Variability in genotypes and relationship between seed quality, pod yield and seed yield parameters of vegetable pea (Pisum sativum L.)

Thesis

SUBMITTED TO THE

V.C.S.G. UTTARAKHAND UNIVERSITY OF HORTICULTURE AND FORESTRY, BHARSAR-246 123, UTTARAKHAND, INDIA

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When heart speaks in seclusion . . .

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

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Ranichauri Campus
August, 2015

(Abhishek Panwar)
Author
CERTIFICATE

This is to certify that the thesis entitled "Variability in genotypes and relationship between seed quality, pod yield and seed yield parameters of vegetable pea (Pisum sativum L.)" submitted in partial fulfilment of the requirements for the degree of Master of Science in Agriculture with major in Seed Science and Technology of the College of Post-Graduate Studies, V.C.S.G. Uttarakhand University of Horticulture and Forestry, Bharsar, is a record of bona fide research carried out by Mr. Abhishek Panwar, Id.No. UUHF/12144 under my supervision and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been acknowledged.

(A.C. Mishra)
Chairman
Advisory Committee
CERTIFICATE

We, the undersigned, members of the Advisory Committee of Mr. Abhishek Panwar, Id. No. 12144, a candidate for the degree of Master of Science in Agriculture with major in Seed Science and Technology agree that the thesis entitled “Variability in genotypes and relationship between seed quality, pod yield and seed yield parameters of vegetable pea (Pisum sativum L.)” may be submitted in partial fulfillment of requirements for the degree.

(A.C. Mishra)
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LIST OF SYMBOLS AND ABBREVIATIONS

% : Per cent
& : And
/ : Per
@ : at the rate of
°C : degree Celsius
CD : Critical difference
cv : Cultivar
DAS : Days After Sowing
DAT : Days After Transplanting
D² : Generalized distance
et al. : et alia
etc. : and so on
Fig. : Figure
ha : Hectare
i.e., : that is
ISI : Indian Standards Institution
IU : International Units
kg plant⁻¹ : Kilogram per plant
kg ha⁻¹ : Kilogram per hectare
kg m⁻² : Kilogram per metre square
m² : meter-square
m² : Per metre square
max. : Maximum
min : Minute
Min. : Minimum
mm : Millimetre
mg : Milligram
MT : Metric tonnes
nm : Nanometre
Plant\(^{-1}\) : Per plant
Pp : page number
q : quintal
q ha\(^{-1}\) : quintal per hectare
RBD : Randomised Block Design
S.Em ± : Standard error mean
SG : Soluble granules
t : Tonne
t acre\(^{-1}\) : Tonne per acre
t ha\(^{-1}\) : Tonne per hectare
var : Variety
Wt. : Weight
Pea (Pisum sativum L.) one of the most important annual legume crop of India, belongs to the family Leguminosae (Fabaceae). Cytologically, it has 2n = 2x = 14. There are two sub species, namely Pisum sativum var. arvense known as field pea, having colored flowers and Pisum sativum var. sativum, the white flowered garden pea, is largely confined to cooler temperate zone between the Tropic of Cancer and Mediterranean region. Being a cool season crop, it is most extensively grown in the temperate region throughout the world.

Pea require a cool, relatively humid climate and grown at higher altitude in tropics with temperature range from 7\(^{\circ}\) C to 30\(^{\circ}\) C (Duke, 1981; Davies et al., 1985) and production is concentrated between the Tropics of Cancer and 50 N (Davies et al. 1985). As winter annual, pea tolerates frost to -2\(^{\circ}\) C in the seedling stage, although top growth may be affected at -6\(^{\circ}\) C. Pea can withstand -10\(^{\circ}\) C, and snow cover protection, tolerance can be increased to -40\(^{\circ}\) C (Slinkard et al., 1994). As described in Slinkard et al. (1994), the optimum temperature levels for the vegetative and reproductive periods of pea were reported to 21 and 16\(^{\circ}\) C, 16 and 10\(^{\circ}\) C (day and night), respectively. Temperatures above 27\(^{\circ}\) C shorten the growing period and adversely affect pollination. A hot spell is more damaging to peas than alight frost. Pea can be grown successfully during mid summer and early fall in those areas having relatively low temperature and good rainfall or where irrigation is practiced. For very early crop, sandy loam is preferred, for higher yield where earliness is not a factor, a well drained clay loam or silt loam is preferred (Duke, 1981).

It is a self pollinated annual herb, bushy or climbing, glabrous, usually glaucous, stems weak, round, and slender, 30-150 cm long; leaves alternate, pinnate with 1-3 pairs of leaflets and a terminal branched tendril leaflets ovate or elliptic, 1.5-6 cm long (Duke, 1981). The leaf type could be conventional, semi-leafless or leafless (Davies et al., 1985). Leaf size in most cases increases up to the first node bearing the first flower. Stipules are large, leaf like and up to 10 cm long. The inflorescence of pea is a raceme arising from the leaf axils. Corolla white or pink or purple, pods swollen or compressed, short-stalked, straight or curved, 4-15 cm long, 1.5-2.5 cm wide, 2-10 seeded, 2-valved, dehiscent on both sutures (Gritton, 1980; Duke, 1981).
Pea is a rich source of dietary protein and also a valuable animal feed, being a leguminous crop it play a key role in improving and sustaining soil productivity on account of biological N$_2$ fixation and addition of huge amount of organic matter.

The edible green pod contains 7.2 percent protein, 15.9 percent carbohydrate and 0.1 percent fat in 100 g of fresh pod. It is also an excellent source of minerals such as potassium (170.0 mg), phosphorus (139.0 mg), calcium (20.0 mg), magnesium (6.0 mg) and iron (1.5 mg) per 100 g of green edible seed. The mature grain may be used as whole or prepared in various ways for human consumption. Pea has adequate amount of carotene (83 µg), vitamin C (9 mg), thiamine (0.25 mg) and riboflavin (0.01 mg) per 100 g of edible portion. Beside, pea contains all essential indispensable amino acids required in human foods (Choudhary, 2003).

Being a cool season crop, it is most extensively grown in the temperate regions throughout the world. In tropics and sub-tropics, its cultivation is restricted to higher altitude and winter season. In India, annual production of vegetables is 162.187 million metric tones from the area 9.205 million hectares. Pea contributes 4.006 million metric tones production from the area of 0.4082 million hectares in the country and productivity is 8.9 metric tones per hectare. In Uttarakhand, pea is grown on an area of 0.11 million hectares with an annual production of 0.078 million metric tones (Anon, 2014).

The physiological quality of seed lot is routinely evaluated by the standard germination test. However the seed does not show frequent performance when they are sown under field condition. So, the technologists have to work on the method which offers more reliable information about the physiological potential of seed lot. Consequently, a great interest has arisen in vigour test, which are used as an attempt to identify possible differences in physiological quality among seed lot that present a similar terminative potential. High quality seeds are an essential and desirable factor to ensure good crop establishment. The seed must be viable and posses physiological traits that allow rapid germination and seedling establishment.

Seed germination and vigour are main physiological quality attributes. Since the standard germination test has proved to be an important tool for measuring seed lot performance under adverse field conditions much effort have been given to develop a test or group of test that can determine seed vigour accurately.

High quality seed is essential and desirable to ensure good crop establishment. For many field crops, one of the main problems observed is poor crop stand establishment of
which is influenced by seed quality, adverse climatic condition, poor field management etc. (Maiti et al., 2002). At present a number of early maturing and high yielding varieties of pea have been recommended for plains, but the varieties for hilly regions are relatively few. In order to get high returns in terms of production and productivity, the selection of appropriate location specific cultivars is indispensible. This necessitates the evaluation and characterization of germplasm.

Seed germination and vigour are main physiological quality attributes. Since the standard germination test has proved to be an important tool for measuring seed lot performance under adverse field conditions, much effort have been given to develop a test or group of tests that can determine seed vigour accurately. Conventionally, the yield potential of a particular genotype is expressed based on the performance realized in the field conditions. Seed technology did not have explored the possibility to assess the yield potential of particular seed before growing in the field on the basis of seed and seedling vigour tests conducted in lab conditions.

Therefore, the present study has been conducted to derive information on superior genotypes based on their seed quality test by conducting field and laboratory experiments with following objectives:

1. To study the variability in seed vigour parameters of vegetable pea genotypes
2. To study the variability in plant growth, pod yield and seed yield parameters across the genotypes
3. To work out inter-relationship between seed vigour parameters, pod yield and seed yield in vegetable pea
Chapter-2

REVIEW OF LITERATURE

The relevant literature available on various aspects pertaining to the present study is briefly reviewed under following heads:

2.1 Variability in seed quality parameters

2.2 Variability in pod and seed yield parameters

2.3 Correlation between seed quality, pod yield and seed yield parameters in seed quality parameters

2.1 Variability in seed quality parameters

Dahiya et al. (1997) evaluated forty seven genotypes of chick pea and revealed that there was significant variation for all seed vigour parameters. Speed of germination was significantly and positively associated with standard germination percentage and seedling length.

Kevin (2005) studied seeds of 330 accessions from the core collection of pea germplasm which were germinated and grown under artificial conditions for 14 days and their root characters were analyzed. Data was also recorded on traits like taproot length, shoot length and root and shoot dry weight. Taproot length ranged from 181 to 433 mm, while root and shoot dry weight ranged from 6 to 57 mg and 13 to 104 mg, respectively. Total root length ranged from 54 to 399 cm, root surface area ranged from 9 to 75 cm$^2$ and root volume ranged from 0.11 to 1.12 cm$^3$. Seed weight was significantly correlated with all the traits whereas root dry weight was positively correlated with total root length, average root diameter, and root volume.

Soltani et al. (2005) conducted an experiment to determine the effect of seed size (Large, medium and small) and their interaction effect on germination and heterotrophic seedling growth of two chickpea (Cicer arietinum L.) cultivars.

Arivazhagen and Kadarmohideen (2006) found wide variability in seedling vigour of French bean and revealed that bold seeded types were superior which recorded higher initial and final germination percentage, root shoot length, vigour index, dry weight of seedling and better field emergence.
Schuab *et al.* (2007) studied on six soybean cultivars which were subjected to water stress and observations were recorded on seedling emergence in field, standard germination (first and final count), vigour and viability test, seedling length, seedling dry biomass and germination test with significant variation among the cultivars.

Grezesiak *et al.* (2008) studied on seed germination, final germination, seedling height, dry matter of root and reported that shoot were significantly affected when field bean, soybean and field pea were exposed to manintol stress.

Renugadevi *et al.* (2009) studied on cluster bean in which seeds were graded according to seed size and subjected to germination as per ISTA, for 10 days. Seed vigour was evaluated through seedling character viz., root length, shoot length, and dry matter production. The latter showed a positive association with seed size, germination and 100 seed weight.

Shukla *et al.* (2010) studied on genetic variability in seed quality in horsegram under mid hill condition and found that wide range of phenotypic variation in plant height, number of pods per plant, seed yield per hectare, first count, pod length, number of seeds per plant, pod length, 100 seed weight, seed yield per hectare, first count, standard germination, root, shoot as well as seedling length, fresh and dry weight of seedling, vigour index 1 and 2.

Khatun and Bhuiyan (2011) studied the seeds were stored in pots for five months before conducting the laboratory study. Significant variation was recorded in all the three varieties of chickpea for all the parameter studied except viogour.

Ogutu *et al.* (2012) studied the on seed quality parameters by the application of N fertilizer in common bean and found positively effect on the root length, shoot length, seedling length.

### 2.2 Variability in pod and seed yield parameters

Variability existing in any crop is a boon to plant breeder and is the basis of all the crop improvement programmes. The extent of improvement expected by selection in any population depends upon the genetic variability present in the population. Vavilov (1951) was probably the first to perceive the importance of a wide range of variability in the initial material to ensure better chances of producing genotypes with desirable traits.
Anju and Sharma (2000) studied on variability in 25 indigenous and exotic genotypes of pea. The highest variations were observed for green pod yield per plant, followed by pod per plant and 100 seed weight.

Chaudhari et al. (2000) studied the variability for twelve traits, i.e. days to 50 percent flowering, days to maturity, plant height, number of branches per plant, number of cluster per plant, number of pod per plant, pod length, number of grains per pod, 100 grain weight, grain protein content and grain yield per plant in sixty genotypes of ricebean. A wide range of variation among genotypes were observed for all traits except pod length, branches per plant, 100 grain weight and protein content..

Chakraborty and Mukherjee (2001) reported variability and patterns of association for yield and other yield attributing traits in fifty eight cultivars of ricebean. High heritability was observed for 100 grain weight grain yield per plant, while high heritability with low genetic advances was also observed for days to maturity and plant height.

Singh et al. (2001) studied the genetic variability in 100 genotypes of pea for nine characters viz., days to flowering, days to maturity, plant height, branches per plant, pods per plant, pod length, seeds per pod, 100 seed weight and seed yield per plant. The analysis of variance revealed significant difference among the genotypes for all the characters studied.

Manivannan (2002) analyzed the genetic variability in thirty three genotypes of green gram (Vigna radiata) derived from ten crosses. The analysis of variance revealed highly significant differences among thirty three genotypes for plant height, branches per plant, clusters per plant, pods per cluster, pods per plant, pod length, seeds per pod, 100 seed weight and seed yield per plant.

Ecran et al. (2005) reported that grain yield was significantly and positively correlated with plant height, pod number, seeds per pod and green pod yield. The highest direct effect was exhibited by pod yield, indirect effects, especially through the pod number of plants.

Ghafoor et al. (2006) studied thirty seven genotypes of pea for seed characters to determine the extent of genetic variation based on morphological charters. High genetic
variance was observed for plant height, days to maturing, number of pods per plant, pod length, seeds per pod, grain yield per plant and harvest index.

Rai et al. (2006) reported that genetic variability was maximum for yield per plant followed by number of pods per plant in vegetable pea and yield plant exhibited positive association with number of pods per plant (0.79), number of internodes (0.56) and plant height (0.54).

Singh and Singh (2006) studied genetic variability for seed yield per plant and related attributes. The maximum variability was observed for seed yield per plant followed by pod per plant, plant height, branches per plant and 100-seed weight. Seed yield per plant had significant and positive association with pods per plant, plant height, harvest index and grains per pod.

Singh et al. (2008) revealed positive and highly significant association of the traits viz., days to flowering and days to maturity, pod length and seeds per pod, pods per plant, seed yield per plant and 100 seed weight with pod length and seed yield per plant in vegetable pea.

Shukla et al. (2009) studied on correlation analysis of seed yield and vigour parameter of vegetable pea under moisture stress condition and found that wide range range of phenotypic variation was noticed for plant height, number of pods per plant, seed yield per hectare, first count, pod length, number of seeds per plant, pod length, 100 seed weight.

Devi et al. (2010) observed that days to first flower showed the highest positive and significant correlation with seed yield, length of internodes, days to first green pod harvest, number of primary branches, length of pods, number of seeds per pod, number of pods per plant, pod yield per plant in vegetable pea.

Shukla et al. (2010) recorded seventeen field and laboratory parameters on five genetically selected plants in each replication. The highest mean value was recorded for plant height in genotype PRH 03 followed by PRH 06, pod length in PRH 06, numbers of seeds/pods in PRG 7 followed by PRH 10 and VL Gahat 1, pod /plant, seed yield/plant and seed yield/hectare in VL Gahat 1 followed by PRH 10. The mean performance of seed quality parameters were highest for seedling length, seedling fresh weight in genotype PRG 04 followed by PRH 03, PRH 01. Seed yield was associated with pod length, plant height, and number of pods per plant and seed yield / plant.
Ghobary (2010) evaluated fifteen genotypes of pea for pod length, numbers of seeds per pod, 100 seed weight and seed yield per plant. At the end of study, data revealed significant differences for all studied traits. Positive and significant relationships were found among seed yield per plant and numbers of pods per plant.

Singh et al. (2011) studied correlation coefficient between different traits of vegetable pea and found that number of pods per plant, 100 seed weight and number of clusters per plant were the major characters contributing to grain yield as these traits were positively and significantly correlated with grain yield per plant.

Pal and Singh. (2013) conducted a trail on variability in garden pea and results indicated highly significant difference among the genotypes for all the characters indicating the presence of wide range of variability in the genotypes.

Pallavi et al. (2013) conducted a trail for variability studies in garden pea. Under the study 10 quantitative characters were taken for variability studies, viz., days to 50 % flowering, number of seeds per pod, 100 seed weight (g), and yield per hectare and pod weight (g).

2.3 Correlation between seed quality, pod yield and seed yield parameters in seed quality parameters

The study of correlation between different characters is more important for a plant breeder in improving the efficiency of selection. Characters of economic importance like yield are complex in inheritance and are product of action and interaction among several traits. Galton (1889) developed the basic concept of correlation and this was later elaborated and discussed by Fisher (1918, 1936) and Wright (1921) for plant breeding programmers.

Kumaran et al. (1995) recorded positive correlations among length of pod, pods per plant and pod yield per plant in pea.

Pratap et al. (1995) was of opinion that pod yield in pea was positively correlated with pod length (0.548), number of seeds per pod (0.388) and pod breadth (0.388). However, pod length exhibited negative correlation with plant height (-0.355).

Dobhal (1996) also reported that number of pods per plant and seeds per pod were the main characters influencing the green pod yield per plant in pea.
Rai et al. (2006) reported that yield per plant exhibited positive association with days to 50% flowering, number of pods per plant (0.79) and plant height (0.54).

Singh et al. (2007) revealed that pods per plant, clusters per plant, seeds per pod and days to 50% flowering were significantly correlated with grain yield in 120 genotypes of pea.

Kumari et al. (2008) reported that pod yield per plant was positively and significantly correlated with number of pods per plant, 100 seed weight and seed vigour.

Sharma et al. (2009) studied correlation in vegetable pea and reported that green pod yield was positively and significantly correlated with grains per pod and pods per plant.

Devi et al. (2010) observed that days to first flower showed the highest positive and significant correlation with seed yield, length of internodes, days to first green pod harvest, number of primary branches, length of pods, breadth of pods, number of seeds per pod, number of pods per plant and pod yield per plant in vegetable pea.

Ram et al. (2010) studied correlation (*Pisum sativum var hortense*) with 20 diverse genotypes of garden pea. The correlation provides information about inter relationship among yield and its components. The information on character association may be used in the prediction of correlated response to directional selection, construction of selection indices and identification of some characters which may have no value by themselves but are useful as indicators of the more important ones under consideration. Correlations furnish information regarding the nature and magnitude of various associates and help in measurement of direct effect of one variable on other. It is most important to know the direct and indirect effect on yield component for selecting suitable genotypes for improving the yield.

Singh et al. (2011) studied correlation between different traits of vegetable pea and found that number of pods per plant and 100 seed weight were the major characters contributing to grain yield as these traits were positively and significantly correlated with grain yield per plant.
Chapter-3

MATERIALS AND METHODS

The present investigation entitled “Variability in genotypes and relationship between seed quality, pod yield and seed yield parameters of vegetable pea (*Pisum sativum* L.)” was carried out during the *Rabi* season of 2014-15 at Vegetable Research Block of Department of Vegetable Science, Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and Forestry, Ranichauri Campus, Tehri Garhwal, Uttarakhand.

The details of experimental materials used and procedures followed during the course of investigation have been described below:

3.1 Experimental Conditions

3.1.1 Location

Geographically, the Vegetable Research Block of Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and Forestry, Ranichauri Campus is located on north facing between 30° 18' N latitude and 78° 24' E longitude at an elevation of 2000-2200 m above mean sea level. It falls in mid hill zone, located at New Delhi-Gangotri National Highway NH 94 and 10 km away from Chamba town of Tehri district.

3.1.2 Meteorological situations

Ranichauri campus experiences humid and temperate type of climate with chilled winters. The mean monthly maximum and minimum temperature during pea crop period (Dec to May) varies between 27.2 to 17.4°C and 17.6°C to 6.5°C, respectively. The average annual rainfall of 1367 mm was experienced during 20 years. Major portion of the total annual rainfall (about 61 %) occurs during monsoon (June-September). Winter rains and snowfall occur during December-February and Hail Storms are frequent from Mid-April to May. Winter is very severe, light to heavy snowfall is a regular feature of this area and summer is mild. The meteorological data for the period of experimentation have been given in Appendix-I.

3.2 Experimental Materials

The experimental material for the present investigation comprised of 16 genotypes obtained from various Agricultural Universities and Institutes of the country. The names and sources of genotypes tested in this experiment are presented in Table 3.1.
Table 3.1 List of pea (*Pisum sativum* L.) genotypes and their sources

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Genotypes</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>PSM-3</td>
<td>GBPUAT, Pantnagar</td>
</tr>
<tr>
<td>2.</td>
<td>PM-2</td>
<td>GBPAUT, Pantnagar</td>
</tr>
<tr>
<td>3.</td>
<td>Pea-1001</td>
<td>VCSG UUHF, Ranichauri Campus</td>
</tr>
<tr>
<td>4.</td>
<td>AP-2</td>
<td>CSAUAT, Kanpur</td>
</tr>
<tr>
<td>5.</td>
<td>PSM-4</td>
<td>GBPUAT, Pantnagar</td>
</tr>
<tr>
<td>6.</td>
<td>JM-1</td>
<td>JNKVV, Jabalpur</td>
</tr>
<tr>
<td>7.</td>
<td>AP-3</td>
<td>CSAUAT, Kanpur</td>
</tr>
<tr>
<td>8.</td>
<td>Pea-901</td>
<td>VCSG UUHF, Ranichauri Campus</td>
</tr>
<tr>
<td>9.</td>
<td>PC-531</td>
<td>IIVR, Varanasi</td>
</tr>
<tr>
<td>10.</td>
<td>Pea-801</td>
<td>VCSG UUHF, Ranichauri Campus</td>
</tr>
<tr>
<td>11.</td>
<td>Arkel</td>
<td>IARI, New Delhi</td>
</tr>
<tr>
<td>12.</td>
<td>VRP-7</td>
<td>IIVR, Varanasi</td>
</tr>
<tr>
<td>13.</td>
<td>V L -7</td>
<td>VPKAS, Almora</td>
</tr>
<tr>
<td>14.</td>
<td>CHP-2</td>
<td>IIVR, Varanasi</td>
</tr>
<tr>
<td>15.</td>
<td>Pea-902</td>
<td>VCSG UUHF Ranichauri Campus</td>
</tr>
<tr>
<td>16.</td>
<td>P-89</td>
<td>PAU, Ludhunia</td>
</tr>
</tbody>
</table>
3.3 Experimental designs and observations recorded

3.3.1 Laboratory Experiments

The random samples of seeds of all sixteen genotypes as mentioned in Table 3.1 were collected and experiment were conducted in complete randomized design (CRD) with three replications. A sample size of 100 seeds was taken in each replication. The data were recorded on following parameters:

3.3.1.1 100 Seed weight (g)

To record the test weight of 16 genotypes, a random sample of 100 seeds was taken from the seeds lot of each genotype and weighing was done with the help of electronic balance for each seed lot. Such observations were recorded in all 3 replications.

3.3.1.2 First Count (%)

The number of normal seedlings was counted at the 5th day after sowing and percentage was calculated.

3.3.1.3 Standard germination (%)

Hundred seeds were placed from samples of each lot on wet paper rolled towels (AOSA, 1993) 25°C ± 1°C with the addition of water of 25 times of paper weight and placed at 20°C. The interpretation of normal seedlings was performed 5 and 8 days after planting according to the seedling classification book (AOSA, 1992). The results were expressed as percentage normal seedlings for each seed lot.

\[
\text{Germination} \, (\%) = \frac{\text{Normal seedlings}}{\text{Total no. of seeds}} \times 100
\]

3.3.1.4 Root length (cm)

The root length was measured with the help of a measuring scale for ten randomly selected seedlings on final count in each replication.

3.3.1.5 Shoot length (cm)

The shoot length was calculated with the help of measuring scale for ten randomly selected seedlings at final count in each replication.

3.3.1.6 Seedling length (cm)

The seedling length was measured with the help of measuring scale on ten randomly selected seedlings at final count in each replication.
3.3.1.7 Seedling fresh weight (g)

Seedling fresh weight was assessed after the final count in the standard germination (8th day). Ten normal seedlings were randomly taken from each replication of each genotype. The fresh seedlings were weighed and the average seedling fresh weight was calculated.

3.3.1.8 Seedling dry weight (g)

Seedling dry weight was recorded after final count in standard germination test (8th day). All the ten normal seedlings taken for fresh weight were cut free from their cotyledons and dried over for 72 hours at 70± 2°C temperature. The dried seedlings were weighed and average seedling dry weight was calculated (AOSA, 1983).

3.3.1.9 Seedling vigour index- I & II

The seedling vigour index- I & II were calculated by the method suggested by Abdul-baki and Anderson, 1973.

\[
\text{Vigour index-I} = \text{Standard germination (%) × Seedling length (cm)}
\]

\[
\text{Vigour index-II} = \text{Standard germination (%) × Seedling dry weight (g)}
\]

3.3.2 Field Experiment

Sixteen genotypes of vegetable pea were grown in Randomized Block Design (RBD) during Rabi season of 2014-15. The sowing was done on December 13, 2014. All recommended agronomic practices were followed during experimentation. The details of experimental layout are given below:

Table 3.2: Details of the experiment conducted in field on vegetable pea (\textit{Pisum sativum} L.) genotypes

<table>
<thead>
<tr>
<th>Location</th>
<th>Vegetable Research Block, VCSG UUHF, Ranichauri Campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop</td>
<td>Pea (\textit{Pisum sativum} L.)</td>
</tr>
<tr>
<td>Statistical design</td>
<td>Randomized Block Design (R.B.D)</td>
</tr>
<tr>
<td>Date of sowing</td>
<td>13 December, 2014</td>
</tr>
<tr>
<td>Number of genotypes</td>
<td>16</td>
</tr>
<tr>
<td>Number of replications</td>
<td>03</td>
</tr>
</tbody>
</table>
The field was prepared by ploughing with power tiller twice upto a depth of 20 cm. Thereafter leveling was done. The crop was fertilized with application of NPK @ 30:60:45 kg/ha. All fertilizers viz., DAP and muriate of potash were applied as basal dose before sowing to supplement major position of NPK whole remaining whereas nitrogen (N) was applied in from of urea in standing crop during weeding and hoeing.

**Seed sowing**

The seeds were sown on Dec 13, 2014 at an about 3-4 cm depth by opening furrows with *kutla*. Each furrow was manually dribbled with seed and covered with soil immediately. The recommended row to row distance of 30 cm was maintained during crop sowing.

**3.8 Crop management**

The crop was raised under rainfed condition. The distribution of rainfall was fairly good enough during the crop season. To maintain a recommended plant to plant distance of 10 cm, the lines were thinned at the time of weeding – cum – hoeing.

**Observations recorded**

**3.3.2.1 Days to 50% flowering (DAS)**

The date of appearance of first flowers in 50% plants in each genotype was recorded. The days taken from transplanting to first flower appearance were counted.

**3.3.2.2 Plant height at 50% flowering (cm)**

Plant heights of ten tagged plants were measured at the time of flowering of almost 50% plants in each genotype summed and divided by ten to get average plant height.

<table>
<thead>
<tr>
<th>Spacing</th>
<th>30x10 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of rows /genotype</td>
<td>05</td>
</tr>
<tr>
<td>No. of plants per row</td>
<td>10</td>
</tr>
<tr>
<td>Net plot area</td>
<td>1.5 m x 1.8 (2.7 m²)</td>
</tr>
<tr>
<td>Net experimental area</td>
<td>129.6 m²</td>
</tr>
<tr>
<td>Gross experimental area</td>
<td>142 m²</td>
</tr>
</tbody>
</table>
3.3.2.3 Number of pods per plant

Total number of green pods from ten tagged plants was counted over all pickings and average green pods per plant were worked out.

3.3.2.4 Pod length (cm)

Length of ten randomly selected pods was measured in centimeter from the point of attachment to the tip of pod.

3.3.2.5 Pod diameter (mm)

Pod width was measured in the middle of the pods and was averaged for five random selected pods.

3.3.2.6 Number of seeds per pod

Number of seeds of ten randomly selected pods were counted and averaged to get number of seeds per pod.

3.3.2.7 10 pod weight (g)

Ten pods were randomly picked up from each plot and weighed to get 10 pod weight.

3.3.2.8 Seed yield per plant (g)

The total seed yield obtained from ten tagged plants in each genotype was divided by five to get seed yield per plant.

3.3.2.9 Pod yield per plant (g)

The total weight of green pods in each picking of the ten tagged plants was recorded and the mean yield per plant was worked out as average of these plants in grams.

4.1 Statistical Analysis

The replicated values of each genotype obtained in laboratory observation were subjected to statistical analysis as per CRD whereas the data on various characters of field experiment were analyzed as per RBD (Panse and Sukhatme, 1967).
I. Analysis of variance (ANOVA) for seed quality parameters (Laboratory experiments)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D.F.</th>
<th>S.S</th>
<th>M.S.</th>
<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treats</td>
<td>k-1</td>
<td>SST</td>
<td>SST(K-1) = MST</td>
<td>MST/MSE=F</td>
</tr>
<tr>
<td>Error</td>
<td>n-k</td>
<td>SSE</td>
<td>SSE(n-k) = MSE</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>n-1</td>
<td>SSY</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Correlation factor  = $G^2/n$

Total S.S. = $\sum \sum Y_{ij}^2$ = SSY

Treat S.S. = $1/r_1 \sum Y_i^2 - G^2/n = SST$

Error S.S. = SSY - SST = SSE
II. Analysis of variance (ANOVA) for field experiment

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degree of freedom</th>
<th>Sum of square</th>
<th>Mean sum of square</th>
<th>Variance ratio (F value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication (r)</td>
<td>r – 1</td>
<td>S r</td>
<td>S r = Mr</td>
<td>Mr</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r-1 = Me</td>
<td></td>
</tr>
<tr>
<td>Treatment (t)</td>
<td>t-1</td>
<td>St</td>
<td>St = Mt</td>
<td>Mt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>t-1 = Me</td>
<td></td>
</tr>
<tr>
<td>Error (e)</td>
<td>(r-1) (t-1)</td>
<td>Se</td>
<td>Se = Me</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(r-1) (t-1)</td>
<td></td>
</tr>
</tbody>
</table>

The calculated 'F' values were compared with tabulated 'F' value for test of significance. Standard Error (SE) Critical Difference (CD) and Coefficient of Variance (CV) were calculated to find out the superiority of one genotype over the others with the help of following formulae.

\[
\text{SE (m)} = \sqrt{\frac{Me}{r}} \\
\text{SE (d)} = \sqrt{\frac{2 \cdot Me}{r}} \\
\text{CD}_{(0.05)} = \text{SE (d)} \times \text{table value of } t_{(0.05)} \text{ at error degree of freedom.} \\
\text{Coefficient variability (\%)} = \sqrt{\frac{Me}{X}} \times 100
\]
Where

SE (m) ± = Standard error of mean

SE (d) ± = Standard error of difference

CD \(_{0.05}\) = Critical difference at 5% level of significance.

X = Mean

4.2 Correlation coefficient:

It was developed by Pearson (1956). In order to determine how strong the relationship is between two variables, a formula must be followed to produce what is referred to as the coefficient value. The coefficient value can range between -1.00 and 1.00. If the coefficient value is in the negative range, it means the relationship between the variables is negative or as one value increases, the other decreases. The value in the positive range, indicated that means the relationship between the variables is positive or both values increase or decrease together. The extent of relation among characters is measured by correlation coefficients \( r \). Correlation coefficient between two characters X and Y can be worked out as follows;

\[
 r = \frac{N \sum xy - [\sum x][\sum y]}{\sqrt{[N \sum x^2 -(\sum x)^2][N \sum y^2 - (\sum y)^2]}}
\]

Where:

\( N \) = number of pairs of scores

\( \sum xy \) = sum of the products of paired scores

\( \sum x \) = sum of x scores

\( \sum y \) = sum of y scores

\( \sum x^2 \) = sum of squared x scores

\( \sum y^2 \) = sum of squared y scores
Chapter 4

RESULTS AND DISCUSSION

The present investigation entitled “Variability in genotypes and relationship between seed quality, pod yield and seed yield parameters of vegetable pea (Pisum sativum L.)” was carried out during the Rabi season of 2014-15 at Vegetable Research Block of Department of Vegetable Science, Veer Chandra Singh Garhwali Uttarakhand University of Horticature and Forestry, Ranichauri Campus, Tehri Garhwal, Uttarakhand. The results obtained for various seed quality, plant growth, pod yield and seed yield parameters are being presented under the following sub heads:

4.1 Variability in seed quality parameters
4.2 Variability in pod and seed yield parameters
4.3 Correlation between seed quality, pod yield and seed yield parameters in seed quality parameters

4.1 Variability in seed quality parameters

4.1.1 100 seed weight (g)

The analyzed data on 100 seed weight presented in Table 4.1 and Fig.1 indicated that there was significant difference between genotypes for this trait. It ranged from 16.30 g to 26.03 g with maximum in VL-7 (26.03 g) followed by VRP-7 (25.03 g) with statistically at par values. The minimum 100 seed weight was recorded in AP-2 (16.30 g). The mean value of population was 21.40 g. The characters like 100 seed weight are related to seed boldness primarily related to seed vigour in vegetable pea. The bold and bulky seeded genotypes might be presumed to have better potentiality of germination and further growth and development. There are meagre works reported on seed weight of vegetable pea. However, Singh and Singh (2006); Kumar (2007) and Shukla et al (2010) have reported a wide range of variability in 100 seed weight across the genotypes of pea. Similarly, Shukla et al (2009) have also realized significant variability in 100 seed weight of horse gram genotypes ranging from 2.65 g in PRH 04 to 3.33 g in PRH 09.

4.1.2 First Count (%)

The first count is percentage of germination of seeds after 5 days of sowing. The different genotypes exhibited significant variation in first count which ranged from 60.0% to 73.66%. Maximum value of first count was observed in Pea-1001 (73.66%) followed by
statistically at par values in Arkel, PSM-3 (70.0%), PM-2 (69.66%) and AP-2 (69.33%). The minimum first count was found in VL-7 (60.0%). The mean value of the population was 68.13% (Table 4.1 and Fig. 2).

First count is an indicator of earliness in germination of the genotypes. Early germinating genotypes may likely to produce early yield in vegetable pea which is an concern of pea growers in hilly areas. Variability in first count has also been reported by Kumar (2007) from 16.67% to 70.0%; Pant (2008) from 5.33% to 16.66%; and Prasad (2009) from 0.0% to 54.04% across the genotypes in vegetable pea.

4.1.3 Standard germination (%)

The standard germination as assessed in lab conditions represents overall viability of seeds. There was significant difference among the genotypes for standard germination. However, the range of maximum to minimum standard germination across the genotypes was narrow (82.33% to 92.33%). Maximum value for this trait was observed in Pea-1001 (92.33%) followed by statistically at par values in P-89 (90.66%), Pea-801 (90.33%), PSM-4 (90.33%), Pea-901 (90.0%), PC-531 (88.33%), PSM-3 (88.33%), Arkel (88.00%) and PM-2 (88.00%). The minimum standard germination was found in JM-1 (82.33%). The Population mean was 87.5% (Table 4.1 and Fig. 2).

Comparable range of standard germination have also been observed by Kumar (2007) from 61.67% to 99.33%; Pant (2008) from 76.66% to 99.00% and Prasad (2009) from 71.06% to 92.80% in vegetable pea.

4.1.4 Root length (cm)

Root length of seedlings implies genetic potentiality of seedling to establish itself in resource (soil moisture) rich delphic atmosphere. Higher seedling root length, there will be more ability of seedlings (further plants) to survive in moisture stress conditions. The analyzed data on root length indicated significant difference among pea genotypes for root ranging from 7.75 cm to 14.85 cm. Maximum value was registered in VRP-7 (14.85 cm) followed by Pea-801 (14.48 cm) which were statistically at par. Some other genotypes with higher root length were Pea-902 (12.66 cm), Pea-1001 (12.20 cm), VL-7 (12.07 cm), PSM-4 (11.48 cm) and P-89 (11.15 cm). The minimum root length was found in PSM-3 (7.75 cm). The population mean was 10.85 cm (Table 4.1 and Fig. 3).

Although, root length is a character not directly related to pod yield but it has importance in stress tolerance. The genotypes with higher root length can better withstand water stress conditions in rainfed hills. In this way, root length has indirect effect on plant
growth and pod yield of garden pea. Variability in root length of garden pea genotypes corresponding to present investigation has also been realized by Kumar (2007) from 11.0 cm to 26.33 cm; Pant (2008) from 11.1 cm to 19.46 cm and Prasad (2009) from 6.94 cm to 18.34 cm in vegetable pea.

4.1.5 Shoot length (cm)

The genotypes exhibited wide range of variability for shoot length ranging from 2.56 cm to 7.96 cm. Significantly higher value of shoot length was recorded in Pea-801 (7.96 cm) followed by Pea-902 (6.98 cm), AP-2 (5.77 cm) and AP-3 (5.37 cm). The minimum root length was found in PM-2 (2.56 cm). The mean value of the population was 4.76 cm (Table 4.1 and Fig. 3).

Shoot length is an indicator of genotypes to have ability of earliness in germination. More shoot length implies earliness of the genotype in respect of germination and probably also of flowering and fruiting. Variability in shoot length of garden pea genotypes has also been reported by Kumar (2007) from 8.0 cm to 19.00 cm; Pant (2008) from 5.66 cm to 9.26 cm and Prasad (2009) from 4.20 cm to 5.60 cm.

4.1.6 Seedling length (cm)

The overall seedling length is function of root and shoots length. It indicates growth rate and growth habit of the genotypes. The analyzed data for seedling length indicated that there was significant difference among the genotypes for this trait ranging from 10.56 cm to 22.43 cm. Significantly higher value of seedling length was noted in Pea-801 (22.43 cm). The other genotypes with comparatively higher seedling length were Pea-902 (19.65 cm) and VRP-7 (19.30 cm) whereas, minimum value was observed in PM-2 (10.56 cm). The general mean of the population was 15.50 cm in (Table 4.1 and Fig.4).

Increasing trend of seedling length in the genotypes was accompanied with good germination capacity of the seeds. Variable results on variability in the seedling length of pea genotypes have also been reported by Kumar (2007) from 23.33 cm to 42.00 cm; Pant (2008) from 18.23 cm to 28.96 cm and Prasad (2009) from 11.15 cm to 15.58 cm.

4.1.7 Seedling fresh weight (g)

The analyzed data on seedling fresh weight as given in Table 4.1 and Fig.4 indicated that all sixteen genotypes included in present investigation had significant variation for this trait. It ranged from 2.36 g to 4.07 g. Maximum value was noted in Pea-
1001 (4.07 g) followed by Pea-801 (3.83 g) which were statistically at par. The other genotypes with higher values of seedling fresh weight were Arkel (3.63 g), PSM-4 (3.57 g), Pea-901 (3.51 g), Pea-902 (3.50 g) and PC531 (3.43 g). The minimum seedling fresh weight was found in JM-1 (2.36 g). The population mean was 3.21 g. Comparable variability in seedling fresh weight of garden pea genotypes have also been reported by Kumar (2007) 4.34 g to 8.51 g; Pant (2008) from 2.86 g to 4.90 g and Prasad (2009) from 3.65 g to 5.11 g.

4.1.8 Seedling dry weight (g)

Seedling dry weight is a measure of total accumulation of dry matter in the seedlings. Since, the dry matter is estimated in laboratory condition at very initial stage of life cycle when photosynthetic system has not been activated. Therefore the level of dry matter content in seedlings at this stage is directly related to food reserves of the seeds. The analyzed data on seedling dry weight as depicted in Table 4.1 and Fig.1 indicate a wide range of variability from 0.52 g to 0.94 g. Maximum value of this parameter was recorded in Pea-1001 (0.94 g) followed by statistically at par values in PSM-4 (0.92 g) and PC-531 (0.87 g). The second group of genotypes with higher seedling dry weight was P-89 (0.86 g), Pea-901 (0.84 g), Pea-801 (0.82 g) and VL-7 (0.79 g). The minimum seedling dry weight was found in PM-2 (0.52 g). The population mean was 0.73 g. A wide range of variability in seedling dry weight of pea genotypes have also been reported by Kumar (2007) from 0.42 g to 1.13 g; Pant (2008) from 0.45 g to 0.95 g and Prasad (2009) from 0.72 g to 1.06 g.

4.1.9 Vigour index-I

Seedling vigour index–I is related to the size factor of seedlings. More is the seedling length, higher will be the vigour index-I. All the sixteen genotypes included in this experiment, exhibited significant variation in vigour index-I ranging from 928.50 to 2027.08 (Table 4.1 and Fig.5). Maximum and significantly higher vigour index-I was worked out in Pea-801 (2027.08). The minimum vigour index-I was found in PM-2 (928.50). The mean value of the population was 1358.20. A comparable range seedling vigour index-I has also been reported by Pant (2008) from 1446 to 2809 and Prasad (2009) from 754.21 to 1143.41. However, Kumar (2007) reported quite high range of variability in vigour index-I from 143.0 to 4142.67 across the garden pea genotypes.
4.1.10 Vigour index-II

The seedling vigour index-II is a parameter related to weight factor of the seedlings. There was significant variation in seedling vigour index-II across the sixteen genotypes ranging from 45.46 to 87.09. Maximum vigour index-II was recorded in Pea-1001 (87.09) followed by statistically at par values in PSM-4 (83.08) and P-89 (78.43). The minimum vigour index-II was found in AP-2 (45.46). The mean value of the population was 63.90 (Table 4.1 and Fig.5). Significant variability in seedling vigour index-II in garden pea genotypes has also been reported by Kumar (2007) from 31.48 to 113.99; Pant (2008) from 36.96 to 101.30 and Prasad (2009) from 52.99 to 85.50.

The above results indicated that sixteen genotypes included in present investigation varied significantly for all the seed and seedling viability and vigour parameters studied. The genotype Pea-1001 registered maximum value for first count (73.66%), standard germination (92.33%), seedling fresh weight (4.07 g), seedling dry weight (0.92 g) and vigour index-II (87.09) whereas, Pea-801 emerged promising for shoot length (7.96 cm), seedling length (22.43 cm) and vigour index-I (2027.08). Maximum value for 100 seed weight was noted in VL-7 (26.03 g) whereas; VRP-7 had highest root length (14.85 cm).

4.2 Variability in pod and seed yield parameters

4.2.1 Days to 50 % flowering (DAS)

The data taken on days to 50% flowering as presented in Table 4.2 and Fig.6 indicated a wide range of variability among the sixteen genotypes included in this investigation from 35.00 DAS to 68.0 DAS. Minimum number of days to 50 % flowering was found in Arkel (35.00 DAS) which was significantly low as compared to any other genotype. Some other genotypes with lower number of days to 50% flowering were VRP-7 (40.00 DAS), PSM- 4 (44.00 DAS) and PM-2 (45.00 DAS). The maximum number of days to flowering was recorded in Pea-901 (68 DAS). The mean value in population is (51.90 DAS). It indicated that all the sixteen genotypes included in this investigation were belonging to early, late early and early mid season groups. Variability in days to flowering is important for selecting population for early, mid and late yielding types. The ultimate remuneration by cultivation of vegetable pea depends on the maturity period of genotype grown in hilly areas. Corresponding to the findings of present investigation, a range of variability in days to 50% flowering among garden pea crosses has also been reported by Sharma and Bora (2013) from 29.33 to 34.46 days and Rai et al. (2006) from 33 to 42
days. Similarly, Siddika et al. (2013) have also reported a range of variability for this character in field pea genotypes from 29 days in IPSA-1 to 59 days in L-160. Significant difference for days to flowering among the genotypes of pea has also been noted by Devi et al. (2010) and Kumar et al. (2013).

4.2.2 Plant height at 50% flowering (cm)

The garden pea can be categorized as dwarf, semi dwarf and climbing types. The plant height at 50 % flowering gives information on earliness and growth behavior of the genotypes. The analyzed data presented in Table 4.2 and Fig. 6 indicated that plant height at 50 % flowering ranged from 42.00 cm to 67.33 cm. The maximum plant height was observed in AP-3 (67.33 cm) followed by statically at par values in CHP-2 (66.66 cm), PSM-3 (63.00 cm) and JM-1 (62.66 cm). The minimum plant height at 50% flowering was reported in Pea-801, Pea-901 (42.00 cm). The mean value of the population was 54.31 cm.

The plant height at 50% flowering is important character for selecting the genotypes suitable for cultivation with support (stacking) or without it. More plant height representing pole type of growth nature of the plants may ultimately affect the pod yield. Corresponding to these findings, variability in plant height of pea has also been reported by Singh et al. (2008) from 21.00 cm in KPMR 526 to 152.00 cm in JPBB 3 and Siddika et al. (2013) from 48.49 cm in L-105 (brown seed) to 90.95 cm in L-72.

4.2.3 Number of pods per plant

The analyzed data on number of pods per plant presented in Table 4.2 and Fig.7 revealed that the number of pods per plant of the genotypes under study ranged from 3.33 to 9.67. The highest number of pods per plant was recorded in P-89 (9.67) followed by statically at par values in Pea-1001 (8.80) and Arkel (8.77). The other genotypes with comparatively higher number of pods per plant were Pea-801 (8.60), VRP-7 (8.54) and PC-531 (8.33). The lowest number of pods per plant was recorded in AP-2 (3.33) whereas the population mean for this trait was 6.94. Higher the number of pods per plant in P-89, Pea-1001 and Arkel could be utilized for enhancing the yield. These results were comparable with those obtained by earlier workers in pea viz., Pal et al. (2013) who reported maximum number of pods per plant in VRP-190 (47.00); Siddika et al. (2013) from 9.2 in L-141 to 4.17 in IPSA-2 and Singh et al. (2008) from 6.04 in Pant P14 to 12.75 in JPBB 3.
4.2.4 Pod length (cm)

The analyzed data presented in Table 4.2 and Fig.7 indicated a wide range of variability in pod length across the genotypes with significant difference. It ranged from 7.32 cm to 10.89 cm. The maximum pod length was observed in P-89 (10.89 cm) followed by Pea-902 (10.03 cm) which were statically at par. The genotypes viz., Pea-1001 (9.93 cm), Pea-801 (9.92 cm), PC-531 (8.93 cm), Pea-901 (8.75 cm) and VRP-7 (8.20 cm) were also promising for pod length where as minimum pod length was found in VL-7 (7.32 cm). The mean value of the population was 8.47 cm.

Pod length is related to the space for accommodating seeds in each pod which could affect the shelling percentage and seed yield both. Yadav et al. (2010) reported variability in pod length from 4.21 cm to 7.07 cm which were comparable to the results of present investigation. Sharma and Bora (2013) observed average pod length of 8.83 cm in pea.

4.2.5 Pod diameter (mm)

The pod diameter ranged from 10.00 mm to 13.26 mm. Significantly higher value of pod diameter was observed in CHP-2 (13.26 mm) followed by JM-1 (12.80 mm), AP-3 (12.73 mm), PM-2 (11.86 mm), Pea-902 (11.76 mm), VRP-7 (11.29 mm), PSM-4 (12.14 mm) Arkel (11.69 mm), Pea-901 (11.68 mm), PC-531 (11.22 mm) and the minimum pod diameter was observed in Pea-1001 (10.06 mm). The general mean of the population was 11.47 mm (Table 4.2 and Fig.8).

As the pod diameter increases with the size of the seed, it ultimately affects the pod and seed yield. The variability in pod diameter has also been reported by Froussios (1970) comparable with the results of present investigation Singh and Singh (1972) has also found a range of pod diameter from 8.26 mm to 11.63 mm in pea.

4.2.6 Number of seeds per pod

The analyzed data on number of seeds per pod as depicted in Table 4.2 and Fig.8 indicated a range from 5.10 to 8.33. Significantly higher value for number of seeds per pod was found in AP-3 (8.33) followed by P-89 (7.44) and Pea-901 (7.20). The minimum number of seeds per pod was found in VL-7 (5.10). The mean value of the population was 6.39. The genotype with higher number seeds per pod may have direct relation with seed yield so the selection should be based on this character for improvement of seed yield in vegetable pea. Variability in number of seeds per plant has also been reported by Devi et
al. (2010) who observed 5.71 seeds per pod and Rai et al. (2006) from 4.5 to 8.9 seed per pod in vegetable pea.

4.2.7 10 pod weight (g)

The analyzed data on 10 pod weight as presented in Table 4.2 and Fig.9 indicated a wide range of variability across the genotypes. It ranged from 41.37 g to 64.54 g with maximum value in PM-2 (64.54 g). The genotypes PSM-3 (58.62 g), P-89 (58.48 g) and Pea-902 (58.27 g) which were also promising for 10 pod weight. The minimum value of 10 pod weight was recorded in PC-531 (41.37 g). The mean value of population was 51.79 g.

Pod weight is generally function of pod size and shelling percentage. High value of pod weight may have direct relationship with pod yield but the seed yield may or may not be increased depending upon the fact whether pod weight was due to leathery shell or bulky and bold seeds. Variability in pod weight could be helpful in improvement of population for this trait. Singh et al. (2006) have reported a wide range of variability for 10 pod weight in vegetable pea.

4.2.8 Pod yield per plant (g)

A wide range of variability was observed across the sixteen genotypes of vegetable pea for pod yield per plant. The analyzed data for pod yield per plant indicated that significantly higher value was observed in P-89 (56.58 g). The other genotypes with comparatively higher value of pod yield per plant were by Pea-1001 (49.58 g), Arkel (47.71 g), Pea-801 (44.65 g), Pea-901 (41.12 g) and VPR-7 (39.63 g). The minimum pod yield per plant was found in AP-2 (13.79 g). The mean value of the population was 35.21 g (Table 4.2 and Fig. 10).

Pod yield in vegetable pea is attributes by several traits. The genotypes exhibiting higher pod yield per plant may be utilized for improvement of population through direct selection. However cross breeding programmes may also be undertaken by using P-89 and other promising genotypes with view to generate recombinants with higher yield and other desirable traits. The variability in pod yield per plant was also reported in pea by Rai et al. (2006) from 21.20 g to 82.83 g, Kumari et al. (2008) from 50.05 g to 114.33 g, Devi et al. (2010) average of 96.31 g, Kumari et al. (2012) of average of 86.87 g, Pal and Singh (2013) from 74.48 g to 240.72 g, Sharma and Bora (2013) from 25.0 g to 129.66 g and Sharma et al. (2013) 41.33 g to 66.25 g.
4.2.9 Seed yield per plant (g)

Significant difference was noted among 16 genotypes of pea for seed yield per plant. It ranged from 5.77 g to 8.58 g. Significantly higher value of seed yield per plant was found in P-89 (8.58 g) followed by Pea-901 (8.18 g), VRP-7 (8.05 g) and PC-531 (8.02 g). The minimum seed yield per plant was recorded in PM-2 (5.77 g). The mean value of population was 6.85 g (Table 4.2 and Fig.10).

Seed yield is one of the most desirable characters for study of genetic variability in genotypes. High seed yield again represents adaptability of genotypes in particular agroclimatic conditions. Existence of variability in gene pool for trait leads to opportunity of directional selection for population improvement. Variability among the pea genotypes for seed yield has also been reported by Kumar (2007) from 1.24 to 5.45; Pant (2008) from 2.95 to 7.95 and Prasad (2009) from 5.41 to 6.67.

On the basis of above results it was observed that P-89 was promising genotype for number of pods per plant (9.67), pod length (10.89 cm), pod yield per plant (56.58 g) and seed yield per plant (8.58 g) whereas AP-3 had maximum values for plant height at 50% flowering (67.33 cm) and number of seeds per pod (8.33). Minimum days to 50% flowering was noted in Arkel (35.0 DAS) and CHP-2 had maximum pod diameter (13.26 mm). The genotype PM-2 registered maximum value for 10 pod weight (64.54 g). As P-89 had many desirable traits along with pod yield and seed yield per plant, therefore, it could be used as one of the parents in cross breeding programme of garden pea in Uttarakhand hills.

4.3 Correlation between seed quality, pod yield and seed yield parameters

4.3.1 Correlation coefficients of pod yield and seed yield per plant with Seed quality characters

The assessment of seed viability and vigour traits by growing the seed samples of different genotypes in the laboratory condition before sowing in main field and further estimation of performance in field conditions enables to establish relationship between seed quality parameters and field performance. With the help of such relations, the potentiality of seed lot of a genotype could be assumed in advance. The estimates of correlation coefficients among different pairs of characters have been presented in Table 4.3.

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The results on correlation studies showed that seed yield per plant exhibited highly significant and positive correlation with seed vigour index-II (0.392) and seedling dry weight (0.390) whereas it established positive but non-significant association with standard germination (0.283) and root length (0.180) and negative and non-significant association with shoot length (0.266). In case of pod yield per plant, positive and significant relation of it was found with standard germination (0.807), seed vigour index-II (0.654), seedling fresh weight (0.600) and seedling dry weight (0.597). It appeared from such type of inter-relationships that the genotypes exhibiting high values for standard germination, seed vigour index-II and seedling fresh and dry weight, could be assumed to have high pod as well as seed yield per plant. Corroborating the findings of present investigation, high positive correlation of seed vigour index, seedling dry weight and standard germination with seed yield per plant have also been reported by Laszolo (1972); Natrajan (2002); Kumar (2007); Pant (2008); Prasad (2009) and Shukla et al. (2009) in vegetable pea.

The trait standard germination had positive and significant relationship with first count (0.435). Shoot length showed parallelism with root length by establishing significant positive association with the latter (0.642). The seedling length was favourably affected by root and shoot length as this had positive and significant correlation with the latter two traits (0.944 and 0.859, respectively). Seedling fresh weight exhibited positive and highly significant correlation with standard germination (0.749), first count (0.432), seedling length (0.406), shoot length (0.382) and root length (0.362) seedling dry weight registered significant positive association with standard germination (0.659), seedling fresh weight (0.612) and root length (0.464). It was evident from the results that root and shoot length were main factor for increasing fresh and dry weight of seedlings.

Positive and significant correlation was noted for seedling vigour index-I with seedling length (0.988), root length (0.952), shoot length (0.818), seedling fresh weight (0.504) and seedling dry weight (0.446). Similarly, positive and significant association was also recorded for seedling vigour index-II with seedling dry weight (0.992), standard germination (0.742), seedling fresh weight (0.665), root length (0.456) and seedling vigour index-I (0.448). The 100 seed weight showed significant and negative correlation with first count (-0.577) and the rest of character pairs had non-significant association.

From the above results it is evident that prior estimation of standard germination, seedling dry weight and seedling vigour index-II of the seed lot any genotype could be
used to predict the yield potentiality of that genotype in open field conditions and the
genotype with higher values for these seed traits could be assumed to give higher pod and
seed yield.

4.3.2 Correlation coefficients of pod yield and seed yield per plant with attributing
characters

The estimates of correlation coefficients among different pairs of characters give an
idea of trends of influence of one trait over the other. Such type of information is useful in
explaining the causes behind an occurrence. The trends of relationship are also useful for
pea breeders to predict possible performance of a population generated through indirect
selection. A detail of the results on correlations between pod and seed yield attributing
traits are given below:

The results depicted in Table 4.4 showed that pod yield per plant was significantly
and positively correlated with number of pods per plant (0.919), pod length (0.581) and 10
pod weight (0.427) while it showed negative and significant correlation with pod diameter
(-0.477). It indicated that high pod yield in vegetable pea could be achieved by practicing
selection for number of pods per plant, pod length and 10 pod weight whereas the
genotypes with more pod diameter should be discouraged. Corresponding to the results of
present investigation, Tyagi and Shrivastava (2002); Sharma et al. (2003); Rai et al.
(2006); Kumari et al. (2008); Singh et al. (2008); Jitender et al. (2010) and Ghobary
(2010) have also reported positive and significant association of pod yield per plant with
number of pods per plant, pod length and pod weight. The pod yield per plant had also
high positive correlation with seed yield per plant (0.306) although the value was non-
significant. It proved from such type of parallelism that these traits could be improved
simultaneously.

Seed yield per plant was positively and significantly correlated with number of
seeds per pod (0.403), number of pods per plant (0.366) and pod length (0.344). It is
evident that selection for number of pods per plant and pod length would lead to
simultaneous improvement in pod yield per plant and seed yield per plant both in vegetable
pea. Significant positive correlation of number of pods per plant and high but non-
significant positive value of number of seeds per pod was also reported by Ghobary (2010)
in vegetable pea. However, Shukla et al. (2009) have realized negative association of
number of seeds per pod and number pods per plant with seed yield per plant.
Days to 50% flowering and plant height at 50% flowering registered high negative association with pod yield per plant (-0.125 and -0.285, respectively) but high positive correlation was noted with seed yield per plant (0.264 and 0.206, respectively) indicating a little favourable effect of these traits on seed yield per plant but adverse effect on pod yield per plant. Kumar et al. (2003) have also found negative association of days to 50% flowering with ovule yield per plant. However, Kumari et al. (2008) have reported slight positive association of plant height with pod yield per plant in garden pea.

Ten pod weights showed positive and highly significant correlation with number of seeds per pod (0.644). Pod diameter exhibited highly significant and positive correlation with plant height at 50 % flowering (0.555) while it showed significant and negative correlation with number of pods per plant (-0.437) and pod length (-0.384). Pod length showed significant and positive correlation with number of pods per plant (0.489), while it established negative and significant association with plant height at 50 % flowering (-0.569). The rest of character pairs had non-significant correlation coefficient values.

From the correlation between pod and seed yield attributing characters, it could be summarized that number pods per plant and pod length were the principal traits contributing to pod and seed yield and practicing selection for these traits would lead to simultaneous improvement in pod and seed yield both in garden pea.

4.3.3 Correlation coefficients between yield attributing and seed quality characters

The studies on correlation between seed vigour and viability parameters and seed and pod yield attributing traits would facilitate to predict the trend of increase or decrease in the value of traits appearing field on the basis of laboratory testing of vigour and viability parameters. The results depicted in Table 4.5 showed that as far as relationship between these set of parameters is concerned, seedling dry weight was positively and significantly correlated with days to 50% flowering (0.376). Plant height at 50% flowering however, established negative and significant association with most of vigour and viability traits viz., seedling vigour index-I (-0.555), seedling length (-0.518), seedling fresh weight (-0.509), root length (-0.491), shoot length (-0.442) and standard germination (-0.405). It indicated that plant height was highly affected by the environmental conditions and there was unparallelism in seed and seedling vigour of laboratory and field vigour. However, in contrary to the results of present investigation Prasad (2009) and Shukla et al. (2009)
noticed positive association of plant height with most of seed and seedling vigour parameters in vegetable pea.

Number of pods per plant was positively and significantly correlated with standard germination (0.745), vigour index-II (0.729), seedling dry weight (0.696), seedling fresh weight (0.540) and root length (0.424). On the basis of this type of result, number of pods per plant which is main pod and seed yield component likely to be produced by a genotype could be assumed. Corresponding pattern of positive correlation of most seed and seedling vigour parameters with number of pods per plant have also been reported by Prasad (2009) and Shukla et al. (2009) in vegetable pea.

Positive and significant correlation coefficient values were recorded for pod length with seedling fresh weight (0.534), vigour index-I (0.527), vigour index-II (0.520), seedling dry weight (0.486), standard germination (0.480), root length (0.478) and seedling length (0.471) whereas significant and negative association was noted with 100 seed weight (-0.369). However, Prasad (2009) and Shukla et al. (2009) have observed negative association of almost all above traits with pod length in vegetable pea.

Pod diameter exhibited significantly or non-significantly high negative correlation with almost all the seed and seedling vigour parameters i.e. seedling fresh weight (-0.574), standard germination (-0.559), vigour index-I (-0.509), root length (-0.460), seedling length (-0.444), vigour index-II (-0.399), seedling dry weight (-0.354), shoot length (-0.318) and first count (-0.213) but it registered positive and significant correlation with 100 seed weight (0.369). The findings of present investigation were in agreement with those reported by Prasad (2009) and Shukla et al. (2009) in vegetable pea. The rest of character pairs did not show significant correlation coefficient value.

Above results indicated that number of pods per plant and pod length was positively correlated with most of seed and seedling vigour parameters whereas plant height at 50% flowering and pod diameter registered negative association with these seed and seedling traits.

Results and Discussion...
Chapter 5

**SUMMARY AND CONCLUSION**

The present investigation entitled “Variability in genotypes and relationship between seed quality, pod yield and seed yield parameters of vegetable pea (*Pisum sativum* L.)” was carried out in experimental field of Department of Vegetable Science, V.C.S.G. Uttarakhand University of Horticulture and Forestry, Ranichauri Campus, Tehri-Garhwal (longitude 78° 24’ E, latitude 30° 18’ N and altitude 2000 m) during Rabi 2014-15. The variability studies were done with the performance of different genotypes of pea under rainfed conditions in temperate hills of Uttarakhand.

The experimental material comprised of 16 genotypes of vegetable pea (*Pisum sativum* L.) including released commercial cultivars and elite lines developed from different Institutes of India. The seed samples of each genotype were subjected to laboratory testing in Complete Randomised Design for 100 seed weight (g), first count (%), standard germination (%), root length (cm), shoot length (cm), seedling length (cm), seedling fresh weight (g), seedling dry weight (g), vigour index-I and vigour index-II. With view to find out relationship of seed viability and seedling vigour parameters with field performance of the genotypes, the crops of all genotypes were raised in Randomized Block Design with three replications. The experimental crops were raised using recommended cultural operations for this region. Observations were recorded for days to 50% flowering (DAS), plant height at 50% flowering (cm), number of pods per plant, pod length (cm), pod diameter (mm), number of seeds per pod, 10 pod weight (g), pod yield per plant (g) and seed yield per plant (g). The data were analysed statistically of variation in general performance for seed viability, seedling vigour and field parameters and correlation coefficients in between them. The salient findings of the study are summarized below:

1. All the sixteen genotypes included in present investigation varied significantly for all the seed and seedling viability and vigour parameters studied.
2. The genotype Pea-1001 registered maximum value for first count (73.66%), standard germination (92.33%), seedling fresh weight (4.07 g), seedling dry weight (0.92 g) and vigour index-II (87.09) whereas, Pea-801 emerged promising for shoot length (7.96 cm), seedling length (22.43 cm) and vigour
index-I (2027.08). Maximum value for 100 seed weight was noted in VL-7 (26.03 g) whereas; VRP-7 had highest root length (14.85 cm).

3. On the basis of field performance it was observed that P-89 was promising genotype for number of pods per plant (9.67), pod length (10.89 cm), pod yield per plant (56.58 g) and seed yield per plant (8.58 g) whereas AP-3 had maximum values for plant height at 50% flowering (67.33 cm) and number of seeds per pod (8.33). Minimum days to 50 % flowering was noted in Arkel (35.0 DAS) and CHP-2 had maximum pod diameter (13.26 mm). The genotype PM-2 registered maximum value for 10 pod weight (64.54 g).

4. As P-89 had many desirable traits along with pod yield and seed yield per plant, therefore, it could be used as one of the parents in cross breeding programme of garden pea in Uttarakhand hills.

5. The results on correlation studies showed that pod yield per plant was positively and significantly correlated with standard germination (0.807), seed vigour index-II (0.654), seedling fresh weight (0.600 g) and seedling dry weight (0.597 g).

6. In case of seed yield per plant, highly significant and positive correlation was observed with seed vigour index-II (0.392) and seedling dry weight (0.390 g).

7. From the results on correlation coefficients, it is evident that prior estimation of standard germination, seedling dry weight and seedling vigour index-II of the seed lot in any genotype could be used to predict the yield potentiality of that genotype in open field conditions and the genotypes with higher values for these seed traits could be assumed to give higher pod and seed yield.

8. From the correlation between pod and seed yield attributing characters, it could be summarized that number pods per plant and pod length were the principal traits contributing to pod and seed yield and practicing selection for these traits would lead to simultaneous improvement in pod and seed yield both in garden pea.

9. Number of pods per plant and pod length was positively correlated with most of seed viability and seedling vigour parameters whereas plant height at 50% flowering and pod diameter registered negative association with these seed and seedling traits.
Conclusion

The present investigation comprised of 16 genotypes of vegetable pea (*Pisum sativum* L.). The seed samples of each genotype were subjected to laboratory testing in Complete Randomised Design for 100 seed weight (g), first count (%), standard germination (%), root length (cm), shoot length (cm), seedling length (cm), seedling fresh weight (g), seedling dry weight (g), vigour index-I and vigour index-II. With view to find out relationship of seed viability and seedling vigour parameters with field performance of the genotypes, the crops of all genotypes were raised in Randomized Block Design with three replications. The experimental crops were raised using recommended cultural operations for this region. Observations were recorded for days to 50% flowering (DAS), plant height at 50% flowering (cm), number of pods per plant, pod length (cm), pod diameter (mm), number of seeds per pod, 10 pod weight (g), pod yield per plant (g) and seed yield per plant (g). The data were analysed statically of variation in general performance for seed viability, seedling vigour and field parameters and correlation coefficients in between them.

An overview of the experimental results of present investigation indicated a wide spectrum of variation with respect to morphological and seed quality parameter among all the sixteen genotypes of vegetable pea. It can be concluded that Pea-1001 had highest value for most of seed viability and seedling vigour traits whereas, P-89 exhibited highest pod yield per plant and seed yield per plant along with many other desirable traits in field conditions. From correlation coefficients, it was evident that prior estimation of standard germination, seedling dry weight and seedling vigour index-II of the seed lot in any genotype could be used to predict the yield potentiality of that genotype in open field conditions.
Literature cited


Appendix-I

Meteorological data during experimentation period (December 2014 to May 2015)

<table>
<thead>
<tr>
<th>Months</th>
<th>Temperature ($^\circ$C)</th>
<th>Rainfall (mm)</th>
<th>Average RH (%)</th>
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<td>55.8</td>
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<td>53.7</td>
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<td>13.6</td>
<td>57.4</td>
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Source: Meteorological observatory, College of Forestry, Ranichauri Campus, Tehri Garhwal, Uttarakhand
### Appendix-III

Analysis of variance (ANOVA) for field traits studied in vegetable pea during *Rabi* 2014-15

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Source of variation</th>
<th>Mean Sum of Square</th>
<th>Degree of freedom</th>
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<td></td>
<td>Replication</td>
<td>Genotypes</td>
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<td>Number of pods per plant</td>
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<td>Pod diameter (mm)</td>
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<td>Number of seeds per plant</td>
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<td>10 pod weight (g)</td>
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<td>Seed yield per plant (g)</td>
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<td>Seed yield (q/ha)</td>
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<td>Pod yield (q/ha)</td>
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* Significant at 5% level of probability
Appendix-II
Analysis of variance (ANOVA) for Quality traits studied in vegetable pea during Rabi 2014-15

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<tr>
<th>S.N.</th>
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* Significant at 5% level of probability
Table 4.1: Mean performance of pea (*Pisum sativum* L.) genotypes for seed quality parameters

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<th>Shoot length (cm)</th>
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<th>Vigour index-II</th>
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Table 4.2: Mean performance of pea (*Pisum sativum* L.) genotypes for different field parameters

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<th>Pod diameter (mm)</th>
<th>Number of seeds per pod</th>
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<th>Pod yield per plant (g)</th>
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Table 4.3: Estimates of correlation coefficients between seed yield and pod yield per plant with seed quality characters in vegetable pea genotypes

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<th>Standard germination (%)</th>
<th>Root length (cm)</th>
<th>Shoot length (cm)</th>
<th>Seedling length (cm)</th>
<th>Seedling fresh weight (g)</th>
<th>Seedling dry weight (g)</th>
<th>Vigour Index-I</th>
<th>Vigour Index-II</th>
<th>100 seed weight (g)</th>
<th>Seed yield per plant (g)</th>
<th>Pod yield per plant (g)</th>
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<td>0.749**</td>
<td>0.659**</td>
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<td>0.742**</td>
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*Significant at 5% level  ** Significant at 1% level
### Table 4.4: Estimates of correlation coefficients of pod yield and seed yield per plant with attributing characters in vegetable pea genotypes

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<tr>
<th>Characters</th>
<th>Plant height at 50% flowering (cm)</th>
<th>Number of pod per plant</th>
<th>Pod length (cm)</th>
<th>Pod diameter (mm)</th>
<th>Number of seeds per pod</th>
<th>10 pod weight (g)</th>
<th>Pod yield per plant (g)</th>
<th>Seed yield per plant (g)</th>
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<td>0.555**</td>
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</tr>
<tr>
<td>Number of pods per plant</td>
<td>0.489*</td>
<td>-0.437*</td>
<td>-0.046</td>
<td>0.057</td>
<td>0.919**</td>
<td>0.366*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pod length (cm)</td>
<td>-0.384*</td>
<td>0.359</td>
<td>0.307</td>
<td>0.581**</td>
<td>0.344</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pod diameter (mm)</td>
<td>0.223</td>
<td>-0.147</td>
<td>-0.477*</td>
<td>-0.035</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of seeds per pod</td>
<td>0.644**</td>
<td>0.206</td>
<td>0.403*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 pod weight (g)</td>
<td></td>
<td></td>
<td>0.427*</td>
<td>-0.055</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pod yield per plant (g)</td>
<td></td>
<td></td>
<td></td>
<td>0.306</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at 5% level  ** Significant at 1% level
Table 4.5: Correlation coefficients between yield attributing characters and seed quality characters in vegetable pea genotypes

<table>
<thead>
<tr>
<th>Characters</th>
<th>Days to 50% flowering</th>
<th>Plant height at 50% flowering</th>
<th>Number of pod per plant</th>
<th>Pod length (cm)</th>
<th>Pod diameter (mm)</th>
<th>Number of seeds per pod</th>
<th>10 pod weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First count (%)</td>
<td>-0.171</td>
<td>-0.176</td>
<td>0.060</td>
<td>0.282</td>
<td>-0.213</td>
<td>0.222</td>
<td>0.281</td>
</tr>
<tr>
<td>Standard germination (%)</td>
<td>0.035</td>
<td>-0.405*</td>
<td>0.745**</td>
<td>0.480*</td>
<td>-0.559**</td>
<td>0.090</td>
<td>0.324</td>
</tr>
<tr>
<td>Root length (cm)</td>
<td>-0.052</td>
<td>-0.491*</td>
<td>0.424*</td>
<td>0.478*</td>
<td>-0.460*</td>
<td>0.044</td>
<td>-0.113</td>
</tr>
<tr>
<td>Shoot length (cm)</td>
<td>-0.006</td>
<td>-0.442*</td>
<td>-0.076</td>
<td>0.353</td>
<td>-0.318</td>
<td>0.066</td>
<td>-0.108</td>
</tr>
<tr>
<td>Seedling length (cm)</td>
<td>-0.037</td>
<td>-0.518**</td>
<td>0.250</td>
<td>0.471*</td>
<td>-0.444*</td>
<td>0.058</td>
<td>-0.122</td>
</tr>
<tr>
<td>Seedling fresh weight(g)</td>
<td>0.095</td>
<td>-0.509**</td>
<td>0.540**</td>
<td>0.534**</td>
<td>-0.574**</td>
<td>0.067</td>
<td>0.297</td>
</tr>
<tr>
<td>Seedling dry weight (g)</td>
<td>0.376*</td>
<td>-0.195</td>
<td>0.696**</td>
<td>0.486*</td>
<td>-0.354</td>
<td>-0.073</td>
<td>-0.041</td>
</tr>
<tr>
<td>Vigour Index-I</td>
<td>-0.028</td>
<td>-0.555**</td>
<td>0.358</td>
<td>0.527**</td>
<td>-0.509**</td>
<td>0.071</td>
<td>-0.075</td>
</tr>
<tr>
<td>Vigour Index- II</td>
<td>0.353</td>
<td>-0.237</td>
<td>0.729**</td>
<td>0.520**</td>
<td>-0.399*</td>
<td>-0.044</td>
<td>0.012</td>
</tr>
<tr>
<td>100 seed weight (g)</td>
<td>-0.255</td>
<td>0.250</td>
<td>0.045</td>
<td>-0.362*</td>
<td>0.369*</td>
<td>0.070</td>
<td>0.055</td>
</tr>
</tbody>
</table>

*Significant at 5% level  ** Significant at 1% level
Plate 1 Seed vigour testing in different genotypes of pea
Plate 1  Field performance of different genotypes of pea
Plate 2  Field performance of different genotypes of pea
Seedling dry weight (g) and 100 seed weight (g)

Genotypes

Fig. 1 Seedling dry weight (g) and 100 seed weight (g)
Fig. 2 First count (%) and standard germination (%)
Fig. 3 Root length (cm) and shoot length (cm)
Fig. 4 Seedling length (cm) and seedling fresh weight (g)

Seedling length (cm) and seedling fresh weight (g)

Genotypes


Legend:
- Blue bars: Seedling length (cm)
- Red bars: Seedling fresh weight (g)
Fig. 5 Vigour index-I and vigour index-II
<table>
<thead>
<tr>
<th>Genotypes</th>
<th>Days to 50% flowering</th>
<th>Plant height at 50% flowering (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP-2</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>PM-2</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Pea-902</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>AP-3</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>JM-1</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>PSM-3</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>VRP-7</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>PSM-4</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>VL-7</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Pea-2001</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>CHP-2</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Pea-801</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>ArIdl</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Pea-901</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>FC-551</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>P-89</td>
<td>40</td>
<td>60</td>
</tr>
</tbody>
</table>

Fig. 6 Days to 50% flowering and plant height at 50% flowering (cm)
Fig. 7 Number of pods per plant and pod length (cm)
Pod diameter (mm) and number of seeds per pod

**Genotypes**

- AP-2
- PM-2
- Per-902
- AP-3
- JM-1
- FSH-3
- VRP-7
- FSH-4
- VL-7
- Per-1001
- CHP-2
- Per-801
- Ark-1
- Per-901
- Per-C311
- P-89

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**Fig. 8** Pod diameter (mm) and number of seeds per pod
Fig. 9 10 pod weight (g)
Pod yield per plant (g) and Seed yield per plant (g)

Genotypes

Pod yield per plant (g)
Seed yield per plant (g)

Fig. 10 Pod yield per plant (g) and seed yield per plant
VITAE


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ABSTRACT

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Institute: College of Forestry, Ranichauri Campus.
V. C. S. G. Uttarakhand University of Horticulture and Forestry.
Advisor: Dr. A.C. Mishra (Associate Professor, Vegetable Science)

Topic: “Variability in genotypes and relationship between seed quality, pod yield and seed yield parameters of vegetable pea (Pisum sativum L.)”

The experimental material comprised of 16 genotypes of vegetable pea (Pisum sativum L.) including released commercial cultivars and elite lines developed from different Institutes of India. The seed samples of each genotype were subjected to laboratory testing in Complete Randomised Design for 100 seed weight (g), first count (%), standard germination (%), root length (cm), shoot length (cm), seedling length (cm), seedling fresh weight (g), seedling dry weight (g), vigour index-I and vigour index-II. With view to find out relationship of seed viability and seedling vigour parameters with field performance of the genotypes, the crops of all genotypes were raised in Randomized Block Design with three replications. The experimental crops were raised using recommended cultural operations for this region. Observations were recorded for days to 50% flowering (DAS), plant height at 50% flowering (cm), number of pods per plant, pod length (cm), pod diameter (mm), number of seeds per pod, 10 pod weight (g), pod yield per plant (g) and seed yield per plant (g). The data were analysed statistically of variation in general performance for seed viability, seedling vigour and field parameters and correlation coefficients in between them.

The genotype Pea-1001 registered maximum value for first count (73.66%), standard germination (92.33%), seedling fresh weight (4.07 g), seedling dry weight (0.92 g) and vigour index-II (87.09) whereas, Pea-801 emerged promising for shoot length (7.96 cm), seedling length (22.43 cm) and vigour index-I (2027.08). Maximum value for 100 seed weight was noted in VL-7 (26.03 g) whereas; VRP-7 had highest root length (14.85 cm). On the basis of field performance it was observed that P-89 was promising genotype for number of pods per plant (9.67), pod length (10.89 cm), pod yield per plant (56.58 g) and seed yield per plant (8.58 g) whereas AP-3 had maximum values for plant height at 50% flowering (67.33 cm) and number of seeds per pod (8.33). Minimum days to 50 % flowering was noted in Arkel (35.0 DAS) and CHP-2 had maximum pod diameter (13.26 mm). The genotype PM-2 registered maximum value for 10 pod weight (64.54 g). From correlation coefficients, it was evident that prior estimation of standard germination, seedling dry weight and seedling vigour index-II of the seed lot in any genotype could be used to predict the yield potentiality of that genotype in open field conditions.
शीर्षक: सभी मटर (पाइसम सैटेलाइट एल) के जनन व्रुत्यों में भिन्नता तथा बीज गुणवत्ता, फली उपज तथा बीज उपज के मापदंडों में सह-सम्बन्ध।

वर्तमान प्रयोग भारत के विभिन्न संस्थाओं से विकसित किये गये सभी मटर के 16 जनन व्रुत्य पर किया गया। प्रत्येक जनन व्रुत्य के बीज नमूने को 100 बीज का बजन (ग्राम) प्रथम गणना (प्रतिशत), मानक अंकुरण (प्रतिशत), जड़ की लम्बाई (से.मी.), तने की लम्बाई (से.मी.), प्राकृतिक ताजा भार (ग्राम), प्राकृतिक का शुक क्षय भार (ग्राम), ओज सूचकांक प्रथम तथा द्वितीय प्रयोगशाला में ज्ञात करने हेतु शी.आर.डी. डिजाइन में प्रयोग लगाया गया। बीज की ओज और प्राकृतिक ओज मापदंडों का फल एवं बीज उपज के साथ सम्बन्ध ज्ञात करने हेतु प्रक्रिया में भी लगाया गया। प्रक्रिया में रैप्रोमाइज क्लास्टर डिजाइन में लगाये गये प्रयोग के माध्यम से 50 प्रतिशत पुष्पन प्रथम दिन, 50 प्रतिशत पुष्पन तक पौधे को ऊँचाई (से.मी.), फली का व्यास (मि.मै), प्रति फली बीजों की संख्या, प्रति 10 फलियाँ का भार (ग्राम), प्रति पौधा फली उपज (ग्राम) तथा प्रति पौधा बीज उपज (ग्राम) के लिए आंके एकत्रित किये गये।

परिणामों से पता चला कि पी०–1001 में सबसे अधिक प्रथम गणना (73.66 प्रतिशत), मानक अंकुरण (92.33 प्रतिशत), प्राकृतिक का ताजा भार (4.07 ग्राम), प्राकृतिक का शुक क्षय भार (9.9 ग्राम) तथा ओज सूचकांक द्वितीय (87.09) पाये गये, जबकि तने की लम्बाई (7.96 से.मी.), प्राकृतिक की लम्बाई (22.43 से.मी.) तथा ओज सूचकांक प्रथम (2027.08) पी०–801 में अधिकतम पायी गयी। अधिकतम 100 बीजों भार (26.03 ग्राम) बी.एल–7 में पाए गए, जबकि बी.आर.पी.–7 में अधिकतम जड़ की लम्बाई (14.85 से.मी.) पाए गई। प्रक्रिया परिकरण के आधार पर यह पाया गया कि प्रति पौधा फलियाँ की संख्या (9.67), फली की लम्बाई (10.89 से.मी.), प्रति पौधा फली उपज (56.58 ग्राम) तथा प्रति पौधा बीज उपज (8.58 ग्राम) पी०–89 में अधिकतम थी। 50 प्रतिशत पुष्पन तक पौधे की लम्बाई (67.33 से.मी.) तथा प्रति फली बीजों की संख्या (8.53) पी.पी.–3 में अधिकतम पायी गई। 50 प्रतिशत पुष्पन में लगे मूल्य तिम दिन (35.00) अर्थात में तथा अधिकतम फली का व्यास (13.26 मि.मै.) सी.एच.पी.–2 में देखी गई। अधिकतम 10 फलियाँ का भार (64.54 ग्राम) पी.पी.–2 में दर्ज किया गया। सहसम्बन्ध गुणांक से यह स्पष्ट था कि मानक अंकुरण, प्राकृतिक का शुक क्षय भार तथा प्राकृतिक का ओज सूचकांक द्वितीय के आधार पर खुले प्रक्रिया में जनन व्रुत्यों की उपज क्षमता की भविष्यवाणी की जा सकती है।