.27, 0.93 to 2.67 and 2.60 to 4.13 with a average performance of 0.15, 1.77 and 3.13 primary branches per plant. The maximum 0.27, 2.67 and 4.13 branches per plant was recorded in genotype GS - 10, while it was recorded minimum in Pusa Pragati 0.00, 0.93 and 2.60 at 30, 60 and 90 DAS respectively.

4.2.1.3 Number of leaves per plant

Number of leaves per plant ranged from 5.80 to 13.47, 15.27 to 24.83 and 28.93 to 43.53 with a overall mean performance of 10.30, 19.72 and 35.74. The maximum 13.47, 24.83 and 43.53 leaves per plant were noted in genotype Arka Ajit, while minimum 5.80, 24.83 and 28.93 leaves per plant were exhibited in genotype Pusa Pragati at 30, 60 and 90 DAS respectively.

Table 4.2a: Mean performance of morphological parameters of Garden pea.

| Genotypes | Plant height (cm) at DAS | | | Primary branches per plant at DAS | | |
|-----------------|--------------------------|--------------|---------------|-----------------------------------|-------------|-------------|
| | 30 | 60 | 90 | 30 | 60 | 90 |
| 2012/ PMVAR – 1 | 13.35 | 31.80 | 47.93 | 0.00 | 2.27 | 3.57 |
| 2012/ PMVAR – 2 | 19.67 | 49.65 | 59.27 | 0.07 | 1.80 | 3.30 |
| 2012/ PMVAR – 3 | 18.29 | 48.44 | 52.75 | 0.27 | 1.73 | 3.47 |
| 2012/ PMVAR – 4 | 14.35 | 33.23 | 48.66 | 0.20 | 1.80 | 2.67 |
| 2012/ PMVAR – 5 | 19.64 | 50.19 | 57.79 | 0.13 | 1.00 | 3.00 |
| Arkel | 18.32 | 31.37 | 46.37 | 0.20 | 2.33 | 3.47 |
| AP –1 | 12.08 | 36.95 | 48.33 | 0.27 | 2.20 | 3.33 |
| GS –10 | 15.45 | 33.42 | 44.56 | 0.27 | 2.67 | 4.13 |
| Pusa Pragati | 17.39 | 39.18 | 51.30 | 0.00 | 0.93 | 2.60 |
| PSM –3 | 16.97 | 38.93 | 48.37 | 0.27 | 2.53 | 2.97 |
| Akra Sampoorna | 13.79 | 33.67 | 48.11 | 0.07 | 2.13 | 3.07 |
| AP –3 | 16.23 | 45.84 | 52.41 | 0.27 | 1.53 | 3.30 |
| BE –06 | 16.63 | 37.03 | 43.51 | 0.20 | 1.60 | 2.70 |
| IIVR –5 | 17.41 | 34.23 | 44.27 | 0.07 | 1.13 | 3.30 |
| Arka Ajit | 20.07 | 53.78 | 103.95 | 0.27 | 2.33 | 2.67 |
| VRP – 5 | 16.92 | 35.41 | 47.85 | 0.20 | 1.00 | 2.97 |
| VRP – 6 | 18.33 | 33.93 | 43.81 | 0.20 | 1.07 | 2.63 |
| VRP – 8 | 16.59 | 41.11 | 46.38 | 0.07 | 1.47 | 3.47 |
| VRP – 16 | 12.00 | 33.21 | 46.17 | 0.07 | 1.70 | 3.33 |
| VRP – 22 | 15.41 | 30.93 | 46.91 | 0.00 | 1.27 | 3.53 |
| VRP –7 (C) | 18.87 | 38.66 | 47.27 | 0.13 | 2.00 | 2.80 |
| PC –531 (C) | 11.80 | 30.19 | 40.03 | 0.07 | 2.53 | 2.80 |
| S.Em± | 1.33 | 3.79 | 3.53 | 0.11 | 0.26 | 0.17 |
| C.D.5% level | 3.82 | 10.83 | 10.11 | N.S. | 0.76 | 0.49 |

Table 4.2b: Mean performance of morphological parameters of Garden pea.

| Genotypes | Leaves per plant at DAS | | | Days to first flowering | Days to 50% flowering | Days to first picking |
|-----------------|----------------------------|--------------|--------------|-------------------------------|-----------------------------|-----------------------------|
| | 30 | 60 | 90 | | | |
| 2012/ PMVAR – 1 | 12.87 | 15.73 | 35.53 | 52.67 | 60.67 | 87.67 |
| 2012/ PMVAR – 2 | 9.47 | 17.69 | 34.93 | 47.67 | 54.33 | 89.00 |
| 2012/ PMVAR – 3 | 10.73 | 19.33 | 40.81 | 37.00 | 46.00 | 84.33 |
| 2012/ PMVAR – 4 | 11.67 | 21.93 | 40.30 | 52.67 | 59.33 | 88.67 |
| 2012/ PMVAR – 5 | 12.53 | 17.80 | 37.00 | 44.33 | 51.00 | 84.00 |
| Arkel | 5.87 | 18.67 | 38.80 | 44.33 | 51.67 | 84.33 |
| AP –1 | 6.73 | 23.00 | 37.97 | 51.33 | 60.33 | 91.67 |
| GS –10 | 8.87 | 23.40 | 33.83 | 47.33 | 57.00 | 76.33 |
| Pusa Pragati | 5.80 | 15.27 | 28.93 | 43.67 | 53.00 | 85.00 |
| PSM –3 | 13.27 | 17.47 | 33.33 | 42.33 | 51.67 | 82.67 |
| Akra Sampurna | 9.73 | 19.60 | 36.70 | 45.00 | 53.00 | 87.00 |
| AP –3 | 10.27 | 24.07 | 31.97 | 41.67 | 51.00 | 85.00 |
| BE –06 | 11.73 | 19.20 | 34.30 | 33.33 | 39.33 | 70.33 |
| IIVR –5 | 12.00 | 17.73 | 32.60 | 42.33 | 51.33 | 85.33 |
| Arka Ajit | 13.47 | 24.83 | 43.53 | 54.67 | 64.67 | 92.00 |
| VRP – 5 | 10.00 | 17.03 | 33.13 | 39.67 | 48.33 | 82.67 |
| VRP – 6 | 11.93 | 19.70 | 32.40 | 39.00 | 47.00 | 84.00 |
| VRP – 8 | 8.53 | 22.00 | 38.93 | 36.00 | 43.33 | 85.67 |
| VRP – 16 | 7.27 | 20.27 | 36.69 | 39.00 | 45.67 | 70.67 |
| VRP – 22 | 9.87 | 17.60 | 36.67 | 41.00 | 45.00 | 87.00 |
| VRP –7 (C) | 11.67 | 20.57 | 35.70 | 52.00 | 58.33 | 90.00 |
| PC –531 (C) | 12.40 | 21.07 | 32.27 | 53.33 | 62.67 | 76.33 |
| S.Em± | 0.83 | 1.38 | 2.22 | 0.86 | 1.69 | 4.83 |
| C.D.5% level | 2.37 | 3.96 | 6.36 | 2.45 | 4.83 | 5.10 |

4.2.1.4 Days to first flowering

Days to first flowering varied from 33.33 to 54.67 days with the average days being 44.56. Early flowering was observed in genotype BE –06 (33.33 days), while the genotype Arka Ajit (54.67 days) was the latest.

4.2.1.5 Days to 50 per cent flowering

Early 50 per cent flowering was recorded in genotype BE –06 (39.33 days), while the genotype Arka Ajit was required the maximum (64.67 days) for 50 per cent flowering. The average days for 50 per cent flowering were 52.48 and it ranged from 39.33 to 64.67 days.

4.2.1.6 Days to first picking

Days to first picking ranged from 70.33 to 92.00 days. Genotype BE –06 was earliest for days to first picking, while Arka Ajit was latest for the same. The mean was calculated to be 84.07 days.

4.2.1.7 Fruiting span

The mean for fruiting span was 36.93 days and it ranged from 31.00 to 42.00 days. Maximum length of fruiting period was observed in BE –06 (42.0 days) and minimum in Arka Ajit (31.00 days).

4.2.1.8 Number of pods per plant

The maximum number of pods per plant was observed in 2012/ PMVAR – 3 (51.80), while it was least in genotype Arka Ajit (15.40). The average number of pods per plant was 27.55 and it ranged from 15.40 to 51.80.

4.2.1.9 Pod length (cm)

The pod length varied from 6.55 to 11.31 cm with a mean value of 8.63 cm. Genotype 2012/ PMVAR – 3 produced considerably long pod (11.31 cm),

while genotypes Arka Ajit and IIVR -5 (15.40 cm and 16.20 cm respectively) produced small pod.

Table 4.2c: Mean performance of various parameters of Garden pea.

| Genotypes | Fruiting span | Number of pods/ plant | Pod length (cm) | Pod width (cm) | Pod weight (g) | Number of seeds / pod | Shelling % | Yield/ plant (g) |
|------------------|----------------------|------------------------------|------------------------|-----------------------|-----------------------|------------------------------|-------------------|-------------------------|
| 2012/ PMVAR – 1 | 41.00 | 31.00 | 9.69 | 1.02 | 4.43 | 8.73 | 52.61 | 178.00 |
| 2012/ PMVAR – 2 | 35.00 | 35.13 | 8.99 | 1.08 | 4.67 | 8.33 | 47.33 | 186.67 |
| 2012/ PMVAR – 3 | 41.00 | 51.80 | 11.31 | 1.21 | 6.58 | 10.27 | 68.82 | 221.67 |
| 2012/ PMVAR – 4 | 32.33 | 35.27 | 8.62 | 1.07 | 5.14 | 10.20 | 60.82 | 193.33 |
| 2012/ PMVAR – 5 | 40.00 | 35.47 | 9.25 | 1.19 | 6.42 | 7.53 | 46.40 | 210.67 |
| Arkel | 39.67 | 17.00 | 7.16 | 1.02 | 4.18 | 6.00 | 65.80 | 78.33 |
| AP –1 | 31.33 | 26.60 | 7.16 | 1.10 | 4.03 | 6.80 | 55.97 | 123.33 |
| GS –10 | 34.67 | 21.13 | 9.32 | 1.10 | 5.07 | 7.10 | 63.84 | 83.33 |
| Pusa Pragati | 38.00 | 22.47 | 8.55 | 1.13 | 4.87 | 7.73 | 59.71 | 113.33 |
| PSM –3 | 41.33 | 30.73 | 8.66 | 1.19 | 5.80 | 6.93 | 45.23 | 155.67 |
| Akra Sampurna | 35.00 | 25.47 | 7.27 | 1.10 | 6.57 | 6.13 | 54.97 | 116.67 |
| AP –3 | 38.00 | 26.20 | 8.62 | 1.18 | 5.92 | 7.33 | 56.78 | 124.67 |
| BE –06 | 42.00 | 30.20 | 8.05 | 1.08 | 5.20 | 7.47 | 57.41 | 125.00 |
| IIVR –5 | 37.67 | 16.20 | 8.03 | 1.11 | 5.02 | 6.80 | 52.78 | 159.67 |
| Arka Ajit | 31.00 | 15.40 | 6.55 | 0.93 | 2.85 | 5.37 | 45.10 | 66.33 |
| VRP – 5 | 40.33 | 28.20 | 8.25 | 1.15 | 5.46 | 7.73 | 53.76 | 158.07 |
| VRP – 6 | 40.33 | 25.67 | 8.32 | 1.15 | 5.72 | 6.93 | 54.47 | 127.13 |
| VRP – 8 | 35.00 | 19.53 | 9.47 | 1.01 | 5.13 | 8.00 | 64.87 | 161.47 |
| VRP – 16 | 37.67 | 38.00 | 8.31 | 1.09 | 6.08 | 8.40 | 53.55 | 75.33 |
| VRP – 22 | 34.67 | 20.13 | 8.44 | 1.06 | 4.87 | 7.50 | 48.77 | 99.60 |
| VRP –7 (C) | 31.67 | 29.13 | 10.21 | 1.17 | 5.58 | 6.93 | 53.89 | 142.27 |
| PC –531 (C) | 35.00 | 25.40 | 9.84 | 1.02 | 5.15 | 9.20 | 50.21 | 115.87 |
| S.Em± | 2.11 | 0.96 | 0.35 | 0.04 | 0.43 | 0.48 | 3.73 | 5.94 |
| C.D.5% level | 6.03 | 2.77 | 1.02 | 0.12 | 1.23 | 1.39 | 10.67 | 16.98 |

4.2.1.10 Pod width (cm)

Pod width ranged from 0.93 to 1.21 cm, and the average was calculated to be 1.09 cm. Pod width was observed highest in 2012/ PMVAR – 3 (1.21 cm) and it was recorded least in Arka Ajit (0.93 cm).

4.2.1.11 Pod weight (gm)

The heaviest pods were observed in genotypes 2012/ PMVAR – 3 and Akra Sampoorna (6.58 gm and 6.57 gm respectively) and they were lightest in Arka Ajit (2.85 gm). The weight of pod lied between 2.85 gm to 6.58 gm, while the average weight of fruit was 5.21 gm.

4.2.1.12 Number of seeds per pod

Maximum number of seeds per pod was observed in 2012/ PMVAR – 3 (10.27), while it was least (5.37) in genotype Arka Ajit. The average number of seeds per pod was 7.61 and it ranged between 5.37 to 10.27 seeds per pod.

4.2.1.13 Shelling per cent

The shelling percentage varied from 45.10% to 68.82% with a mean value of 55.29 %. Genotype 2012/ PMVAR – 3 produced considerably more 68.82 % shelling percentage. Whereas, genotype Arka Ajit was recorded minimum 45.10% shelling percentage.

4.2.1.14 Pod yield per plant (gm)

Maximum pod yield per plant was recorded in 2012/ PMVAR – 3 (221.67 gm) which was closely followed by 2012/ PMVAR – 5 (210.67 gm). Genotypes Arka Ajit (66.33 gm) was poor yielder. The average yield per plant was 137.68 gm and it ranged from 66.33 gm to 221.67 gm.

4.2.2 Coefficient of variations

Estimation of components of genetic parameters of variation for yield and its attributes exhibited a wide range of variation for the character studies (Table 4.3). Result indicated that the value of phenotypic coefficient of variations were of higher in magnitude than that of genotypic coefficient of variation for all the characters showing that the environment had an important role in influencing the expression of the characters,

4.2.2.1 Phenotypic coefficient of variations

The phenotypic coefficient of variation ranged from 7.62% for days to first picking to 119.17% for number of primary branches per plant at 30 DAS. The phenotypic coefficient of variations was highest for characters viz., number of primary branches per plant at 30 DAS (119.17%), number of primary branches per plant at 60 DAS (37.78%), pod yield per plant (32.55%), number of pods per plant (31.05%), plant height at 90 DAS (26.88%), number of leaves per plant at 30 DAS (25.38%), plant height at 60 DAS (23.09%) and pod weight (20.59%). However, it was exhibited in low for characters like days to first picking (7.62%), followed by pod width (8.41%), fruiting span (12.52%). The rest of the characters such as plant height at 30 DAS (19.39%), number of seeds per pod (18.53%), number of leaves per plant at 60 DAS (16.74%), shelling percentage (15.52%), number of primary branches per plant at 90 DAS (14.83%), days to first flowering (14.14%), pod length (14.03%), days to 50 per cent flowering (13.54%), and number of leaves per plant at 60 DAS (13.04%) exhibited moderate phenotypic coefficient of variation.

4.2.2.2 Genotypic coefficient of variation

It is revealed from the Table 4.3 that genotypic coefficient of variation varied from 5.15% for pod width to 42.98% for number of primary branches per plant at 30 DAS.

Table 4.3: Genetic parameters in twenty characters in Garden pea.

| Characters | Grand Mean | Range | | Coefficient of variations | | Heritability % (BS) | Genetic Advance | GA as % of mean |
|--------------------------------|------------|-------|--------|---------------------------|-----------|---------------------|-----------------|-----------------|
| | | Min. | Max. | Phenotypic | Genotypic | | | |
| Plant height 30 DAS | 16.34 | 11.80 | 20.07 | 19.39 | 13.22 | 46.52 | 3.03 | 18.58 |
| Plant height 60 DAS | 38.23 | 30.19 | 53.78 | 23.09 | 15.43 | 44.67 | 8.12 | 21.25 |
| Plant height 90 DAS | 50.72 | 40.03 | 103.95 | 26.88 | 24.02 | 79.81 | 22.42 | 44.21 |
| Primary branches /plant 30 DAS | 0.15 | 0.00 | 0.27 | 119.17 | 42.98 | 13.01 | 0.05 | 33.42 |
| Primary branches /plant 60 DAS | 1.77 | 0.93 | 2.67 | 37.78 | 27.35 | 52.39 | 0.72 | 40.85 |
| Primary branches /plant 90 DAS | 3.13 | 2.60 | 4.13 | 14.83 | 11.36 | 58.67 | 0.56 | 17.98 |
| Leaves /plant 30DAS | 10.30 | 5.80 | 13.47 | 25.38 | 21.19 | 69.71 | 3.75 | 36.46 |
| Leaves /plant 60DAS | 19.72 | 15.27 | 24.83 | 16.74 | 11.47 | 46.97 | 3.19 | 16.19 |
| Leaves /plant 90DAS | 35.74 | 28.93 | 43.53 | 13.04 | 7.34 | 31.67 | 3.04 | 8.51 |
| Days to first flowering | 44.56 | 33.33 | 54.67 | 14.14 | 13.74 | 94.41 | 12.25 | 27.51 |
| Days to 50% flowering | 52.48 | 39.33 | 64.67 | 13.54 | 12.34 | 83.03 | 12.16 | 23.17 |
| Days to first picking | 84.07 | 70.33 | 92.00 | 7.62 | 6.67 | 76.73 | 10.13 | 12.05 |
| Fruiting span | 36.93 | 31.00 | 42.00 | 12.52 | 7.66 | 37.45 | 3.56 | 9.66 |
| No. of pods/ plant | 27.55 | 15.40 | 51.80 | 31.05 | 30.45 | 96.15 | 16.94 | 61.51 |
| Pod length (cm) | 8.63 | 6.55 | 11.31 | 14.03 | 12.06 | 73.86 | 1.84 | 21.37 |
| Pod width (cm) | 1.09 | 0.93 | 1.21 | 8.41 | 5.15 | 37.57 | 0.07 | 6.54 |
| Pod weight (g) | 5.21 | 2.85 | 6.58 | 20.59 | 14.82 | 51.80 | 1.14 | 21.96 |
| No. of seeds/pod | 7.61 | 5.37 | 10.27 | 18.53 | 14.82 | 63.95 | 1.85 | 24.42 |
| Shelling (%) | 55.29 | 45.10 | 68.82 | 15.52 | 10.16 | 42.85 | 7.55 | 13.65 |
| Pod yield/plant (g) | 137.68 | 66.33 | 221.67 | 32.55 | 31.68 | 94.68 | 87.06 | 63.23 |

High genotypic coefficient of variation was noted for number of primary branches per plant at 30 DAS (42.98%), followed by pod yield per plant (31.68%), number of pods per plant (30.45%), number of primary branches per plant at 60 DAS (27.35%), plant height at 90 DAS (24.02%) and number of leaves per plant at 30 DAS (21.19%). Pod width (5.15%), days to first picking (6.67%), number of leaves per plant at 90 DAS (7.34%), fruiting span (7.66%), shelling percentage (10.16%), number of primary branches per plant at 90 DAS (11.36%) and number of leaves per plant at 60 DAS (11.47%) showed lowest genotypic coefficient of variation. While it was moderate for rest of the characters such as plant height at 60 DAS (15.43%), pod weight (14.82%), number of seeds per plant (14.82%), days to first flowering (13.74%), plant height at 30 DAS (13.22%), days to 50 per cent flowering (12.34%) and pod length (12.06%).

4.2.3 Heritability

The heritability (BS) was computed for each of the characters by the variance components for estimating their relative magnitudes of genotypic and phenotypic variability contributed through environmental factors. The estimates of heritability (BS) for all the characters have been discussed as follows (Table 4.3). It was partitioned as very high (above 90%), high (70 to 90%), medium (50-70%) and low (less than 50%).

Result indicated that the heritability estimates were observed very high for number of pods per plant (96.15%), followed by pod yield per plant (94.68%) and days to first flowering (94.41%). However, it was recorded to be high for days to 50 per cent flowering (83.03%), plant height at 90 DAS (79.81%), days to first picking (76.73%) and pod length (73.86%).

Low estimation of heritability was recorded for number of primary branches per plant at 30 DAS (13.01%), number of leaves per plant at 90 DAS (31.67%), fruiting span (37.45%), pod width (37.57%), shelling percentage (42.85%), plant height at 60 DAS (44.67%), plant height at 30 DAS (46.52%) and number of leaves per plant at 60 DAS (46.97%). It was moderate for pod weight (51.80%), number of primary branches per plant at 60 DAS (52.39%), number of

primary branches per plant at 90 DAS (58.67%), number of seeds per pod (63.95%) and number of leaves per plant at 30 DAS (69.71%).

4.2.4 Genetic advance

Based on the estimate of heritability (BS) expected genetic advance was computed on the hypothetical selection at 5 per cent best individual ($K= 2.06$). Due to masking influence of environment upon characters concerned, values of genetic advance exhibited high fluctuations. Therefore, to attain relative comparison of the characters in relation to environment genetic advance as percentage of mean was calculated to predict the genetic gain (Table 4.3).

Genetic advance as percentage of mean ranged between 6.54% for pod width to 63.23% for pod yield per plant. The highest estimate of genetic advance as percentage of mean was recorded for pod yield per plant (63.23%), number of pods per plant (61.51%), plant height at 90 DAS (44.21%), number of primary branches per plant at 60 DAS (40.85%), number of leaves per plant at 30 DAS (36.46%), number of primary branches per plant at 30 DAS (33.42%), days to first flowering (27.51%), number of seeds per pod (24.42%), days to 50 per cent flowering (23.17%), pod weight (21.96%), pod length (21.37%) and plant height at 60 DAS (21.25%).

Plant height at 30 DAS (18.58%), number of primary branches per plant at 90 DAS (17.98%), number of leaves per plant at 60 DAS (16.19%), shelling percentage (13.65%) and days to first picking (12.05%) showed moderate value of genetic advance as percentage of mean. Whereas, low estimates were observed for fruiting span (9.66%), number of leaves per plant at 90 DAS (8.51%) and pod width (6.54%).

4.3 Correlation coefficient analysis

Correlation coefficient was worked out at phenotypic, genotypic and environmental levels for all possible combination of nineteen yield and its attributing characters (Table 4.4).

Table 4.4: Estimates of genotypic and phenotypic correlation coefficients among yield and its contributing traits in Pea.

| Characters | | Plant height | | Primary branches /plant | | Leaves /plant | | | Days to 1 st flowering | Days to 50% flowering | Days to 1 st picking | Fruiting span | No of pods/plant | Pod length (cm) | Pod width (cm) | Pod weight (gm) | Seeds /pod | Shelling (%) | Pod yield/plant (g) |
|--------------------------------|---|--------------|---------|-------------------------|---------|---------------|---------|--------|-----------------------------------|-----------------------|---------------------------------|---------------|------------------|-----------------|----------------|-----------------|------------|--------------|---------------------|
| | | 60 DAS | 90 DAS | 60 DAS | 90 DAS | 30DAS | 60 DAS | 90 DAS | | | | | | | | | | | |
| Plant height 30 DAS | G | 0.820 | 0.458 | -0.361 | -0.512 | 0.817 | 0.200 | -0.447 | -0.019 | 0.013 | 0.087 | 0.037 | 0.597 | 0.177 | 0.321 | 0.051 | 0.167 | -0.542 | 0.539 |
| | P | 0.455** | 0.422** | -0.165 | -0.269* | 0.696** | -0.017 | -0.063 | 0.011 | 0.033 | 0.077 | 0.026 | 0.425** | 0.170 | 0.119 | 0.106 | 0.114 | -0.312* | 0.334** |
| Plant height 60 DAS | G | | 0.782 | -0.178 | -0.017 | 0.416 | 0.240 | -0.312 | -0.016 | 0.057 | 0.194 | 0.133 | 0.826 | -0.175 | 0.001 | -0.106 | -0.225 | -0.192 | 0.708 |
| | P | | 0.640** | -0.088 | -0.015 | 0.283* | 0.376** | -0.121 | 0.009 | 0.018 | 0.163 | -0.203 | 0.550** | -0.126 | 0.196 | 0.036 | -0.094 | -0.090 | 0.489** |
| Plant height 90 DAS | G | | | 0.197 | -0.192 | 0.371 | 0.458 | -0.284 | 0.374 | 0.426 | 0.220 | -0.398 | 0.765 | -0.431 | -0.520 | -0.557 | -0.336 | -0.100 | 0.293 |
| | P | | | 0.125 | -0.199 | 0.349** | 0.370** | -0.108 | 0.320** | 0.333** | 0.232 | -0.294* | 0.671** | -0.287* | -0.273* | -0.380** | -0.163 | -0.044 | 0.256* |
| Primary branches /plant 60 DAS | G | | | | 0.176 | -0.366 | 0.530 | 0.365 | 0.650 | 0.718 | 0.045 | -0.625 | 0.044 | -0.003 | -0.679 | -0.580 | 0.062 | 0.451 | -0.262 |
| | P | | | | 0.071 | -0.196 | 0.364** | 0.020 | 0.504** | 0.469** | 0.046 | -0.309* | 0.025 | -0.051 | -0.300* | -0.306* | 0.015 | 0.375** | -0.156 |
| Primary branches /plant 90 DAS | G | | | | | -0.375 | -0.399 | 0.255 | 0.117 | 0.104 | 0.177 | -0.039 | -0.074 | 0.376 | -0.034 | 0.054 | 0.354 | 0.434 | 0.307 |
| | P | | | | | -0.278* | -0.191 | 0.253* | 0.070 | 0.090 | 0.030 | 0.035 | -0.065 | 0.206 | -0.068 | -0.037 | 0.098 | 0.217 | 0.197 |
| Leaves /plant 30DAS | G | | | | | | 0.074 | -0.458 | -0.021 | 0.003 | 0.162 | 0.073 | 0.452 | 0.132 | 0.360 | 0.251 | 0.107 | -0.494 | 0.248 |
| | P | | | | | | 0.019 | -0.113 | 0.002 | 0.068 | 0.132 | -0.048 | 0.366** | 0.137 | 0.213 | 0.090 | 0.104 | -0.334** | 0.181 |
| Leaves /plant 60DAS | G | | | | | | | -0.334 | 0.091 | 0.214 | -0.328 | -0.453 | 0.016 | -0.399 | -0.326 | -0.299 | -0.399 | 0.648 | -0.350 |
| | P | | | | | | | -0.101 | 0.084 | 0.162 | -0.151 | -0.346** | 0.030 | -0.311* | -0.013 | -0.182 | -0.156 | 0.239 | -0.241 |
| Leaves /plant 90DAS | G | | | | | | | | 0.229 | 0.106 | -0.283 | -0.230 | -0.008 | 0.451 | -0.424 | 0.292 | 0.403 | 0.210 | 0.380 |
| | P | | | | | | | | 0.125 | 0.106 | -0.060 | -0.214 | -0.024 | 0.221 | -0.112 | 0.019 | 0.171 | -0.023 | 0.080 |
| Days to first flowering | G | | | | | | | | | 0.990 | 0.464 | -0.757 | 0.381 | 0.247 | -0.421 | -0.582 | 0.343 | 0.030 | 0.119 |
| | P | | | | | | | | | 0.950** | 0.369** | -0.468** | 0.372** | 0.167 | -0.232 | -0.403** | 0.258* | 0.019 | 0.107 |
| Days to 50% flowering | G | | | | | | | | | | 0.417 | -0.669 | 0.400 | 0.191 | -0.393 | -0.567 | 0.255 | 0.108 | 0.109 |
| | P | | | | | | | | | | 0.300* | -0.430** | 0.372** | 0.073 | -0.210 | -0.411** | 0.143 | 0.017 | 0.078 |
| Days to first picking | G | | | | | | | | | | | -0.217 | 0.517 | -0.101 | 0.157 | -0.365 | -0.028 | -0.092 | 0.311 |
| | P | | | | | | | | | | | -0.237 | 0.449** | -0.080 | 0.064 | -0.177 | 0.040 | -0.065 | 0.254* |
| Fruiting span | G | | | | | | | | | | | | -0.161 | -0.163 | 0.645 | 0.566 | -0.342 | -0.428 | 0.140 |
| | P | | | | | | | | | | | | -0.106 | -0.056 | 0.100 | 0.276* | -0.252* | -0.120 | 0.050 |
| No. of pods/ plant | G | | | | | | | | | | | | | 0.016 | -0.128 | -0.268 | 0.053 | -0.245 | 0.765 |
| | P | | | | | | | | | | | | | -0.008 | -0.082 | -0.141 | 0.034 | -0.196 | 0.735** |
| Pod length (cm) | G | | | | | | | | | | | | | | 0.287 | 0.344 | 0.914 | -0.056 | 0.407 |
| | P | | | | | | | | | | | | | | 0.132 | 0.212 | 0.810** | -0.094 | 0.331** |
| Pod width (cm) | G | | | | | | | | | | | | | | | 0.108 | 0.186 | -0.280 | 0.198 |
| | P | | | | | | | | | | | | | | | 0.397** | 0.057 | -0.246* | 0.106 |
| Pod weight (g) | G | | | | | | | | | | | | | | | | 0.179 | -0.522 | 0.169 |
| | P | | | | | | | | | | | | | | | | 0.116 | -0.370** | 0.144 |
| No. of seeds/pod | G | | | | | | | | | | | | | | | | | -0.122 | 0.318 |
| | P | | | | | | | | | | | | | | | | | -0.086 | 0.252* |

| | | | | | | | | | | | | | | | | | | | |
|--------------|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--------|
| Shelling (%) | G | | | | | | | | | | | | | | | | | | -0.294 |
| | P | | | | | | | | | | | | | | | | | | -0.152 |

Significant at 5% level = *

Significant at 1% level = **

Results indicated that genotypic correlation coefficient, in general, were of higher magnitude than the corresponding phenotypic correlation coefficient for all the characters.

The results of phenotypic correlation coefficients have been discussed only as the genotypic and environmental correlation were mostly influenced by the environmental conditions, hence phenotypic correlation will give the correct idea about the association between two variables.

4.3.1 Plant height (cm)

Plant height at 30 DAS, showed significant and positive correlation with number of leaves per plant at 30 DAS (0.696), plant height at 60 DAS (0.455), number of pods per plant (0.427), plant height at 90 DAS (0.422) and pod yield per plant (0.329). Significant and negative association of this character was observed with shelling percentage (-0.312).

Correlation coefficient of plant height at 60 DAS showed significant and positive with plant height at 90 DAS (0.640), number of pods per plant (0.548), pod yield per plant (0.466), number of leaves per plant at 60 DAS (0.376) and number of leaves per plant at 30 DAS (0.283).

Plant height at 90 DAS expressed a highly significant and positive correlation coefficient with number of pods per plant (0.649), number of leaves per plant at 60 DAS (0.370), number of leaves per plant at 30 DAS (0.349), days to 50 % flowering (0.349), days to first flowering (0.321) and pod yield per plant (0.247). But it was exhibited significant and negative with pod weight (-0.374), fruiting span (-0.294), pod length (-0.287) and pod width (-0.273).

4.3.2 Number of primary branches per plant

Number of primary branches per plant at 60 DAS expressed significant and positive correlation with days to first flowering (0.444) and days to 50 %

flowering (0.361). While it was found significant and negative with pod weight (-0.292).

Number of primary branches per plant at 90 DAS expressed with significantly and positively associated with number of leaves per plant at 90 DAS (0.249), while it was found significant and negative with pod weight (-0.309).

4.3.3 Number of leaves per plant

Correlation coefficient of number of leaves per plant at 30 DAS was exhibited significant and positive with number of pods per plant (0.379). Highly significant and negative association of this character was observed with shelling percentage (-0.334).

Number of leaves per plant at 60 DAS expressed significant and negative correlation with fruiting span (-0.346) and pod length (-0.311).

4.3.4 Days to first flowering

Association of days to first flowering was recorded significant and positive with days to 50 per cent flowering (0.902), number of pods per plant (0.344), days to first picking (0.374) and number of seeds per pod (0.275), while it was found significant and negative with fruiting span (-0.441) and pod weight (-0.366).

4.3.5 Days to 50 per cent flowering

Days to 50 per cent flowering was recorded highly significant and positive association with number of pods per plant (0.324) and days to first picking (0.301), while it was found significant and negative with fruiting span (-0.441), pod weight (-0.373) and pod width (-0.254).

4.3.6 Days to first picking

Days to first picking were recorded highly significant and positive association with number of pods per plant (0.429) and pod yield per plant (0.256).

4.3.7 Fruiting span

Fruiting span expressed significant and positive correlation with pod weight (0.253). Also, significant and negative association was exhibited with number of seeds per pod (-0.252).

4.3.7 Number of pods per plant

The correlation coefficient of number of pods per plant was found significant and positive correlation with pod yield per plant (0.742).

4.3.8 Pod length (cm)

Pod length was recorded highly significant and positive association with number of seeds per pod (0.810) and pod yield per plant (0.316).

4.3.9 Pod width (cm)

Pod width expressed significant and positive correlation with pod weight (0.478). Also, significant and negative association was exhibited with shelling percentage (-0.246).

4.3.10 Fruit weight (gm)

Fruit weight expressed highly significant and negative association with shelling percentage (-0.309).

4.3.11 Pod yield per plant (gm)

Correlation coefficient of pod yield per plant was recorded highly significant and positive with number of pods per plant (0.742), plant height at 60 DAS (0.466), plant height at 30 DAS (0.329), pod length (0.316), plant height at 90 DAS (0.247) and days to first picking (0.256).

4.4 Path coefficient analysis

To measure the direct as well as indirect association of one variable (cause) through another on the end product (effect), path coefficients were

calculated at genotypic and phenotypic levels for all the yield attributing traits. The observed correlation coefficients of yield with its contributing traits were partitioned into direct and indirect effects. In the present investigation, important characters viz., pod yield per plant have been used as dependable variables with other traits. Since the values of genotypic path are more reliable in predicting the correct idea about the direct and indirect effects of the component traits, only this has been discussed as below.

The estimates of path coefficient were furnished in the Table 4.5 and 4.6. In general the genotypic direct as well as indirect effects were slightly higher in magnitude as compared to corresponding phenotypic direct and indirect effects. The results obtained from genotypic direct and indirect effects are presented as under.

Direct effect

Path coefficient analysis of different characters contributing towards pod yield per plant showed that number of pods per plant (0.927) had highest positive direct effect followed by pod weight (0.317), pod length (0.266), fruiting span (0.216), number of leaves per plant at 90 DAS (0.180), days to first flowering (0.173) and days to first picking (0.116). Whereas days to 50 per cent flowering (-0.263) had the highest negative direct effect on pod yield per plant followed by pod width (-0.204) and number of seeds per pod (-0.121).

Indirect effect

Plant height (cm)

Plant height at 90 DAS imparted highest positive indirect effect on pod yield per plant via pod weight (0.037), pod width (0.033), pod length (0.027), fruiting span (0.025), number of primary branches per plant at 90 DAS (0.022) and number of seeds per pod (0.021). Whereas negative indirect effect was visible to be highest via number of pods per plant (-0.049), days to 50 per cent flowering (-0.026) and days to first flowering (-0.023).

Table 4.5: Phenotypic path coefficients showing direct and indirect effects of different characters on pod yield per plant (gm)

| Character | Plant height 90 DAS | Primary branches 90 DAS | Leaves 90 DAS | Days to 1st flowering | Days 50% flowering | Days to 1st picking | Fruiting span | Pods/ plant | Pod length (cm) | Pod width (cm) | Pod weight (gm) | Seeds / pod | Shelling % | 'r' value of pod yield /plant |
|--------------------------|---------------------|-------------------------|---------------|-----------------------|--------------------|---------------------|---------------|--------------|-----------------|----------------|-----------------|--------------|--------------|-------------------------------|
| Plant Height 90 Days | -0.029 | 0.003 | 0.004 | -0.009 | -0.010 | -0.007 | 0.008 | -0.019 | 0.008 | 0.008 | 0.011 | 0.004 | 0.001 | 0.247 |
| Primary Branches 90 Days | -0.019 | 0.182 | 0.045 | 0.010 | 0.022 | 0.012 | -0.016 | 0.013 | 0.023 | -0.023 | -0.056 | 0.017 | 0.034 | 0.239 |
| Leaves 90 Days | -0.015 | 0.023 | 0.095 | 0.009 | 0.009 | -0.013 | -0.018 | 0.002 | 0.011 | -0.019 | 0.005 | 0.004 | 0.002 | 0.154 |
| Days to 1st Flowering | 0.005 | 0.001 | 0.001 | 0.017 | 0.015 | 0.006 | -0.007 | 0.005 | 0.003 | -0.003 | -0.006 | 0.004 | 0.004 | 0.105 |
| Days 50% Flowering | -0.061 | -0.022 | -0.018 | -0.159 | -0.176 | -0.053 | 0.078 | -0.057 | -0.021 | 0.044 | 0.065 | -0.036 | -0.006 | 0.057 |
| Days to 1st Picking | 0.004 | 0.001 | -0.002 | 0.007 | 0.006 | 0.020 | -0.004 | 0.008 | -0.001 | 0.001 | -0.003 | 0.008 | -0.001 | 0.256 |
| Fruiting Span | -0.040 | -0.012 | -0.026 | -0.060 | -0.060 | -0.032 | 0.136 | -0.017 | -0.007 | 0.013 | 0.034 | -0.034 | -0.016 | 0.078 |
| Pods/ Plant | 0.567 | 0.065 | 0.020 | 0.301 | 0.283 | 0.375 | -0.111 | 0.874 | -0.029 | -0.056 | -0.211 | 0.003 | -0.172 | 0.742 |
| Pod Length (cm) | -0.082 | 0.036 | 0.034 | 0.053 | 0.034 | -0.022 | -0.016 | -0.009 | 0.285 | 0.037 | 0.054 | 0.231 | -0.026 | 0.316 |
| Pod Width (cm) | -0.015 | -0.007 | -0.011 | -0.012 | -0.014 | 0.003 | 0.005 | -0.003 | 0.007 | 0.057 | 0.027 | 0.003 | -0.014 | 0.117 |
| Pod Weight (gm) | -0.059 | -0.0494 | 0.009 | -0.058 | -0.059 | -0.028 | 0.040 | -0.038 | 0.030 | 0.076 | 0.159 | 0.015 | -0.049 | 0.056 |
| Seeds/ Pod | -0.002 | 0.0016 | 0.008 | 0.004 | 0.003 | 0.007 | -0.004 | 0.001 | 0.013 | 0.001 | 0.001 | 0.017 | -0.001 | 0.224 |
| Shelling % | -0.003 | 0.0160 | 0.002 | 0.002 | 0.002 | -0.005 | -0.010 | -0.016 | -0.008 | -0.021 | -0.026 | -0.007 | 0.085 | -0.164 |

R square = 0.8032

Residual Effect = 0.4436

Table 4.6: Genotypic path coefficients showing direct and indirect effects of different characters on pod yield per plant (gm)

| Character | Plant height 90 DAS | Primary branches 90 DAS | Leaves 90 DAS | Days to 1st flowering | Days 50% flowering | Days to 1st picking | Fruiting span | Pods/ plant | Pod length (cm) | Pod width (cm) | Pod weight (gm) | Seeds / pod | Shelling % | 'r' value of pod yield /plant |
|--------------------------|---------------------|-------------------------|---------------|-----------------------|--------------------|---------------------|---------------|--------------|-----------------|----------------|-----------------|---------------|--------------|-------------------------------|
| Plant Height 90 Days | -0.063 | 0.022 | 0.017 | -0.023 | -0.026 | -0.014 | 0.025 | -0.049 | 0.027 | 0.033 | 0.037 | 0.021 | 0.006 | 0.299 |
| Primary Branches 90 Days | -0.040 | 0.113 | 0.029 | 0.019 | 0.009 | 0.022 | 0.021 | -0.032 | 0.069 | 0.010 | 0.077 | 0.057 | 0.070 | 0.348 |
| Leaves 90 Days | -0.050 | 0.046 | 0.180 | 0.058 | 0.022 | -0.042 | -0.051 | -0.013 | 0.126 | -0.059 | 0.059 | 0.125 | 0.032 | 0.382 |
| Days to 1st Flowering | 0.065 | 0.030 | 0.055 | 0.173 | 0.177 | 0.080 | -0.135 | 0.069 | 0.041 | -0.074 | -0.112 | 0.057 | 0.004 | 0.121 |
| Days 50% Flowering | -0.109 | -0.021 | -0.033 | -0.268 | -0.263 | -0.110 | 0.174 | -0.113 | -0.042 | 0.093 | 0.166 | -0.055 | -0.025 | 0.123 |
| Days to 1st Picking | 0.025 | 0.023 | -0.027 | 0.053 | 0.048 | 0.116 | -0.025 | 0.061 | -0.011 | 0.018 | -0.045 | -0.003 | -0.010 | 0.311 |
| Fruiting Span | -0.086 | 0.040 | -0.061 | -0.168 | -0.142 | -0.047 | 0.216 | -0.031 | -0.035 | 0.139 | 0.135 | -0.074 | -0.092 | 0.116 |
| Pods/ Plant | 0.724 | -0.264 | -0.069 | 0.369 | 0.399 | 0.492 | -0.133 | 0.927 | 0.030 | -0.133 | -0.182 | 0.069 | -0.225 | 0.762 |
| Pod Length (cm) | -0.114 | 0.164 | 0.186 | 0.062 | 0.043 | -0.026 | -0.043 | 0.008 | 0.266 | 0.076 | 0.101 | 0.243 | -0.015 | 0.417 |
| Pod Width (cm) | 0.106 | -0.019 | 0.067 | 0.087 | 0.072 | -0.032 | -0.131 | 0.029 | -0.058 | -0.204 | -0.217 | -0.038 | 0.057 | 0.189 |
| Pod Weight (gm) | -0.187 | 0.215 | 0.103 | -0.204 | -0.199 | -0.123 | 0.198 | -0.062 | 0.121 | 0.338 | 0.317 | 0.067 | -0.195 | 0.253 |
| Seeds/ Pod | 0.040 | -0.060 | -0.084 | -0.040 | -0.025 | 0.003 | 0.041 | -0.009 | -0.110 | -0.022 | -0.025 | -0.121 | 0.014 | 0.337 |
| Shelling % | -0.009 | 0.0579 | 0.016 | 0.002 | 0.009 | -0.008 | -0.040 | -0.022 | -0.005 | -0.026 | -0.057 | -0.011 | 0.093 | -0.285 |

R square = 0.9322

Residual Effect = 0.2604

Number of primary branches per plant at 90 DAS

Number of primary branches per plant at 90 DAS exhibited highest positive indirect effect via pod weight (0.077), shelling percentage (0.070), pod length (0.069), number of seeds per pod (0.057), number of leaves per plant at 90 DAS (0.029), days to first picking (0.022), fruiting span (0.021) and days to first flowering (0.019). Whereas it was expressed high negative indirect effect via plant height at 90 DAS (-0.040) and number of pods per plant (-0.032).

Number of leaves per plant

Number of leaves per plant at 90 DAS exhibited significant positive indirect effect via pod length (0.126), number of seeds per pod (0.125), pod weight (0.059), days to first flowering (0.058), number of primary branches per plant at 90 DAS (0.046), shelling percentage (0.032) and days to 50 per cent flowering (0.022). Highest negative indirect effect was observed through pod width (-0.059), fruiting span (-0.051), plant height at 90 DAS (-0.050) and days to first picking (-0.042).

Days to first flowering

Days to first flowering was reported to have highest positive indirect effect on pod yield per plant through, days to 50 per cent flowering (0.177), days to first picking (0.080), number of pods per plant (0.069), plant height at 90 DAS (0.065), number of seeds per pod (0.057), number of leaves per plant at 90 DAS (0.055), and pod length (0.041). Whereas it was expressed high negative indirect effect via fruiting span (-0.135), pod weight (-0.112) and pod width (-0.074).

Days to 50 per cent flowering

Days to 50 per cent flowering was reported to have highest positive indirect effect on pod yield per plant through, fruiting span (0.174), pod weight (0.166) and pod width (0.093). Whereas it was expressed high negative indirect effect via days to first flowering (-0.268), number of pods per plant (-0.113), days to first picking (-0.110), plant height at 90 DAS (-0.109), number of seeds per pod (-0.055), pod length (-0.042) and number of leaves per plant at 90 DAS (-0.033).

Days to first picking

Days to first picking expressed highest positive indirect effect through number of pods per plant (0.061), days to first flowering (0.053), days to 50 per cent flowering (0.048), plant height at 90 DAS (0.025) and number of primary branches per plant at 90 DAS (0.023). Its indirect negative effect was high via pod weight (-0.045), number of leave per plant at 90 DAS (-0.027), fruiting span (-0.025) and pod length (-0.011).

Fruiting span

Fruiting span manifested highest positive indirect effect on fruit yield per plant through pod width (0.139), pod weight (0.135) and number of primary branches per plant at 90 DAS (0.040). However rest of the characters showed negative indirect effect viz., days to first flowering (-0.168), days to 50 per cent flowering (-0.142), shelling percentage (-0.092), plant height at 90 DAS (-0.086), number of seeds per pod (-0.074), number of leave per plant at 90 DAS (-0.061), days to first picking (-0.047), pod length (-0.035) and number of pods per plant (-0.031).

Number of pods per plant

Highest positive indirect effect of number of pods per plant on fruit yield per plant was recorded through plant height at 90 DAS (0.724), days to first picking (0.492), days to 50 per cent flowering (0.399), days to first flowering (0.369), number of seeds per pod (0.069) and pod length (0.030). Its indirect negative effect was high via number of primary branches per plant at 90 DAS (-0.264), shelling percentage (-0.225), pod weight (-0.182), pod width (-0.133), fruiting span (-0.133) and number of leaves per plant at 90 DAS (-0.069).

Pod length

Pod length revealed high values of positive indirect on fruit yield per plant through number of seeds per pod (0.243), number of leaves per plant at 90 DAS (0.186), number of primary branches per plant at 90 DAS (0.164), pod weight

(0.101), pod width (0.076), days to first flowering (0.062) and days to 50 per cent flowering (0.043). While the remaining characters showed high negative indirect effect i.e. plant height at 90 DAS (-0.114), fruiting span (-0.043), days to first picking (-0.026) and shelling percentage (-0.015).

Pod width

Pod width expressed a positive indirect effect on fruit yield per plant through plant height at 90 DAS (0.106), days to first flowering (0.087), days to 50 per cent flowering (0.072), number of leaves per plant at 90 DAS (0.067), shelling percentage (0.057) and number of pods per plant (0.029). While the remaining characters showed high negative indirect effect i.e. pod weight (-0.217), fruiting span (-0.131), pod length (-0.058), number of seeds per pod (-0.038), days to first picking (-0.032) and number of primary branches per plant at 90 DAS (-0.019).

Pod weight

Highest positive indirect effect of pod weight on fruit yield per plant was recorded through pod width (0.338), number of primary branches per plant at 90 DAS (0.215), fruiting span (0.198), pod length (0.121), number of leaves per plant at 90 DAS (0.103) and number of seeds per pod (0.067). It showed negative indirect effect through days to first flowering (-0.204), days to 50 per cent flowering (-0.199), shelling percentage (-0.195), plant height at 90 DAS (-0.187), days to first picking (-0.123) and number of pods per plant (-0.062).

Number of seeds per pod

Number of seeds per pod manifested positive indirect effect through fruiting span (0.041), plant height at 90 DAS (0.040) and shelling percentage (0.014). Whereas, it was expressed high negative indirect effect via pod length (-0.110), number of leaves per plant at 90 DAS (-0.084), number of primary branches per plant at 90 DAS (-0.060), days to first flowering (-0.040), days to 50 per cent flowering (-0.025), pod weight (-0.025) and pod width (-0.022).

Shelling percentage

Shelling percentage exhibited significant positive indirect effect via number of primary branches per plant at 90 DAS (0.057) and number of leaves per plant at 90 DAS (0.016). Highest negative indirect effect was observed through pod weight (-0.057), fruiting span (-0.040), pod width (-0.026), number of pods per plant (-0.022) and number of seeds per pod (-0.011).

4.5 Quality parameters

Qualitative characters like protein per cent, colour of pod, shape of pod and presence of tendrils are summarized in Table 4.7

Protein percentage

The significantly maximum protein content was recorded in the genotypes BE –06 (26.43 %), Pusa Pragati (26.37%), 2012/ PMVAR – 5 (26.12%) and VRP – 5 (26.06%). However it was exhibited lowest in genotype IIVR –5 (18.55%) and it ranged from 18.55% to 26.43%.

Colour of pod

Colour of pods was observed to be dark green, green and light green. Genotypes 2012/ PMVAR – 3, Arkel, AP –1, Akra Sampoorna, AP –3, BE –06 and Arka Ajit exhibited dark green pods. Whereas, PC –531 (C) was observed light green pods. Remaining genotypes exhibited green pods.

Shape of pod

Significant variation was observed among the genotypes for shape of pods i.e. straight, slightly curved and curved (Table 4.7). Shape of pods was observed to be straight in genotypes 2012/ PMVAR – 1, 2012/ PMVAR – 3, 2012/ PMVAR – 4, 2012/ PMVAR – 5, Arka Ajit and VRP –7 (C). Genotype Akra Sampoorna was produced curved pod. The remaining genotypes produced slightly curved pods.

Presence of tendrils

No variation was observed among the genotypes for presence of tendrils.

Tendrils are present in all the genotypes.

Table 4.7: Qualitative characters in garden pea genotypes.

| Genotypes | Protein (%) | Pod colour | Shape of pod | Presence of tendrils |
|------------------|--------------------|-------------------|---------------------|-----------------------------|
| 2012/ PMVAR – 1 | 21.43 | Green | Straight | Present |
| 2012/ PMVAR – 2 | 23.36 | Green | Slightly curved | Present |
| 2012/ PMVAR – 3 | 23.81 | Dark green | Straight | Present |
| 2012/ PMVAR – 4 | 25.72 | Green | Straight | Present |
| 2012/ PMVAR – 5 | 26.12 | Green | Straight | Present |
| Arkel | 25.95 | Dark green | Slightly curved | Present |
| AP –1 | 19.68 | Dark green | Slightly curved | Present |
| GS –10 | 25.98 | Green | Slightly curved | Present |
| Pusa Pragati | 26.37 | Green | Slightly curved | Present |
| PSM –3 | 21.96 | Green | Slightly curved | Present |
| Akra Sampurna | 23.88 | Dark green | curved | Present |
| AP –3 | 21.08 | Dark green | Slightly curved | Present |
| BE –06 | 26.43 | Dark green | Slightly curved | Present |
| IIVR –5 | 18.55 | Green | Slightly curved | Present |
| Arka Ajit | 21.77 | Dark green | Straight | Present |
| VRP – 5 | 26.06 | Green | Slightly curved | Present |
| VRP – 6 | 22.31 | Green | Slightly curved | Present |
| VRP – 8 | 25.46 | Green | Slightly curved | Present |
| VRP – 16 | 19.51 | Green | Slightly curved | Present |
| VRP – 22 | 22.92 | Green | Slightly curved | Present |
| VRP –7 (C) | 21.26 | Green | Straight | Present |
| PC –531 (C) | 24.93 | Light green | Slightly curved | Present |
| S.Em± | 0.18 | - | - | - |
| C.D.5% level | 0.53 | - | - | - |

4.6 Incidence of pest and diseases

The result of percentage of disease incidence and insect pest has been depicted in the Table 4.8. The results are based on the total score of disease and insect pest in a given genotype.

4.6.1 Incidence of pod borer (%)

Pod borer incidence was observed maximum in genotypes VRP – 22 (6.20%) followed by VRP – 6 (5.73%), VRP – 6 (5.11%) and PSM –3 (5.03%) was found to highly susceptible to pod borer. The low incidence of pod borer was found in genotypes Arka Ajit (0.78), Akra Sampurna (1.10), 2012/ PMVAR – 3 (1.78) and VRP –7 (C) (1.80).

Table 4.8: Mean performance of incidence of disease and insect pest of Garden pea.

| Genotypes | Incidence of pod borer (%) | Incidence of powdery mildew (%) |
|-----------------|----------------------------|---------------------------------|
| 2012/ PMVAR – 1 | 2.27 | 3.33 |
| 2012/ PMVAR – 2 | 3.00 | 20.00 |
| 2012/ PMVAR – 3 | 1.67 | 8.33 |
| 2012/ PMVAR – 4 | 3.93 | 8.33 |
| 2012/ PMVAR – 5 | 3.40 | 13.33 |
| Arkel | 1.83 | 16.67 |
| AP –1 | 4.27 | 20.00 |
| GS –10 | 2.85 | 13.33 |
| Pusa Pragati | 4.73 | 8.33 |
| PSM –3 | 5.07 | 15.00 |
| Akra Sampurna | 1.10 | 6.67 |
| AP –3 | 2.33 | 8.33 |
| BE –06 | 1.83 | 11.67 |
| IIVR –5 | 5.11 | 13.33 |
| Arka Ajit | 0.78 | 1.67 |
| VRP – 5 | 2.43 | 10.00 |
| VRP – 6 | 5.73 | 16.67 |
| VRP – 8 | 4.75 | 11.67 |
| VRP – 16 | 2.90 | 11.67 |
| VRP – 22 | 6.20 | 6.67 |
| VRP –7 (C) | 1.80 | 10.00 |
| PC –531 (C) | 2.53 | 5.00 |
| S.Em± | 1.74 | 4.07 |
| C.D.5% level | N.S. | N.S. |

4.6.2 Incidence of powdery mildew (%)

The incidence of powdery mildew was observed maximum in genotypes 2012/ PMVAR – 2 (20.00%), AP –1 (20.0%), Arkel (16.67%) and VRP – 6 (16.67%). Whereas, genotypes Arka Ajit (1.67%), 2012/ PMVAR – 1 (3.33%), PC –531 (C) (5.00%), VRP – 22 (6.67%) and Akra Samporna (6.67%) were slightly tolerant to the same.

DISCUSSION

The experimental findings of the present investigation “Studies on genetic parameter, correlation and path coefficient analysis of yield and its components in garden pea (*Pisum sativum* L.)” have been discussed on the following heads in the light of the available literature.

5.1 Analysis of variance

5.2 Genetic Variability

5.2.1 Range and Mean Performance

5.2.2 Coefficient of variation

5.2.3 Heritability

5.2.4 Genetic advance

5.3 Correlation Coefficient analysis

5.4 Path coefficient analysis

5.5 Quality parameters

5.6 Incidence of pest and diseases

5.1 Analysis of variance

The main objective of the present investigation was to study the diversity present in twenty two genotypes of garden pea. The estimates of mean sum of square due to genotypes were highly significant for all the characters except for number of primary branches per plant at 30 DAS (Table 4.1), indicating the presence of genetic diversity in the existing material. The findings of Shinde (2000), Sharma *et al.* (2003), Singh and Dhillon (2004), Mehta *et al.* (2005), Seema *et al.* (2006), Gupta *et al.* (2006), Nawab *et al.* (2008), Bhupendra Kumar (2008), Choudhary *et al.* (2010), Lal *et al.* (2011) and Million (2012) are similar to that of the present findings.

5.2 Genetic variability

5.2.1 Mean performance of the genotypes

The mean performance of the genotypes (Table 4.3) revealed a wide range of variability for all the traits. The variation was highest for pod yield per plant (66.33 – 221.67 gm), followed by plant height at 90 DAS (40.03 – 103.95 cm), number of pods per plant (15.40 – 51.80), days to 50 per cent flowering (39.33 – 64.67 days), shelling percentage (45.10% – 68.82%), plant height at 60 DAS (30.19 – 53.78 cm), days to first picking (70.33 – 92.00 days), days to first flowering (33.33 – 54.67 days) and fruiting span (31.00 - 42.00 days). The findings were quite similar to as reported by Tyagi and Srivastava (2002) reported that the wide range of variability was evidenced for plant height and pods per plant. Singh *et al.* (2003) revealed that the magnitude of variability was higher for number of pods per plant. Singh and Dhillon (2004) reported that the pod yield per plant ranged from 9.12 to 101.45 g, whereas the number of pods per plant ranged from 4.36 to 38.60. The plant height and days to flower initiation varied from 38.35 to 256.76 cm and 32.93 to 63.07 days respectively. Mehta *et al.* (2005) revealed that a wide range of variability for pod yield per plant (42.99-100.78 g) and plant height (42.83-131.23 cm). Singh and Singh (2006) reported that the variability was greatest for number of pods per plant and plant height. Rakesh Kumar *et al.* (2007) revealed that the high magnitude of variability was observed for plant height and yield per plant. Bhupendra Kumar (2008) reported that the wide range of variation exhibited for plant height, days to flowering and number of pods per plant.

5.2.2 Coefficient of variation

In the present findings phenotypic coefficient of variation were observed to be higher than the corresponding genotypic coefficient of variation for all the characters studied, however the differences was narrow which implied their relative resistance to environmental variation. It also described that genetic factors were predominantly responsible for expression of those attributes and

selection could be made effectively on the basis of phenotypic performance. The finding of Singh and Dhillon (2004) and Sanjay *et al.* (2008) were similar to that of the present findings.

5.2.2.1 Phenotypic coefficient of variations

The phenotypic coefficient of variation ranged from 7.62% for days to first picking to 119.17% for number of primary branches per plant at 30 DAS. The phenotypic coefficient of variations was highest for characters viz., number of primary branches per plant at 30 DAS (119.17%), number of primary branches per plant at 60 DAS (37.78%), pod yield per plant (32.55%), number of pods per plant (31.05%), plant height at 90 DAS (26.88%), number of leaves per plant at 30 DAS (25.38%), plant height at 60 DAS (23.09%) and pod weight (20.59%), indicated that these characters would respond to selection. The findings are in close harmony with the result of Ramesh *et al.* (2002) for number of pods per plant, weight of pods per plant, plant height and mean pod weight. Tyagi and Srivastava (2002), Sharma *et al.* (2003), Singh and Mir (2005), Bhupendra Kumar (2008), Choudhary *et al.* (2010), Singh *et al.* (2012) for pods per plant, Singh and Mir (2005), Singh (2010), Singh *et al.* (2012) for number of branches per plant, Gupta *et al.* (2006), Bhupendra Kumar (2008), Choudhary *et al.* (2010) for pod yield per plant, Sharma *et al.* (2007), Choudhary *et al.* (2010), Singh *et al.* (2012) for plant height.

However, it was exhibited in low for characters like days to first picking (7.62%), followed by pod width (8.41%), fruiting span (12.52%), which indicated that there is limited scope for improvement. The rest of the characters such as plant height at 30 DAS (19.39%), number of seeds per pod (18.53%), number of leaves per plant at 60 DAS (16.74%), shelling percentage (15.52%), number of primary branches per plant at 90 DAS (14.83%), days to first flowering (14.14%), pod length (14.03%), days to 50 per cent flowering (13.54%), and number of leaves per plant at 60 DAS (13.04%) exhibited moderate phenotypic coefficient of variation. The finding of Singh (2010) for number of seeds per pod and number of branches per plant was similar to the present finding.

5.2.2.2 Genotypic coefficient of variation

It is revealed from the Table 4.3 that genotypic coefficient of variation varied from 5.15% for pod width to 42.98% for number of primary branches per plant at 30 DAS. High genotypic coefficient of variation was noted for number of primary branches per plant at 30 DAS (42.98%), followed by pod yield per plant (31.68%), number of pods per plant (30.45%), number of primary branches per plant at 60 DAS (27.35%), plant height at 90 DAS (24.02%) and number of leaves per plant at 30 DAS (21.19%). The findings are in close harmony with the result of Pathak and Jamwal (2002), Ramesh *et al.* (2002), Singh and Dhillon (2004), Mehta *et al.* (2005), Gupta *et al.* (2006), Nawab *et al.* (2008), Bhupendra Kumar (2008), Choudhary *et al.* (2010), Lal *et al.* (2011) for pod yield per plant, Ramesh *et al.* (2002), Mehta *et al.* (2005), Sharma *et al.* (2007), Choudhary *et al.* (2010), Singh *et al.* (2012) for plant height, Ramesh *et al.* (2002), Tyagi and Srivastava (2002), Sharma *et al.* (2003), Singh and Mir (2005), Nawab *et al.* (2008), Bhupendra Kumar (2008), Choudhary *et al.* (2010), Lal *et al.* (2011), Singh *et al.* (2012) for number of pods per plant, Singh and Dhillon (2004), Singh and Mir (2005), Lal *et al.* (2011), Singh (2010), Singh *et al.* (2012) for primary branches per plant. The high values of GCV suggested greater phenotypic genotypic variability among the genotypes and responsiveness of the attributes for making further improvement by selection.

Pod width (5.15%), days to first picking (6.67%), number of leaves per plant at 90 DAS (7.34%), fruiting span (7.66%), shelling percentage (10.16%), number of primary branches per plant at 90 DAS (11.36%) and number of leaves per plant at 60 DAS (11.47%) showed lowest genotypic coefficient of variation. The finding of Pathak and Jamwal (2002) for number of days to first picking was similar to the present finding which indicated that there is limited scope for improvement.

While it was moderate for rest of the characters such as plant height at 60 DAS (15.43%), pod weight (14.82%), number of seeds per pod (14.82%), days to

first flowering (13.74%), plant height at 30 DAS (13.22%), days to 50 per cent flowering (12.34%) and pod length (12.06%). The finding of Pathak and Jamwal (2002) for number of days to 50% flowering and plant height Sardana *et al.* (2007), Lal *et al.* (2011) for plant height, pod length, Lal *et al.* (2011), Singh (2010) for seeds per pod for was similar to the present finding.

5.2.3 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. The estimated values of heritability in broad sense were classified as very high (more than 90%), high (more than 70- 90%), medium (50-70%) and low (less than 50%).

The heritability estimates were observed very high for number of pods per plant (96.15%), followed by pod yield per plant (94.68%) and days to first flowering (94.41%). However, it was recorded to be high for days to 50 per cent flowering (83.03%), plant height at 90 DAS (79.81%), days to first picking (76.73%) and pod length (73.86%). The results were in close proximity to that of Sureja and Sharma (2000), Mahanta *et al.* (2001), Ramesh *et al.* (2002), Singh and Singh (2004), Singh and Singh (2006), Sardana *et al.* (2007), Choudhary *et al.* (2010), Singh *et al.* (2011) for plant height, Sureja and Sharma (2000), Shinde (2000), Mahanta *et al.* (2001), Pathak and Jamwal (2002), Singh and Dhillon (2004), Gupta *et al.* (2006), Choudhary *et al.* (2010) for pod yield per plant, Sureja and Sharma (2000), Mahanta *et al.* (2001), Ramesh *et al.* (2002), Sharma *et al.* (2003), Singh and Singh (2004), Singh and Mir (2005), Singh and Singh (2006), Sardana *et al.* (2007), Choudhary *et al.* (2010) for number of pods per plant, Sureja and Sharma (2000) for number of primary branches, Singh and Singh (2004), Singh and Mir (2005) for days to 50 per cent flowering, Singh and Singh (2004), Sardana *et al.* (2007), Singh *et al.* (2011) for pod length, Bora *et al.*

(2009) for days to first picking. High values of broad sense heritability for the above characters expressed that they were least influenced by environmental modification. It reflected that the phenotypes were the true representative of their genotypes and selection based on phenotypic performance would be reliable.

Low estimation of heritability was recorded for number of primary branches per plant at 30 DAS (13.01%), number of leaves per plant at 90 DAS (31.67%), fruiting span (37.45%), pod width (37.57%), shelling percentage (42.85%), plant height at 60 DAS (44.67%), plant height at 30 DAS (46.52%) and number of leaves per plant at 60 DAS (46.97%). This is indicative of the fact that these characters are rather more influenced by the environment and may not respond much to selection.

It was moderate for pod weight (51.80%), number of primary branches per plant at 60 DAS (52.39%), number of primary branches per plant at 90 DAS (58.67%), number of seeds per pod (63.95%) and number of leaves per plant at 30 DAS (69.71%), which indicated that selection based on phenotypic performance would be rewarding. The results were in close proximate to that of Singh and Dhillon (2004), Lal *et al.* (2011) for number of seeds per pod, Singh and Mir (2005), Lal *et al.* (2011) for number of primary branches per plant

5.2.4 Genetic advance

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 gains are more effective and reliable in predicting the improvement through selection (Johnson *et al.*, 1955). Estimates of genetic advance helps to predict the extent of improvement that can be achieved for improving the different characters. The estimated values of genetic advance as percent of mean were classified as high (more than 20%), moderate (10-20%) and low (less than 10%).

Genetic advance as percentage of mean ranged between 6.54% for pod width to 63.23% for pod yield per plant. The highest estimate of genetic advance as percentage of mean was recorded for pod yield per plant (63.23%), number of

pods per plant (61.51%), plant height at 90 DAS (44.21%), number of primary branches per plant at 60 DAS (40.85%), number of leaves per plant at 30 DAS (36.46%), number of primary branches per plant at 30 DAS (33.42%), days to first flowering (27.51%), number of seeds per pod (24.42%), days to 50 per cent flowering (23.17%), pod weight (21.96%), pod length (21.37%) and plant height at 60 DAS (21.25%). The results were in consonance with Sureja and Sharma (2000), Mahanta *et al.* (2001), Ramesh *et al.* (2002), Tyagi and Srivastava (2002), Singh and Mir (2005), Singh and Singh (2006), Sardana *et al.* (2007), Choudhary *et al.* (2010) for plant height, Sureja and Sharma (2000), Shinde (2000), Mahanta *et al.* (2001), Pathak and Jamwal (2002), Singh and Dhillon (2004), Gupta *et al.* (2006), Choudhary *et al.* (2010) for pod yield per plant, Sureja and Sharma (2000), Mahanta *et al.* (2001), Ramesh *et al.* (2002), Tyagi and Srivastava (2002), Sharma *et al.* (2003), Singh and Mir (2005), Singh and Singh (2006), Sardana *et al.* (2007), Choudhary *et al.* (2010) for number of pods per plant, Sureja and Sharma (2000), Singh and Dhillon (2004), Singh and Mir (2005) for number of primary branches, Singh and Mir (2005), Sardana *et al.* (2007) for pod length.

Plant height at 30 DAS (18.58%), number of primary branches per plant at 90 DAS (17.98%), number of leaves per plant at 60 DAS (16.19%), shelling percentage (13.65%) and days to first picking (12.05%) showed moderate value of genetic advance as percentage of mean. The findings were in agreement to the findings of Pathak and Jamwal (2002) Singh *et al.* (2011) for plant height.

Whereas, low estimates were observed for fruiting span (9.66%), number of leaves per plant at 90 DAS (8.51%) and pod width (6.54%). The findings were in agreement to Singh (2010) for pod width.

High heritability coupled with high genetic advance for traits like pod yield per plant followed by number of pods per plant, days to first flowering, days to 50 per cent flowering, plant height at 90 DAS and pod length. Suggested that the preponderance of additive genes. It also indicated higher response for selection of high yielding genotypes as these characters are governed by additive gene actions. The findings were in agreement to the findings of Sureja and Sharma

(2000), Mahanta *et al.* (2001), Ramesh *et al.* (2002), Gupta *et al.* (2006), Singh and Singh (2006), Sardana *et al.* (2007), Bora *et al.* (2009), Choudhary *et al.* (2010) for plant height, Sureja and Sharma (2000), Shinde (2000), Mahanta *et al.* (2001), Pathak and Jamwal (2002), Gupta *et al.* (2006), Rakesh Kumar *et al.* (2007), Nawab *et al.* (2008), Bora *et al.* (2009), Choudhary *et al.* (2010) for pod yield per plant, Sureja and Sharma (2000), Mahanta *et al.* (2001), Ramesh *et al.* (2002), Sharma *et al.* (2003), Singh and Mir (2005), Singh and Singh (2006), Sardana *et al.* (2007), Nawab *et al.* (2008), Choudhary *et al.* (2010) for number of pods per plant, Sureja and Sharma (2000), Gupta *et al.* (2006) for number of primary branches, Sardana *et al.* (2007) for pod length, Bora *et al.* (2009) for 50% flowering.

High heritability supplemented with moderate genetic advances as percentage of mean were manifested by days to first picking which might be attributed to additive gene action conditioning their expression and phenotypic selection for their amenability can be brought about.

Low estimates of heritability coupled with low genetic advances as percentage of mean were displayed by fruiting span, number of leaves per plant at 90 DAS and pod width, indicated that this character was highly influenced by environmental effects and consequently its selection would be ineffective.

5.3 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. The findings were in agreement to Pathak and Jamwal (2002), Chaudhary and Sharma (2003), Kumar *et al.* (2003), Singh and Singh (2005), Nawab *et al.* (2008) and Dhama *et al.* (2010).

In the present findings significant positive phenotypic correlation of pod yield per plant was observed with number of pods per plant, plant height at 60 DAS, plant height at 30 DAS, pod length, plant height at 90 DAS and days to first picking indicating that these characters is the primary yield determinant in pea. These findings corroborated the earlier findings of Mahanta *et al.* (2001), Tiwari *et al.* (2001), Singh and Mishra (2002), Tyagi and Srivastava (2002), Pathak and Jamwal (2002), Sharma *et al.* (2003), Chaudhary and Sharma (2003), Kumar *et al.* (2003), Mehta *et al.* (2005), Singh *et al.* (2005), Singh and Singh (2005), Singh and Singh (2006), Sharma *et al.* (2007), Singh *et al.* (2007), Usmani and Dubey (2007), Kaur *et al.* (2007), Togay *et al.* (2008), Sharma *et al.* (2009), Jitendra Kumar *et al.* (2010), Singh *et al.* (2011) and Kosev and Mikic (2012) for number of pods per plant, Tiwari *et al.* (2001), Tyagi and Srivastava (2002), Pathak and Jamwal (2002), Arya *et al.* (2004), Singh and Singh (2005), Singh and Singh (2006), Usmani and Dubey (2007), Singh *et al.* (2008), Sharma *et al.* (2009) and Singh *et al.* (2011) for plant height. Sharma *et al.* (2003), Chaudhary and Sharma (2003), Kumar *et al.* (2003), Arya *et al.* (2004), Mehta *et al.* (2005), Singh and Yadav (2005), Singh and Singh (2005), Sharma *et al.* (2007), Kaur *et al.* (2007) and Singh *et al.* (2008) for pod length. Kumar *et al.* (2003) for days to first picking.

Plant height (cm)

Plant height at 30 DAS, showed significant and positive correlation with number of leaves per plant at 30 DAS, plant height at 60 DAS, number of pods per plant, plant height at 90 DAS and pod yield per plant. Significant and negative association of this character was observed with shelling percentage.

Correlation coefficient of plant height at 60 DAS showed significant and positive with plant height at 90 DAS, number of pods per plant, pod yield per plant, number of leaves per plant at 60 DAS and number of leaves per plant at 30 DAS.

Plant height at 90 DAS expressed a highly significant and positive correlation coefficient with number of pods per plant, number of leaves per plant at 60 DAS and at 30 DAS, days to 50 % flowering, days to first flowering and pod yield per plant. But it was exhibited significant and negative with pod weight, fruiting span, pod length and pod width. This indicates the importance of this character in selection. The positive correlation of plant height with number of pods per plant, number of leaves per plant at 60 DAS and at 30 DAS, days to 50 % flowering, days to first flowering and pod yield per plant indicates that allocation and translocation of photosynthates from the source to the sink. These findings corroborated the earlier findings of Tiwari *et al.* (2001), Tyagi and Srivastava (2002), Pathak and Jamwal (2002), Arya *et al.* (2004), Singh and Singh (2005), Singh and Singh (2006), Usmani and Dubey (2007), Singh *et al.* (2008), Sharma *et al.* (2009) and Singh *et al.* (2011) for pod yield per plant, Pathak and Jamwal (2002) for days to 50 % flowering.

Number of primary branches per plant

Number of primary branches per plant at 60 DAS expressed significant and positive correlation with days to first flowering and days to 50 % flowering. While it was found significant and negative with pod weight. These results are in close harmony with the findings of Singh and Yadav (2005) for days to 50 % flowering.

Number of primary branches per plant at 90 DAS expressed with significantly and positively associated with number of leaves per plant at 90 DAS, while it was found significant and negative with pod weight.

Number of leaves per plant

Correlation coefficient of number of leaves per plant at 30 DAS was exhibited significant and positive with number of pods per plant. Highly significant and negative association of this character was observed with shelling percentage.

Number of leaves per plant at 60 DAS expressed significant and negative correlation with fruiting span and pod length.

Days to first flowering

Association of days to first flowering was recorded significant and positive with days to 50 per cent flowering, number of pods per plant, days to first picking and number of seeds per pod, while it was found significant and negative with fruiting span and pod weight. These results are in close harmony with the findings of Sirohi *et al.* (2006) for number of pods per plant.

Days to 50 per cent flowering

Days to 50 per cent flowering was recorded highly significant and positive association with number of pods per plant and days to first picking, while it was found significant and negative with fruiting span, pod weight and pod width. These findings corroborated the earlier findings of Pathak and Jamwal (2002) for days to first picking, Pathak and Jamwal (2002), Singh and Yadav (2005) and Sirohi *et al.* (2006) for number of pods per plant.

Days to first picking

Days to first picking were recorded highly significant and positive association with number of pods per plant and pod yield per plant. These results are in close harmony with the findings of Kumar *et al.* (2003) for pod yield per plant.

Fruiting span

Fruiting span expressed significant and positive correlation with pod weight. Also, significant and negative association was exhibited with number of seeds per pod.

Number of pods per plant

The correlation coefficient of number of pods per plant was found significant and positive correlation with pod yield per plant. These findings corroborated the earlier findings of Mahanta *et al.* (2001), Tiwari *et al.* (2001), Singh and Mishra (2002), Tyagi and Srivastava (2002), Pathak and Jamwal (2002), Sharma *et al.* (2003), Chaudhary and Sharma (2003), Kumar *et al.* (2003), Mehta *et al.* (2005), Singh and Yadav (2005), Singh *et al.* (2005), Singh and Singh (2005), Singh and Singh (2006), Sharma *et al.* (2007), Singh *et al.* (2007), Usmani and Dubey (2007), Kaur *et al.* (2007), Sharma *et al.* (2009), Jitendra Kumar *et al.* (2010), Dhama *et al.* (2010) and Singh *et al.* (2011) for pod yield per plant.

Pod length (cm)

Pod length was recorded highly significant and positive association with number of seeds per pod and pod yield per plant. These results are in close harmony with the findings of Pathak and Jamwal (2002) and Nawab *et al.* (2008) for number of seeds per pod, Sharma *et al.* (2003), Chaudhary and Sharma (2003), Kumar *et al.* (2003), Arya *et al.* (2004), Mehta *et al.* (2005), Singh and Yadav (2005), Singh and Singh (2005), Sharma *et al.* (2007), Kaur *et al.* (2007) and Singh *et al.* (2008) for pod yield per plant.

Pod width (cm)

Pod width expressed significant and positive correlation with pod weight. Also, significant and negative association was exhibited with shelling percentage.

Pod weight (gm)

Fruit weight expressed highly significant and negative association with shelling percentage.

5.4 Path coefficient analysis

Correlation coefficients are the indication of simple association between variables. In a biological system, however the relationship may exist in a very complex form. It is therefore, essential to study the relationship among variable in a comprehensive way. Path coefficient analysis is a powerful tool, which enable portioning of the given relationships in its further components. In other words, it takes into account not only the relationship of component characters with the dependent character, but simultaneously takes care of its relationship with other component also. Thus, it helps in understanding the causal system in a better way because it enables portioning the total correlations coefficient into direct and indirect effects of various characters.

In the present investigation path coefficient analysis was carried out for characters under study using genotypic and phenotypic correlation coefficient and taking pod yield per plant as dependable variables, in order to see the causal factor and so as to identify the components which are responsible for producing pod yield per plant. In general the genotypic direct as well as indirect effects were slightly higher in magnitude as compared to corresponding phenotypic direct and indirect effects.

Path coefficient analysis of the different characters revealed that number of pods per plant had highest positive direct effect on pod yield per plant followed by pod weight, pod length, fruiting span, number of leaves per plant at 90 DAS, days to first flowering and days to first picking. The results are in propinquity with Tiwari *et al.* (2001), Singh and Mishra (2002), Ramesh and Tawatia (2002), Chaudhary and Sharma (2003), Kumar *et al.* (2003), Arya *et al.* (2004), Singh and Yadav (2005), Mehta *et al.* (2005), Singh *et al.* (2005), Singh and Singh (2005), Kumar and Sharma (2006), Kaur *et al.* (2007), Sharma *et al.* (2007), Nawab *et al.* (2008), Togay *et al.* (2008), Singh *et al.* (2008), Sharma *et al.* (2009), Lal *et al.* (2011) and Singh *et al.* (2011) for number of pods per plant, Tiwari *et al.* (2001), Chaudhary and Sharma (2003), Singh and Yadav (2005),

Mehta *et al.* (2005), Singh and Singh (2005), Kaur *et al.* (2007) and Sharma *et al.* (2007) for pod length, Ramesh and Tewatia (2002) and Kumar *et al.* (2003) for pod weight, Ramesh and Tewatia (2002) and Kumar and Sharma (2006) for days to first picking. The characters number of pods per plant had correlation coefficient values at par with their direct effect on pod yield per plant. This indicates true relationships with pod yield per plant and direct selection for this trait would result in higher breeding efficiency for improving yield. Thus, this trait might be reckoned as the most important component trait for pod yield per plant.

Whereas days to 50 per cent flowering had the highest negative direct effect on pod yield per plant followed by pod width and number of seeds per pod. The results corroborated the findings of Chaudhary and Sharma (2003) and Kumar *et al.* (2003) for days to 50 per cent flowering. But days to 50 per cent flowering, pod width and number of seeds per pod was positively correlated to it. This indicated that the indirect effect was the cause of correlation and the indirect causal factors are to be considered simultaneously for selection.

Other characters like number of primary branches per plant, shelling percentage and plant height did not exhibit, higher direct effect on pod yield, they expressed higher indirect effect on it through pod weight, number of primary branches per plant at 90 DAS and number of pods per plant respectively and hence simultaneous selection for these characters can be made for the improvement of yield.

Path coefficient analysis revealed that number of pods per plant, pod weight, pod length, fruiting span, number of leaves per plant at 90 DAS, days to first flowering, days to first picking, days to 50 per cent flowering, pod width and number of seeds per pod were the most important characters contributing towards pod yield per plant and hence purposeful and balanced selection based on these characters would be made rewarding for improvement of pea.

5.5 Quality parameters

Qualitative characters like protein per cent, colour of pod, shape of pod and presence of tendrils are summarized in Table 4.7

Protein percentage

The significantly maximum protein content was recorded in the genotypes BE –06 (26.43 %), Pusa Pragati (26.37%), 2012/ PMVAR – 5 (26.12%) and VRP – 5 (26.06%). However it was exhibited lowest in genotype IIVR –5 (18.55%) and it ranged from 18.55% to 26.43%. The results corroborated the findings of Shinde (2000) Singh *et al.* (2003) Singh and Singh (2004) reported that this trait was high contribution by the additive genetic component; thus, this trait may be improved by mass, progeny or family selection.

Colour of pod

Colour of pods was observed to be dark green, green and light green. Genotypes 2012/ PMVAR – 3, Arkel, AP –1, Akra Samporna, AP –3, BE –06 and Arka Ajit exhibited dark green pods. Whereas, PC –531 (C) was observed light green pods. Remaining genotypes exhibited green pods. The results corroborated the findings of Nisar *et al.* (2008) and Sharma *et al.* (2010).

Shape of pod

Significant variation was observed among the genotypes for shape of pods i.e. straight, slightly curved and curved (Table 4.7). Shape of pods was observed to be straight in genotypes 2012/ PMVAR – 1, 2012/ PMVAR – 3, 2012/ PMVAR – 4, 2012/ PMVAR – 5, Arka Ajit and VRP –7 (C). Genotype Akra Samporna was produced curved pod. The remaining genotypes produced slightly curved pods. The results corroborated the findings of Nisar *et al.* (2008) and Sharma *et al.* (2010).

Incidence of pod borer (%)

Pod borer incidence was observed maximum in genotypes VRP – 22 (6.20%) followed by VRP – 6 (5.73%), VRP – 6 (5.11%) and PSM –3 (5.03%) was found to highly susceptible to pod borer. The low incidence of pod borer was found in genotypes Arka Ajit (0.78), Akra Sampurna (1.10), 2012/ PMVAR – 3 (1.78) and VRP –7 (C) (1.80).

Incidence of powdery mildew (%)

The incidence of powdery mildew was observed maximum in genotypes 2012/ PMVAR – 2 (20.00%), AP –1 (20.0%), Arkel (16.67%) and VRP – 6 (16.67%). Whereas, genotypes Arka Ajit (1.67%), 2012/ PMVAR – 1 (3.33%), PC –531 (C) (5.00%), VRP – 22 (6.67%) and Akra Sampurna (6.67%) were slightly tolerant to the same. The results corroborated the findings of Mahanta *et al.* (2001)

SUMMARY, CONCLUSION AND SUGGESTIONS

FOR FUTURE WORK

6.1 Summary

The present investigation “Studies on genetic parameter, correlation and path coefficient analysis of yield and its components in garden pea (*Pisum sativum* L.)” was carried out during rabi season of 2012-2013 at the Vegetable Research Farm, Department of Horticulture, College of Agriculture, J.N.K.V.V., Jabalpur (M.P.). The experimental material for the present investigation was comprised of 22 genotypes of garden pea. These genotypes were sown in Randomized Complete Block Design with three replications, to estimate the genetic variability and association analysis (Correlation and Path coefficient). Observations were recorded on the basis of five random competitive plants selected from each genotype separately for morphological, yield and quality parameters were evaluated as per standard procedure. The variance components and coefficient of variation were determined according to Burton (1952). The heritability (broad sense) and genetic advance was worked out by Hanson *et al.* (1956) and Johnson *et al.* (1955). Correlation coefficient and path coefficient was computed by the formula suggested by Miller *et al.* (1958) and Dewey and Lu (1959). On the basis of results, the present investigation is summarized as follows:

The estimates of mean sum of square due to genotypes were highly significant for all the characters except for number of primary branches per plant at 30 DAS, indicating the presence of genetic diversity in the existing material.

The mean performance of the genotypes revealed a wide range of variability for all the traits. The variation was highest for pod yield per plant, followed by plant height at 90 DAS, number of pods per plant, days to 50 per cent flowering, shelling percentage, plant height at 60 DAS, days to first picking, days to first flowering and fruiting span.

The present study revealed that the phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for all the traits which might be due to interaction of the genotypes with the environment to some degree or other explaining environmental factors influencing the expression of these characters. High phenotypic and genotypic coefficient of variation was observed for number of primary branches per plant at 30 DAS, number of primary branches per plant at 60 DAS, pod yield per plant, number of pods per plant, plant height at 90 DAS, number of leaves per plant at 30 DAS, plant height at 60 DAS and pod weight. The high values of GCV suggested greater phenotypic and genotypic variability among the genotypes and responsiveness of the attributes for making further improvement by selection. However, days to first picking, followed by pod width, fruiting span showed low estimates of genotypic and phenotypic coefficient of variation, indicating the potential of heterosis breeding for their amelioration.

Very high estimates of heritability were obtained for the traits like number of pods per plant, followed by pod yield per plant and days to first flowering. However, high heritability was recorded in the character viz., days to 50 per cent flowering, plant height at 90 DAS, days to first picking and pod length. Indicated that the high values of broad sense heritability for these characters expressed that they were least influenced by environmental modification. It reflected that the phenotypes were the true representative of their genotypes and selection based on phenotypic performance would be reliable.

High heritability coupled with high genetic advance as percentage of mean for traits like pod yield per plant followed by number of pods per plant, days to first flowering, days to 50 per cent flowering, plant height at 90 DAS and pod length. Suggested that the preponderance of additive genes. It also indicated higher response for selection of high yielding genotypes as these characters are governed by additive gene actions.

High heritability supplemented with moderate genetic advances as percentage of mean were manifested by days to first picking, which might be attributed to additive gene action conditioning their expression and phenotypic selection for their amenability can be brought about.

Low estimates of heritability coupled with low genetic advances as percentage of mean were displayed by fruiting span, number of leaves per plant at 90 DAS and pod width, indicated that this character was highly influenced by environmental effects and consequently its selection would be ineffective.

The genotypic correlation coefficients were higher in magnitude than their corresponding phenotypic one, indicating there by strong inherent association between different traits studied. The phenotypic expression of correlation was lessened possibly due to multiple influences of environmental components. In view of their correspondence, selection on phenotypic basis would be effective.

The highest positive and significant correlation coefficient of pod yield per plant was observed with number of pods per plant, plant height at 60 DAS, plant height at 30 DAS, pod length, plant height at 90 DAS and days to first picking, which indicated that effective improvement in garden pea yield through these components could be achieved. The yield attributing characters exhibited varying trend amongst them.

Plant height at 30 DAS, showed significant and positive correlation with number of leaves per plant at 30 DAS, plant height at 60 DAS, number of pods per plant, plant height at 90 DAS and pod yield per plant. Correlation coefficient of plant height at 60 DAS showed significant and positive with plant height at 90 DAS, number of pods per plant, pod yield per plant, number of leaves per plant at 60 DAS and number of leaves per plant at 30 DAS. Plant height at 90 DAS expressed a highly significant and positive correlation coefficient with number of pods per plant, number of leaves per plant at 60 DAS and at 30 DAS, days to 50 % flowering, days to first flowering and pod yield per plant, which indicates that allocation and translocation of photosynthates from the source to the sink. This indicates the importance of this character in selection.

Number of primary branches per plant at 60 DAS expressed significant and positive correlation with days to first flowering and days to 50 % flowering. While it was found significant and negative with pod weight. Number of primary branches per plant at 90 DAS expressed with significantly and positively associated with number of leaves per plant at 90 DAS, while it was found significant and negative with pod weight.

Correlation coefficient of number of leaves per plant at 30 DAS was exhibited significant and positive with number of pods per plant. Highly significant and negative association of this character was observed with shelling percentage. Number of leaves per plant at 60 DAS expressed significant and negative correlation with fruiting span and pod length. Association of days to first flowering was recorded significant and positive with days to 50 per cent flowering, number of pods per plant, days to first picking and number of seeds per pod, while it was found significant and negative with fruiting span and pod weight. Days to 50 per cent flowering was recorded highly significant and positive association with number of pods per plant and days to first picking, while it was found significant and negative with fruiting span, pod weight and pod width. Days to first picking were recorded highly significant and positive association with number of pods per plant and pod yield per plant. Fruiting span expressed significant and positive correlation with pod weight. Also, significant and negative association was exhibited with number of seeds per pod. The correlation coefficient of number of pods per plant was found significant and positive correlation with pod yield per plant. Pod length was recorded highly significant and positive association with number of seeds per pod and pod yield per plant. Pod width expressed significant and positive correlation with pod weight. Also, significant and negative association was exhibited with shelling percentage. Fruit weight expressed highly significant and negative association with shelling percentage.

Path coefficient analysis of the different characters revealed that number of pods per plant had highest positive direct effect on pod yield per plant followed by pod weight, pod length, fruiting span, number of leaves per plant at 90 DAS, days to first flowering and days to first picking.

These characters had correlation coefficient values at par with their direct effect on pod yield per plant. This indicates true relationships with pod yield per plant and direct selection for these traits would result in higher breeding efficiency for improving yield. Thus, these traits might be reckoned as the most important component trait of pod yield per plant.

Whereas days to 50 per cent flowering had the highest negative direct effect on pod yield per plant followed by pod width and number of seeds per pod. But days to 50 per cent flowering, pod width and number of seeds per pod was positively correlated to it. This indicated that the indirect effect was the cause of correlation and the indirect causal factors are to be considered simultaneously for selection.

Other characters like number of primary branches per plant, shelling percentage and plant height did not exhibit, higher direct effect on pod yield, they expressed higher indirect effect on it through pod weight, number of primary branches per plant at 90 DAS and number of pods per plant respectively and hence simultaneous selection for these characters can be made for the improvement of yield.

The significantly maximum protein content was recorded in the genotypes BE – 06 (26.43 %), Pusa Pragati (26.37%), 2012/ PMVAR – 5 (26.12%) and VRP – 5 (26.06%). The low incidence of pod borer was found in genotypes Arka Ajit (0.78), Akra Sampurna (1.10), 2012/ PMVAR – 3 (1.78) and VRP –7 (C) (1.80). Whereas, genotypes Arka Ajit (1.67%), 2012/ PMVAR – 1 (3.33%), PC –531 (C) (5.00%), VRP – 22 (6.67%) and Akra Sampurna (6.67%) were slightly tolerant to the powdery mildew.

Considerable variability was observed among the genotypes for pod colour, pod shape and presence of tendrils. Pod colour and shape of garden pea are most important characteristics to help customers in choosing cultivars on the market.

6.2 Conclusion

The estimates of mean sum of square due to genotypes were highly significant for all the characters except for number of primary branches per plant at 30 DAS, indicating the presence of genetic diversity in the existing material.

The mean performance of the genotypes revealed a wide range of variability for all the traits. The variation was highest for pod yield per plant, followed by plant height at 90 DAS, number of pods per plant, days to 50 per cent flowering, shelling percentage, plant height at 60 DAS, days to first picking, days to first flowering and fruiting span.

The PCV was higher than the GCV for all the characters. High PCV and GCV was observed for number of primary branches per plant at 30 DAS, number of primary branches per plant at 60 DAS, pod yield per plant, number of pods per plant, plant height at 90 DAS, number of leaves per plant at 30 DAS, plant height at 60 DAS and pod weight, indicating greater diversity for these traits and their further improvement through selection.

High heritability supplemented with high genetic advance as percentage of mean was manifested by pod yield per plant followed by number of pods per plant, days to first flowering, days to 50 per cent flowering, plant height at 90 DAS and pod length, suggested that they can be improved through direct selection.

The association studies indicated that the advantages of upgrading garden pea genotypes through simultaneous selection for number of pods per plant, plant height at 60 DAS, plant height at 30 DAS, pod length, plant height at 90 DAS and days to first picking.

Path coefficient analysis revealed that number of pods per plant, pod weight, pod length, fruiting span, number of leaves per plant at 90 DAS, days to first flowering, days to first picking, days to 50 per cent flowering, pod width and number of seeds per pod were the most important characters contributing towards pod yield per plant and hence purposeful and balanced selection based on these characters would be made rewarding for improvement of pea.

The significantly maximum protein content was recorded in the genotypes BE – 06 (26.43 %), Pusa Pragati (26.37%), 2012/ PMVAR – 5 (26.12%) and VRP – 5 (26.06%). The low incidence of pod borer was found in genotypes Arka Ajit (0.78), Akra Sampurna (1.10), 2012/ PMVAR – 3 (1.78) and VRP – 7 (C) (1.80). Whereas, genotypes Arka Ajit (1.67%), 2012/ PMVAR – 1 (3.33%), PC – 531 (C) (5.00%), VRP – 22 (6.67%) and Akra Sampurna (6.67%) were slightly tolerant to the powdery mildew.

Considerable variability was observed among the genotypes for pod colour, pod shape and presence of tendrils. Pod colour and shape of garden pea are most important characteristics to help customers in choosing cultivars on the market.

6.3 Suggestions for further work

1. Stability of distinct traits of garden pea should be established over the years.
2. Traits identified for high heritability coupled with high or moderate genetic gain may be considered well in selection for the improvement of crop.
3. Characters having desirable association and direct effects with pod yield should be given due consideration for genetic improvement in garden pea.
4. The genotypes showing greater yield potential with other desirable qualities may be tested under different agro climatic conditions and those found suitable could be recommended for general cultivation.

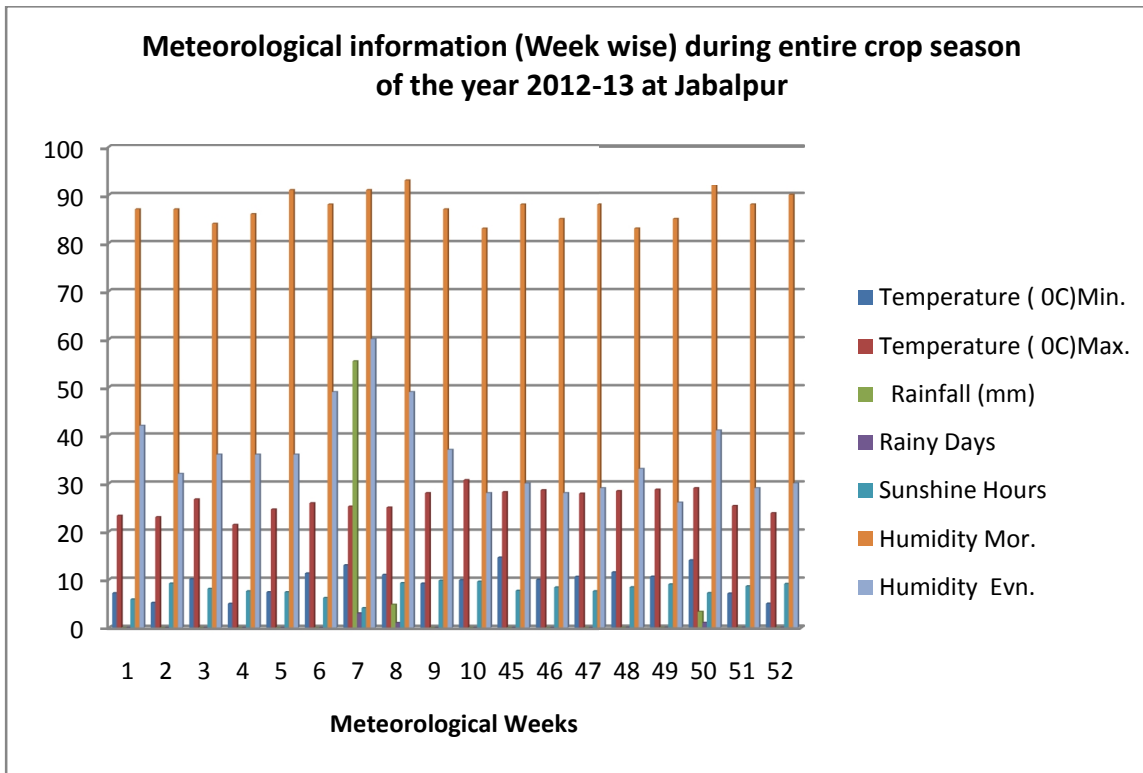


Fig 1: Meteorological information (week wise) during entire crop season of the year 2012-13 at Jabalpur

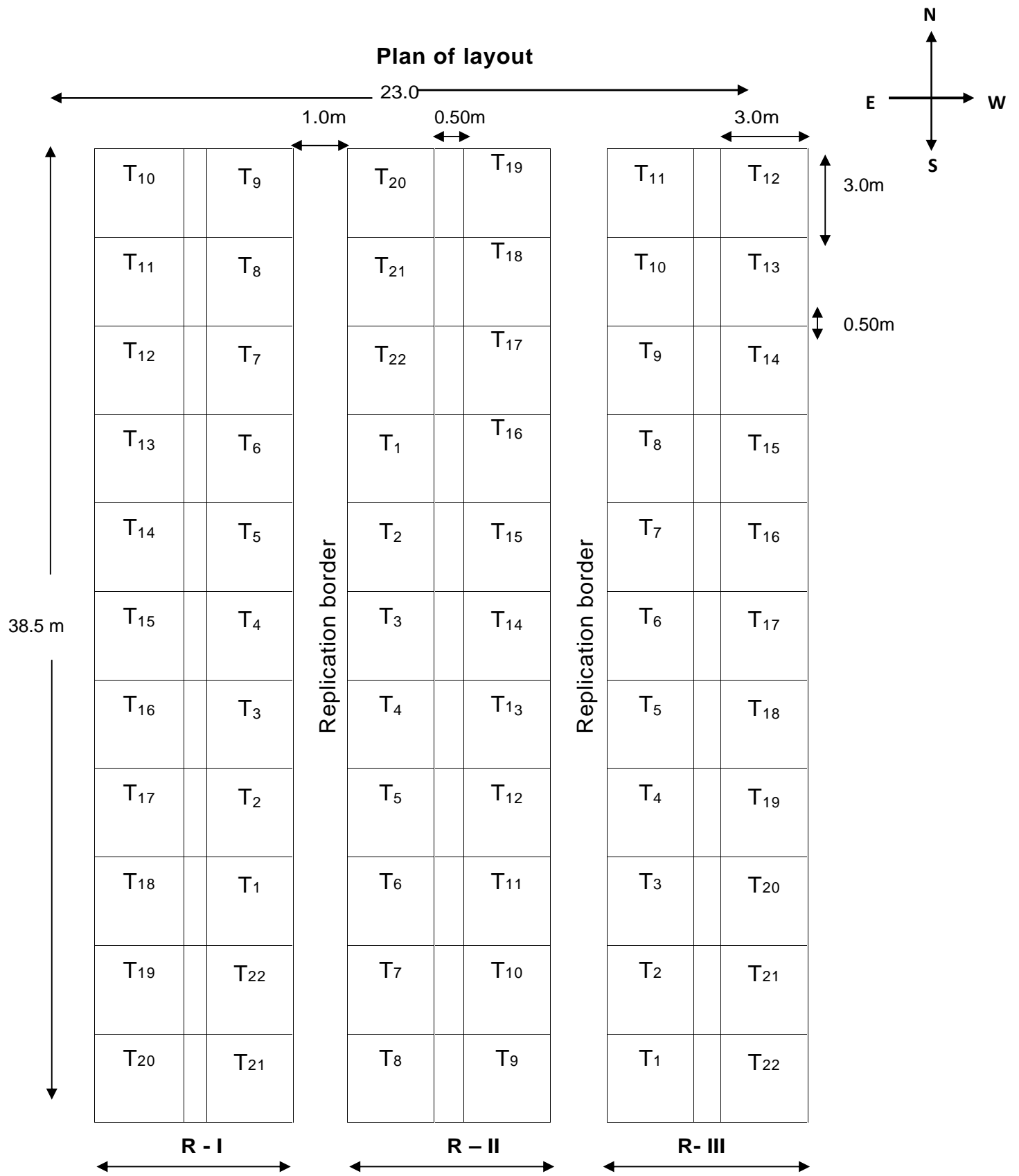


Fig.2. Plan of the layout of experimental plot

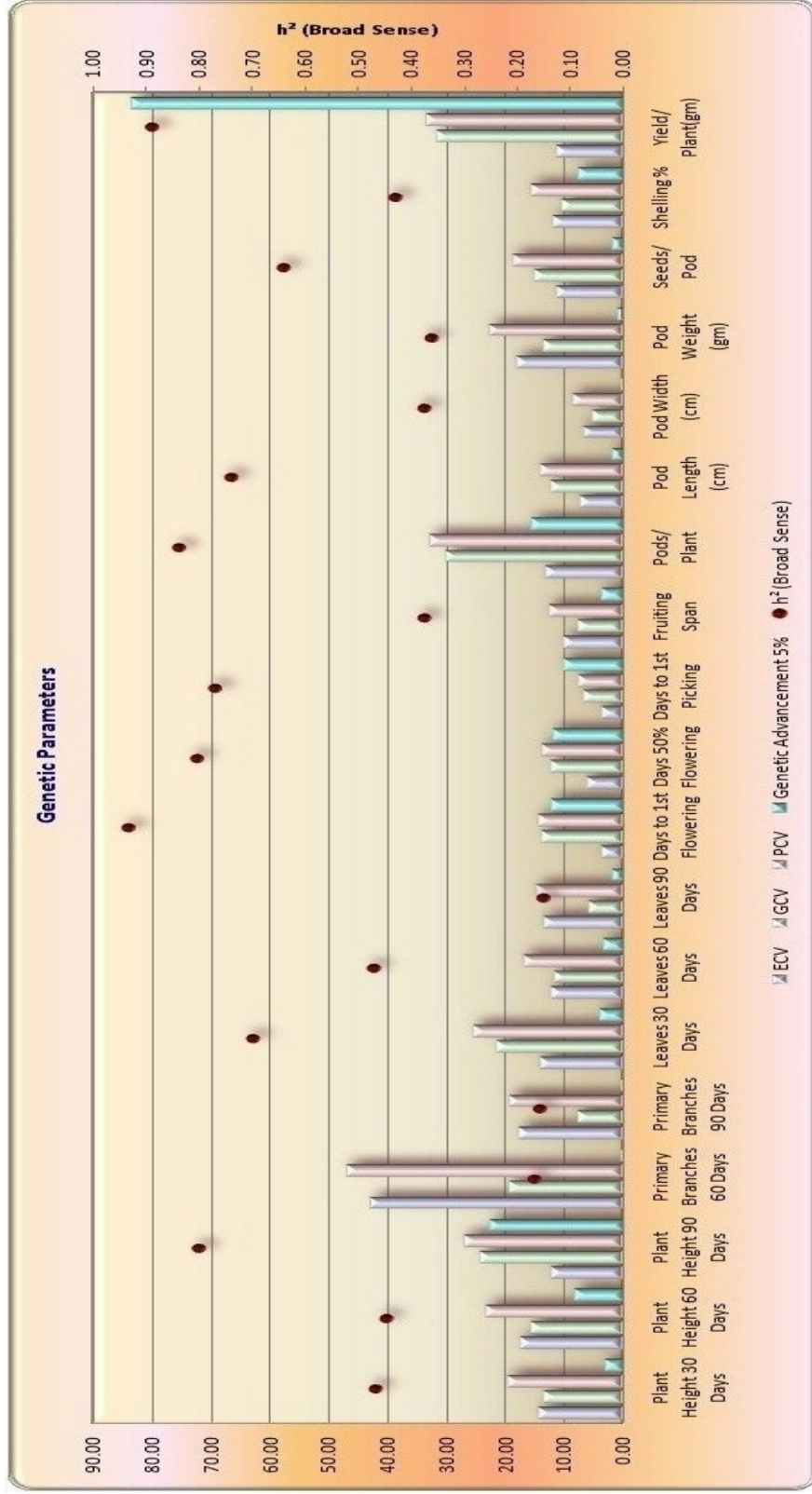


Fig. 3: Genetic Parameters in twenty characters in garden pea

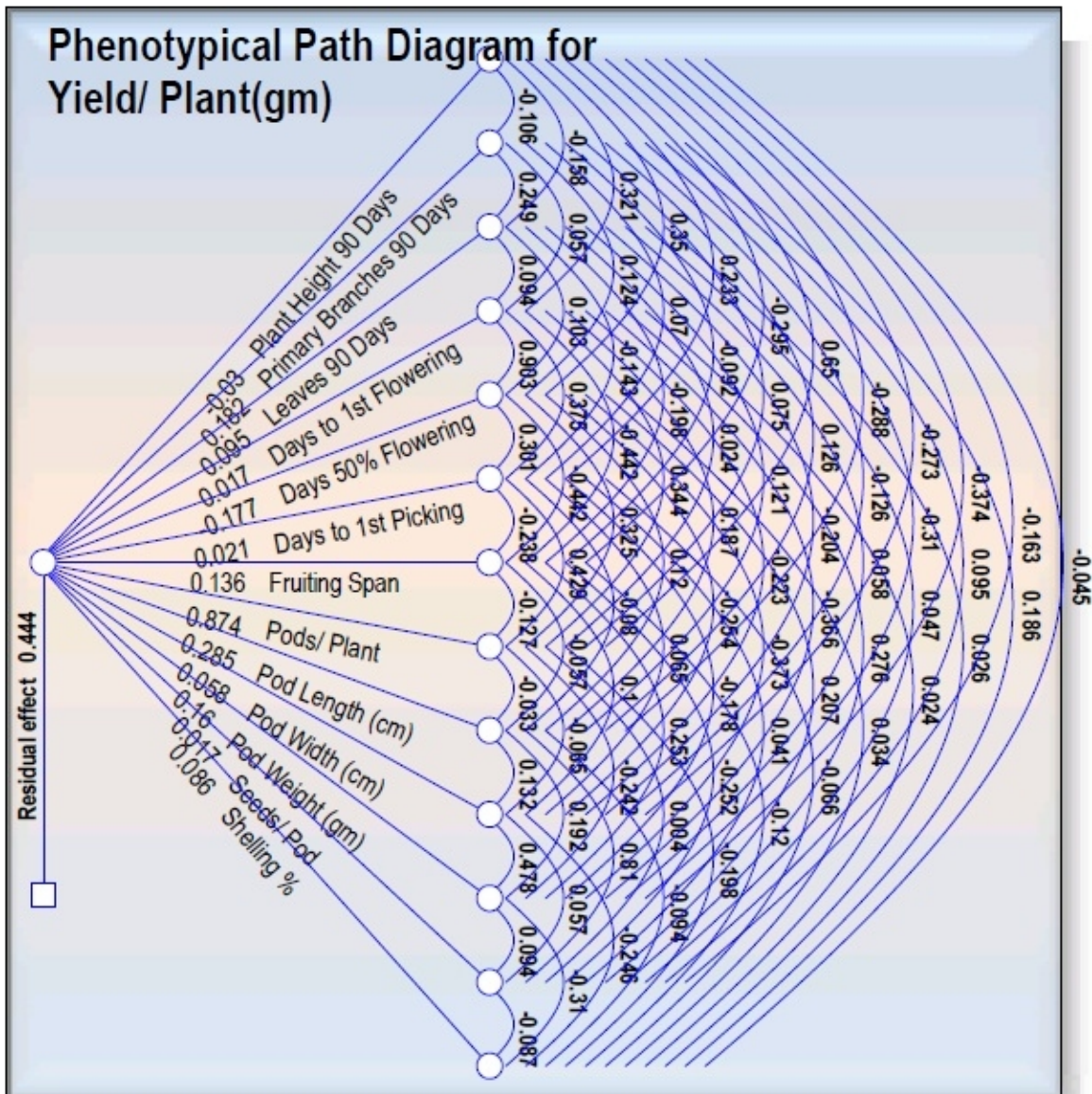


Fig. 4, Phenotypical path diagram for Yield/ plant(gm)

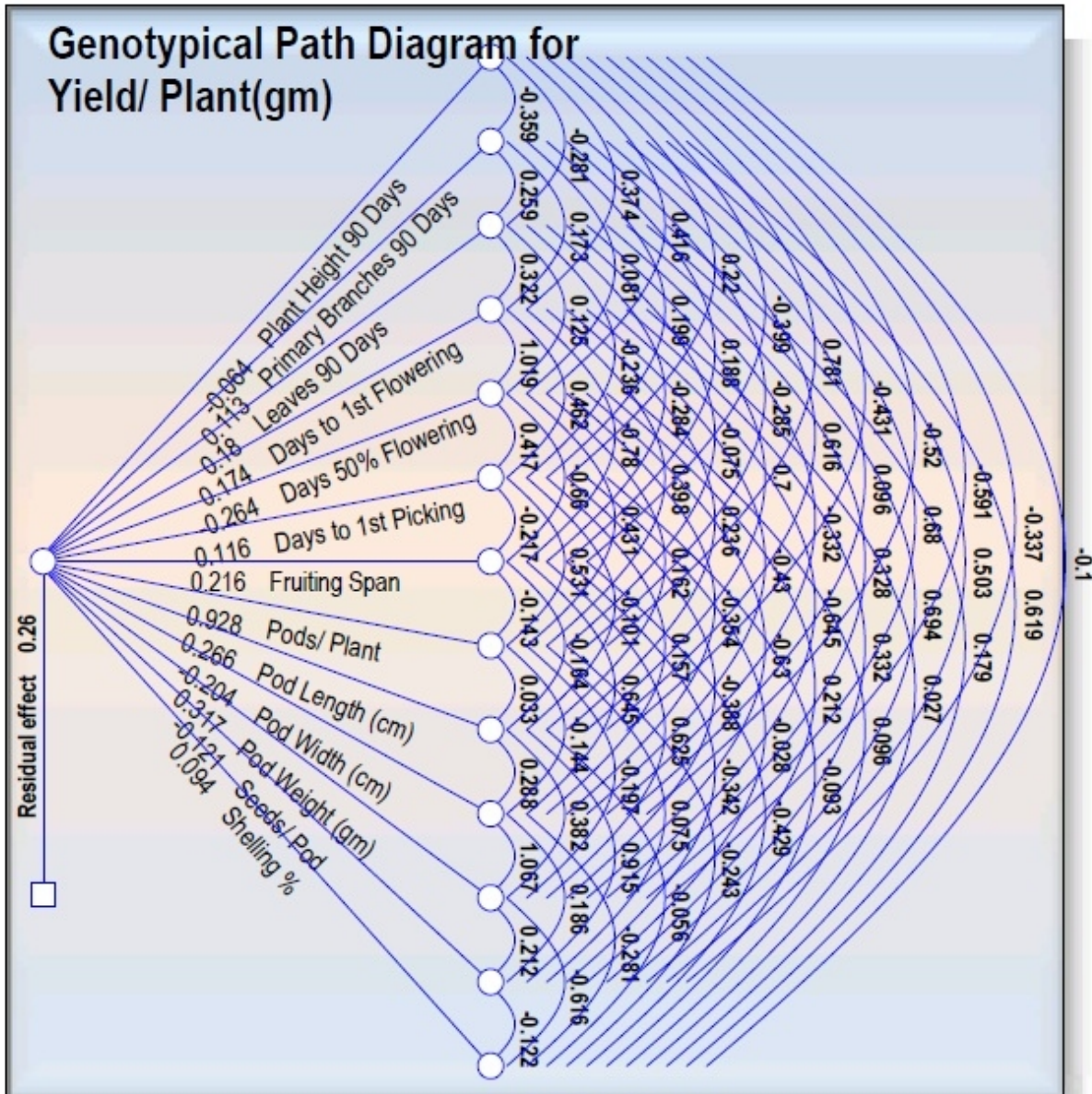


Fig. 5, Genotypical path diagram for Yield/ plant(gm)



2012/PMVAR-12



2012/PMVAR-3



2012/PMVAR-4



2012/PMVAR-5



Arkel



AP-1



GS-10



Pusa Pragati



PSM-3



Arka Sampurna



AP-3

PLATE-1, SHOWING PODS OF DIFFERENT GENOTYPES UNDER INVESTGATION



BE-6



IIVR-5



ArkaAjit



VRP-5



VRP-6



VRP-8



VRP-16



VRP-22



VRP-7(C)



PC-531(C)

PLATE-2, SHOWING PODS OF DIFFERENT GENOTYPES UNDER INVESTGATION

REFERENCES

- Arya, Satyawan; Malik, B. P. S.; Ram Kumar and Ram Dhari (2004). Variability, correlation and path analysis in field pea (*Pisum sativum* L.). *Haryana Agricultural University Journal of Research*. 34 (2): 149-153.
- Bhupendra Kumar (2008). Variability, heritability and genetic advance in pea (*Pisum sativum* L.). *International Journal of Plant Sciences* (Muzaffarnagar). 3 (1): 211-212.
- Bora, Lila; Sharma, V. K.; Raturi, H. C. and Maurya, S. K. (2009). Studies on hybrid breeding and genetic variability in vegetable pea under high hilly condition of Uttarakhand. *Annals of Horticulture*. 2 (2): 171-176.
- Burton, G.W. (1952). Quantitative inheritance in grasses. Proc. 6th Int. Grassland Cong., 1: 227-285.
- Chaudhary, D. K. and Sharma, R. R. (2003). Genetic variability, correlation and path analysis for green pod yield and its components in garden pea. *Indian Journal of Horticulture*. 60 (3): 251-256.
- Chaudhary, Harshawardhan; Verma, M. K. and Sofi, A. A. (2010). Genetic variability, heritability and genetic advance for yield components in garden pea. *Pantnagar Journal of Research*. 8 (2): 195-197.
- Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.* 51: 515-518.
- Dhama, S. K.; Tyagi, N. K. and Singh, P. B. (2010). Interrelationship and path analysis for seed yield and its component characters under eight environments in pea (*Pisum sativum* L.). *Legume Research*. 33 (2): 87-94.

- Guleria, Sonali; Chongtham, Nirmala and Dua, Saroj (2009). Genetic variability, correlation and path analysis studies in pea (*Pisum sativum* L.). *Crop Research* (Hisar). 38 (1/3): 179-183.
- Gupta, A. J.; Singh, Y. V. and Verma, T. S. (2006). Genetic variability and heritability in garden pea (*Pisum sativum* L.). *Indian Journal of Horticulture*. 63 (3): 332-334.
- Hanson, C.H.; Robinson, H.F. and Comstock, R.E. (1956). Bimetric studies of yield in segregating population of Korean Lespedeza. *Agron, J.*, 48: 268-272.
- Jitendra Kumar; Nazima Ashraf and Krishan Pal (2010). Variability and character association in garden pea (*Pisum sativum* L. sub sp. *hortense* Asch. and Graebn.). *Progressive Agriculture*. 10 (1): 124-131.
- Johnson, H.W.; Robinson, H.F. and Comstock, R.E. (1955). Estimates of genetics and environment variability in soybean. *Agron. J.*, 47: 314-318.
- Kaur, Harpreet; Singh, Mohan and Brar, P. S. (2007). Correlation and path analysis in garden pea (*Pisum sativum* L.). *Crop Improvement*. 34 (2): 186-191.
- Kosev, V. and Mikic, A. (2012). Short communication. assessing relationships between seed yield components in spring-sown field pea (*Pisum sativum* L.) cultivars in Bulgaria by correlation and path analysis. *Spanish Journal of Agricultural Research*. 10 (4): 1075-1080.
- Kumar, Manoj; Tewatia, A. S. and Sharma, N. K. (2003). Correlation and path analysis in pea (*Pisum sativum* L.). *Haryana Journal of Horticultural Sciences*. 32 (1/2): 104-107.
- Kumar, V. R. A. and Sharma, R. R. (2006). Path coefficient analysis for pod yield and its attributes in garden pea (*Pisum sativum* L. sub sp. *hortense* Asch. and Garebn.). *Annals of Agricultural Research*. 27 (1): 32-36.

- Lal, G. M.; Meena, M. L.; Kunj Chandra and Singh, C. M. (2011). Assessment of genetic variability and interrelation between yield and its contributing components in field pea (*Pisum sativum* L.). *Environment and Ecology*. 29 (3A): 1235-1239.
- Li, C.C. (1956). The concept of path coefficient and its impact on population genetics. *Biometrics*. 12: 190-210.
- Mahanta, I. C.; Senapati, N.; Samal, K. M. and Dhal, A. (2001). Genetic variability performance character association and coheritability in field pea (*Pisum sativum* L.). *Legume Research*. 24 (2): 92-96.
- Mehta, Seema; Kohli, U. K.; Mehta, Devinder and Dharminder Kumar (2005). Genetic variability studies in pea (*Pisum sativum* L.). *Haryana Journal of Horticultural Sciences*. 34 (1/2): 140-141.
- Mehta, Seema; Kohli, U. K.; Mehta, Devinder and Dharminder Kumar (2005). Character association and path analysis in pea (*Pisum sativum* L.). *Horticultural Journal*. 18 (2): 128-130.
- Miller, D.A.; Williams, J.C.; Robinson, H.F. and Comstock, K.B. (1958). Estimates of genotypic and environmental variances and covariances in upland cotton and their implication in selection. *Agron. J.*, 50: 126-131.
- Million Fikreselassie (2012). Variability, heritability and association of some morpho-agronomic traits in field pea (*Pisum sativum* L.) genotypes. *Pakistan Journal of Biological Sciences*. 15 (8): 358-366.
- Nair, Priya and Khare, Dharendra (2009). Genetics of factors ascertaining transportability of pods of vegetable pea (*Pisum sativum*). *Indian Journal of Agricultural Sciences*. 79 (11): 939-940.
- Nawab, N. N.; Subhani, G. M.; Khalid Mahmood Qamar and Shakil Akhtar Saeed (2008). Genetic variability, correlation and path analysis studies in garden pea (*Pisum sativum* L.). *Journal of Agricultural Research (Lahore)*. 46 (4): 333-340.

- Panes, V.G. and Sukhatme, P.V. (1963). Statistical methods for Agricultural workers, ICAR, New Delhi.
- Pathak, Sanjeev and Jamwal, R. S. (2002). Variability and correlations for economic traits in powdery mildew resistant genotypes of garden pea (*Pisum sativum* L.). *Himachal Journal of Agricultural Research*. 28 (1/2): 34-39.
- Rakesh Kumar; Ram Dhari; Ram Kumar and Malik, B. P. S. (2007). Assessment of morphological variability and genetic diversity in pea germplasm (*Pisum sativum* L.). *National Journal of Plant Improvement*. 9 (1): 5-8.
- Ramesh, C. and Tewatia, A. S. (2002). Character association and path analysis studies in garden pea (*Pisum sativum* L.). *Haryana Journal of Horticultural Sciences*. 31 (1/2): 94-97.
- Ramesh, C.; Tewatia, A. S. and Dahiya, M. S. (2002). Genetic variability and heritability studies in garden peas (*Pisum sativum* L.). *Haryana Journal of Horticultural Sciences*. 31 (3/4): 250-252.
- Sanjay Chadha; Sharma, Rajeev and Chaudhary, D. R. Vidyasagar (2008). Genetic variability studies in summer pea under cold desert areas of North-Western Himalayas. *Agricultural Science Digest*. 28 (1): 10-13.
- Sardana, S.; Mahajan, R. K.; Gautam, N. K. and Ram, B. (2007). Genetic variability in pea (*Pisum sativum* L.) germplasm for utilization. *SABRAO Journal of Breeding and Genetics*. 39 (1): 31-41.
- Seema Ranjan; Manoj Kumar and Pandey, S. S. (2006). Genetic variability in peas (*Pisum sativum*). *Legume Research*. 29 (4): 311-312.
- Sharma, A. K.; Singh, S. P. and Sarma, M. K. (2003). Genetic variability, heritability and character association in pea (*Pisum sativum* L.). *Crop Research (Hisar)*. 26 (1): 135-139.

- Sharma, Akhilesh and Kalia, Pritam (2002). Genetic analysis for pod yield and its contributing traits in garden pea (*Pisum sativum* L.). *Vegetable Science*. 29 (2): 106-109.
- Sharma, Akhilesh; Sood, Meenakshi; Rana, Ashwini and Singh, Yudhvair (2007). Genetic variability and association studies for green pod yield and component horticultural traits in garden pea under high hill dry temperate conditions. *Indian Journal of Horticulture*. 64 (4): 410-414.
- Sharma, M. K.; Anil Chandel and Kohli, U. K. (2009). Genetic evaluation, correlations and path analysis in garden pea (*Pisum sativum* Var. hortense L.). *Annals of Horticulture*. 2 (1) 33-38.
- Shinde, K. G. (2000). Genetic parameters for some quantitative and qualitative traits in pea (*Pisum sativum* L.). *Orissa Journal of Horticulture*. 28 (1): 21-24.
- Singh, A. K. and Mir, M. S. (2005). Genetic variability, heritability and genetic advance in pea (*Pisum sativum* L.) under cold arid region of Ladakh. *Environment and Ecology*. 23S (Special 3): 445-449.
- Singh, A. K. and Yadav, V. K. (2005). Character association and path coefficient analysis studies for certain metric traits in pea (*Pisum sativum* L.) under cold arid region of Ladakh. *Horticultural Journal*. 18 (1): 35-38.
- Singh, Akansha; Singh, Shalini and Babu, J. D. P. (2011). Heritability, character association and path analysis studies in early segregating population of field pea (*Pisum sativum* L. var. *arvense*). *International Journal of Plant Breeding and Genetics*. 5 (1): 86-92.
- Singh, Dharmendra and Mishra, V. K. (2002). Correlation and path analysis in a diallel cross of pea. *Legume Research*. 25 (1): 44-46.
- Singh, G.; Singh, M.; Singh, V. and Singh, B. (2003). Genetic variability, heritability and genetic advance in pea (*Pisum sativum* L.). *Progressive Agriculture*. 3 (1/2): 70-73.

- Singh, J. D. and Singh, I. P. (2004). Selection parameters for seed yield in field pea (*Pisum sativum* L.). *National Journal of Plant Improvement*. 6 (1): 51-52.
- Singh, J. D. and Singh, I. P. (2005). Studies on correlation and path coefficient analysis in field pea (*Pisum sativum* L.). *National Journal of Plant Improvement*. 7 (1): 59-60.
- Singh, J. D. and Singh, I. P. (2006). Genetic variability, heritability, expected genetic advance and character association in field pea (*Pisum sativum* L.). *Legume Research*. 29 (1): 65-67.
- Singh, J. D.; Brijendra Kumar and Singh, J. P. (2007). Genetic variability, heritability and character association in dwarf field pea (*Pisum sativum* L.). *Progressive Agriculture*. 7 (1/2): 102-104.
- Singh, K. P. (2010). Selection criteria for improving yield and its components in table pea (*Pisum sativum*). *Current Advances in Agricultural Sciences*. 2 (1): 22-24.
- Singh, Manender ; Malik, Sunil; Mukesh Kumar; Singh, K. V.; Sanjiv Kumar; Pavitra Dev and Vinuj Kumar (2012). Studies of variability, heritability and genetic advance in field pea (*Pisum sativum* L.). *Progressive Agriculture*. 12 (1): 219-222.
- Singh, Mohan; Yuvinder Kumar; Harinder Singh and Brar, P. S. (2005). Correlation and path coefficient analysis in garden pea (*Pisum sativum* L.). *Environment and Ecology*. 23 (2): 315-318.
- Singh, Nirmal and Dhillon, G. S. (2004). Genetic variability for pod yield and its contributing traits in garden pea (*P. sativum* L. var. *Hortense*). *Haryana Journal of Horticultural Sciences*. 33 (3/4): 300-301.
- Singh, V. S.; Rai, Geeta and Mishra, Akhilesh (2008). Correlation and path-analysis in field pea. *Plant Archives*. 8 (2): 859-860.

- Sirohi, S. P. S.; Yadav, Ramashray and Malik, Sanjai (2006). Genetic variability, correlations and path coefficient analysis for seed yield and its component characters in pea [*Pisum sativum* L.]. *Plant Archives*. 6 (2): 737-740.
- Sureja, A. K. and Sharma, R. R. (2000). Genetic variability and heritability studies in garden pea (*Pisum sativum* L.). *Indian Journal of Horticulture*. 57 (3): 243-247.
- Tiwari, S. K.; Singh, H. L.; Kumar, R.; Nigam, H. K. and Singh, A. P. (2001). A postmortem of selection parameters in pea (*Pisum sativum* L.). *Research on Crops*. 2 (2): 237-242.
- Togay, N.; Togay, Y.; Yildirim, B. and Dogan, Y. (2008). Relationships between yield and some yield components in Pea (*Pisum sativum* ssp. *arvense* L.) genotypes by using correlation and path analysis. *African Journal of Biotechnology*. 7 (23): 4285-4287.
- Tyagi, M. K. and Srivastava, C. P. (2002). Genetic variability and correlations among yield and yield characters over two environments in pea. *Indian Journal of Agricultural Research*. 36 (1): 53-56.
- Usmani, M. G. and Dubey, R. K. (2007). Association and path coefficient analysis in field pea (*Pisum sativum* var. *arvense*). *Advances in Plant Sciences*. 20 (2): 603-607.
- Wright, S. (1921). Correlation and causation. *J. agric. Res.* 20: 557-587.
- Nisar, M.; Ghafoor, A.; Habib Ahmad; Khan, M. R.; Qureshi, A. S.; Haider Ali and Islam, M. (2008). Evaluation of genetic diversity of pea germplasm through phenotypic trait analysis. *Pakistan Journal of Botany*. 40 (5): 2081-2086.
- Sharma, Neerja; Jamwal, S. S. and Raju Gupta (2010). Performance of different varieties of peas (*Pisum sativum* var *hortense*) under intermediate zone of Jammu Region. *Environment and Ecology*. 28 (2A): 1183-1185.

ABSTRACT

Title of the thesis : **“Studies on genetic parameter, correlation and path coefficient analysis of yield and its components in garden pea (*Pisum sativum* L.)”**

Student Name (full) : **Geetha Ravi**

Address : S/O Shri R. Malleswara Rao
D No. 11-6-11, Gandhi Nagar – 2,
Narsapur,
Distt. – West Godavari (A.P.)
PIN-534 275

Advisor Name : **Dr. S.K. Sengupta**

Address (Office) : Senior Scientist
: Department of Horticulture,
Jawaharlal Nehru Krishi Vishwa Vidyalaya,
Jabalpur - 482 004 (M.P.)

Degree awarded : Master of Science In Horticulture (Vegetable Science)

Year of award of : 2013
degree

Major subject : Vegetable Science

Total number of :
pages in the thesis

Number of words in : 583
the abstract

Signature

(S. K. Sengupta)

Signature

(Professor and head)

(Seal)

Signature

(Geetha Ravi)

ABSTRACT

The present investigation “Studies on genetic parameters, correlation and path coefficient analysis of yield and its components in garden pea (*Pisum sativum* L.)” was carried out during rabi season of 2012-2013 at the Vegetable Research Farm, Department of Horticulture, College of Agriculture, J.N.K.V.V., Jabalpur (M.P.). The experimental material for the present investigation was comprised of 22 genotypes of garden pea. These genotypes were sown in Randomized Complete Block Design with three replications, to estimate the genetic variability and association analysis (Correlation and Path coefficient). The variance components and coefficient of variation were determined according to Burton (1952). The heritability (broad sense) and genetic advance was worked out by Hanson *et al.* (1956) and Johnson *et al.* (1955). Correlation coefficient and path coefficient was computed by the formula suggested by Miller *et al.* (1958) and Dewey and Lu (1959). On the basis of results, the present investigation is summarized as follows:

The estimates of mean sum of square due to genotypes were highly significant for all the characters except for number of primary branches per plant at 30 DAS, indicating the presence of genetic diversity in the existing material. The mean performance of the genotypes revealed a wide range of variability for all the traits. The variation was highest for pod yield per plant, followed by plant height at 60 and 90 DAS, number of pods per plant. The PCV was higher than the GCV for all the characters. High PCV and GCV was observed for number of primary branches per plant at 30 and 60 DAS, pod yield per plant indicating greater diversity for these traits and their further improvement through selection.

High heritability supplemented with high genetic advance as percentage of mean was manifested by pod yield per plant, number of pods per plant, days to first flowering, days to 50 per cent flowering, plant height at 90 DAS and pod length, suggested that they can be improved through direct selection.

Path coefficient analysis revealed that number of pods per plant, pod weight, pod length, fruiting span, number of leaves per plant at 90 DAS, days to first flowering, days to

first picking were the most important characters contributing towards pod yield per plant and hence purposeful and balanced selection based on these characters would be made rewarding for improvement of pea. Maximum protein content was recorded in the genotypes BE –06, Pusa Pragati. The low incidence of pod borer and powdery mildew was found in genotypes Arka Ajit and Akra Sampoorna. Considerable variability was observed among the genotypes for pod colour and pod shape.

VITA

The author of the thesis, Geetha Ravi daughter of Mr.R. Malleswararao and Mrs. Lilly Grace was born on 12th of June 1989 at Narsapur (A.P.). She passed her high school from SunShine School, Narsapur (A.P.) in the year 2004 with 75% and higher secondary examination in the year 2007 from biology stream with 76%.

The author joined the College of Horticulture, Andhra Pradesh Horticulture University, V.R.gudem in the year 2007-08 and completed her B.Sc. (Ag. Hort.) degree in the year 2011 with an OGPA of 7.62.

Subsequently after graduation she joined for M.Sc.(Ag.) Hort(Vegetable science) at College Of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur and completed courses with OGPA of 7.8. in the year 2013.