DISSCUSSION

Owing to the important status of pea in the agricultural and social arena of the country, the seeds used for its cultivation are not of superior quality which is the main reason for its meager economic yield. The use of quality seeds has a profound effect on the overall yield of any crop and thus of pea as well. The success of any breeding programme primarily depends upon the choice of parents for initiating a meaningful hybridization programme. The first step for achieving genetic improvement in yield is the understanding of the genetic parameters viz. variability heritability pattern, correlation among characters and the selection of genotypes with desired genetic background. The next step lies with the involvement of superior genotypes in the breeding programmes in a definite procedure and the analysis of results obtained from it. Finally, a specific breeding programme is designed based on the information such as combining ability, gene action and heterosis pattern of F1s over different seasons. These techniques have been used in many crop plants with a view of formulating purposeful and efficient breeding programmes. However, a little work has been done in this regard in pea.

The present investigation was therefore, initiated with forty genotypes of pea and their subsequent selection into three testers and twenty lines, on the basis of their performances for twelve laboratory vigor tests. These genotypes were crossed in line x tester mating design. All the hybrids and their parents were evaluated in laboratory and field to obtain information on combining ability and gene action involved in the expression of quantitative characters; extent of heritability and genetic advance, extent of heterosis, path coefficient analysis and phenotypic and genotypic correlation among seed vigor and seed yield in laboratory and field respectively. The data was recorded for twelve characters in laboratory viz. 100 seed weight (gm), germination percentage, speed of germination, seedling root length (cm), seedling shoot length (cm), total seedling length (cm), fresh seedling weight (gm), dry seedling weight (mg), vigor index I, vigor index II, electrical conductivity (µs/gm) and viability percentage and five characters in field viz. plant height (cm), pods per plant, pod length (cm), seeds per pod and yield per plant (gm). The results obtained in the present investigation have been discussed under the following headings.

5.1 VARIABILITY, HERITABILITY AND GENETIC ADVANCE

The analysis of variance revealed a wide range of variability among the forty accessions of pea for all the laboratory characters from both the seed sources viz. Mountain Research Centre for Field Crops (MRCFC) Khudwani Anantnag, SKUAST-K and Kisan (PG) College Simbhaoli (KPGC), Hapur. This was confirmed by wide range of phenotypic and genotypic coefficient of variability observed for all characters. The results were in partial confirmation with the results of Torfason and Nonnecke (1959), Perry (1980), Kumar et al. (1997) and Horcika and Hosnedi, 1997).

Estimation of mean performance, genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance for location I and location II seed sources has been presented in the Table 4.1 (e) and Table 4.1 (f) respectively. Wide range of differences for GCV was observed which varied from 7.59 (location I) and 8.19 (location II) for viability percentage to 61.08 (location I) and 58.39 (location II) for vigor index I. Other parameters such as seedling shoot length, total seedling length, seedling root length, vigor index II, electrical conductivity, dry seedling weight and fresh seedling weight from both the seed sources had moderate coefficient of genotypic variation, indicating the heritable portion of total variation existing in the population. The phenotypic coefficient of variation was higher than genotypic of variation for all characters in both seed sources indicating greater role of environment in the manifestation of these characters. Our results are in confirmation of the earlier works carried out by Taweekul et al. (1998) and Ali et al. (2003) who found that germination of rice varieties in low temperature was influenced more by genotype than seed quality. Bhupendra and Gangwar (2005) evaluated genetically pure seeds of several mungbean cultivars and revealed that all the cultivars differed in their seed vigor index. Krishnan and Surya Rao (2005) also found in rice, that certain characters such as seed leachate conductivity, potential of seed longevity, percentage of seed germination and proportion of seed discoloration were influenced by environment and others such as yield, panicle number, seed weight, and proportion of high-density grains by genotype.

The analysis of variance for field characters of parents also showed a wide range of variability for all five characters studied {Table 4.1 (g) and Table 4.1 (h)}. It is evident from Table 4.1 (i) that phenotypic coefficient of variation was higher than genotypic coefficient of variation. The genotypic coefficient of variation ranged from 12.29 for seeds per pod to 43.95 for pods per plant, whereas phenotypic coefficient of variation ranged from 19.69 for seeds per pod to 47.22 for pods per plant. The estimates of genotypic coefficient of variation and phenotypic coefficient of variation were moderate/high in order of their magnitude for characters pods per plant, seed yield per plant, plant height and pod length. These results are similar to that of Townsend (1974) who reported the existence of highly significant differences among progenies of Cicermilk-vetch (*Astragelus cicer* L.) for speed of germination and seedling emergence and suggested that improvement in seedling vigor is possible through breeding. Our results are also in accordance with the results of Nandpuri et al., (1973) and Sing et al., (1978) who reported the small differences between estimates of GCV and PCV in pea. Our studies also coincide with the earlier findings of Kalloo et al (2005), Sirohi et al., (2006), Singh and Singh (2006), Sardana et al., (2007), Nawab et al., (2008) and Ceyhan et al., (2008) etc. These results indicate that there was adequate amount of variability in the experimental for the above mentioned characters. Therefore, these characters offer an ample scope through selection.

Genetic coefficient of variation does not give the idea of total variation that is heritable. The relative amount of heritable portion of variation can be assessed through heritable estimates. Heritability estimates in the broad sense include both additive and non-additive gene effects and in the narrow sense includes only additive effects.

In the present study, the estimates of heritability were high for all the characters ranging from 0.76 to 0.98 for speed of germination, 100 seed weight, fresh seedling weight and electrical conductivity for the seeds raised at location I. The heritability values of the seeds raised at location II ranged from 0.79 to 0.99 for speed of germination, 100 seed weight, germination percentage, vigor index II and viability percentage. Thus the material under study appears to be promising. High heritability values for quantitative characters are always preferred by the breeders as characters with high heritability estimates enable them to base their selection on the basis of expression of these characters. The genetic advance showed wide range from 2.27 for fresh seedling weight to 17073.49 for vigor index II from seeds raised at location I and 3.03 for speed of germination to 24056.28 for vigor index II from seeds raised at location II. In general high genetic advance was observed for the characters vigor index II, vigor index I, dry seedling weight, speed of germination, electrical conductivity, viability percentage and total seedling length for the seeds raised from both the sources. However, the low estimate of genetic advance were observed for fresh seedling weight, speed of germination, 100 seed weight, seedling root length as well as seedling shoot length for the seeds raised from both the sources. Our results are in accordance to the earlier findings of Makkawi et al., (1999) and Amaritsut (2004).

Among the field characters of parents, heritability was estimated to be high for all the characters except number of seeds per pod. It ranged from 0.38 for number of seeds per pod to 0.98 for seed yield per plant. High genetic advance was observed for the characters plant height, where as moderate genetic advance was recorded for pods per plant and seed yield per plant. Low genetic advance was observed for seeds per pod and pod length. {Table 4.1 (i)}. Our results are coincide with the earlier findings of Sureja and Sharma (2000), Chaudhary and Sharma (2003), Gupta et al., (2006), Salam et al.,(2007), and Lal et al., (2011). Seed yield per plant, pods per plant and plant height had high heritability coupled with a moderate genetic gain suggesting the role of both additive and non additive gene action in the expression of these traits. Pod length was found to be highly heritable character with low genetic advance. As such phenotypic selection for these traits is likely to be effective for their improvement.

5.2 CORRELATION AND PATH COEFFICIENT STUDIES

Genotypic correlations among different traits may arise because of linkage, pleiotrophy or developmentally induced functional relationships. Seed vigor as well as seed yield is the end product of contributions from different characters. Not only these characters are associated with vigor index and seed yield but they are associated among themselves.

5.2.1 Association of vigor index and other traits

Vigor index I exhibited highly significant and significant positive phenotypic correlation with total seedling length, fresh seedling weight, speed of germination, germination percentage and 100 seed weight, dry seedling weight respectively from seeds produces at both locations. A highly significant positive genotypic correlation was found between 100 seed weight and speed of germination, fresh seedling weight, total seedling length and vigor index I in seeds produced from both seed sources. The characters which showed highly significant positive genotypic correlation were speed of germination with total seedling length, seedling fresh weight and vigor index I;

total seedling length with seedling fresh weight, vigor index I and vigor index II and seedling fresh weight with vigor index I and vigor index II from the seeds produced at both the locations. Germination percentage exhibited significant genotypic correlation with speed of germination, total seedling length and vigor index I from the seeds produced at both sites. The germination percentage showed negative correlation with seedling dry weight and electrical conductivity from the seeds obtained from location I as well as location II. The characters which showed highly significant negative genotypic correlation includes electrical conductivity with speed of germination, total seedling length, fresh seedling weight and vigor index I from the seeds of both sites. The relationship between electrical conductivity and viability was found to be negative and highly significant in seeds from MRCFC origin while negative and non-significant in seeds from KPGC, {Table 4.2 (a) and Table 4.2 (b)} Similar results were recorded by earlier workers such as Wang et al., (2003). Our results also coincide with the earlier findings of Parimal and Chakraborty (2009) who studied the relationship between seed coat color and seed deterioration in green gram (*Vigna radiata* L.) and revealed that the germination percentage had positive and significant correlation with vigor index but had negative significant correlation with hundred-seed weight and electrical conductivity. Seedling fresh weight was found to have negative non-significant correlation with electrical conductivity. Vigor index exhibited negative significant correlation in all the situations with seed protein content, hundred-seed weight and electrical conductivity. Our results are also in confirmation of earlier findings of You X. F. (2005) who studied correlation between seed vigor and germination rate of melon and later revealed that that there was an extremely significant and positive correlation between tetrazolium test and the standard germination methods. Miguel and Cicero (A) (1999) (soybean), Roozrokh et al., (2002) (chickpea), Amaritsut (2004) (soybean), Peksen et al., (2004) (pea), Narwal et al., (2004) (okra), and Shukla et al., (2009) (pea) also got the similar results.

5.2.2 Association of seed yield and other traits

At this point, it is intended to consider issues concerning the significant interrelationship among the component characters which might aid in conceiving an ideal plant type. Seed yield had significant positive phenotypic correlation with number of pods per plant and number of seeds per pod. However, it showed non significant phenotypic association with other characters such as plant height. Positive and high genotypic correlation was found between seed yield and pods per plant, plant height, seeds per pod as well as pod length. Pods per plant also exhibited positive significant genotypic correlation with plant height. The seeds per pod showed high significant negative correlation with pods per plant and a non significant negative correlation with pod length. Our results are similar to that of Singh and Singh (2006) who reported that seed yield per plant had significant and positive association with number of pods per plant, plant height, and number of grains per pod. Sirohi et al., (2006), Nawab et al., (2008), Jitendra et al., (2010) in pea also reported the similar results.

The study of correlation alone when considered as the criteria for selection for high yield would be misleading, since a character may not be directly correlated with seed vigor or seed yield but may further depend on other characters. By path analysis, it is possible to find out the direct and indirect influences of component characters on seed vigor and seed yield.

In the present study eleven characters for laboratory studies and four characters for field studies were considered for path analysis.

Out of eleven laboratory characters, the characters that showed positive direct effects on vigor index II in order of their magnitude from the seeds produced at location I were total seedling length (36.06), germination percentage (1.92), speed of germination (0.79), 100 seed weight (0.18), and seedling root length (0.16). Similarly the direct effects for the seeds produced at location II were total seedling length (5.62), dry seedling weight (0.61), viability percentage (0.47), fresh seedling weight (0.41) and germination percentage (0.21).Total seedling length contributed high positive indirect effects via seedling shoot length (35.94 & 5.55), seedling root length (35.71 & 5.27), and fresh seedling weight (30.21 & 4.60) from the seeds produced at location I and location II respectively.{(Table 4.2 (c) & Table 4.2 (d)}. Germination percentage contributed high positive direct effect (1.92 & 0.21) and positive indirect effects towards vigor index II via speed of germination (1.34 & 0.14), total seedling length (0.96 & 0.07) and fresh seedling weight (0.80 & 0.07) from the seeds produced at location I and location II respectively. However, its negative indirect effects was recorded via dry seedling weight (-0.27 & -0.056) and electrical conductivity (-0.042 & -0.042). Our results are in confirmation of earlier findings of Makkawi et al., (2008) who studied correlation and path coefficient analysis of laboratory tests in Lentil (*Lens culinaris* M.) and concluded that seedling dry weight and 100-seed weight consistently reflected the highest positive direct contribution towards field emergence, whereas the highest negative direct effect was shown by seedling growth rate. The highest positive direct contribution was exhibited by seedling growth rate, followed by speed of germination and standard germination towards seed vigor. Our results are also similar to that of Parimal and Chakraborty (2009) who studied the relationship between seed coat color and seed deterioration in green gram (*Vigna radiata* L.) in different environmental conditions and from the path analysis of pooled data of three years and in three different environmental conditions indicated that the germination percentage had negative direct effects on electrical conductivity. The maximum direct effect was exhibited by root-shoot ratio followed by vigor index over seed vigor.

From the field studies it is evident {Table 4.2 (f)} that the characters which showed positive direct effects on seed yield in order of their magnitude were pods per plant (0.467), seeds per pod (0.168) and plant height (0.146). Pods per plant contributed high positive direct effect on seed yield (0.467) and its positive indirect effects were recorded via, plant height (0.168) and pod length (0.039). However, its negative indirect effect was recorded via seeds per pod (-0.254). Seeds per pod contributed high positive direct effect on seed yield (0.168) and its positive indirect effect was recorded via plant height (0.001). However, it had negative indirect effect on seed yield, via pods per plant (0.091) and pod length (-0.018). Plant height contributed high positive direct effect (0.146) towards seed yield and its positive indirect effects were recorded via pods per plant (0.052), pod length (0.036) and seeds per pod (0.001). Our results are in accordance with the earlier findings of Chaudhary and Sharma (2003) who reported that 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 in pea. Sirohi et al., (2006) and (2007) also reported in pea that the number of seeds per pod had highest direct effects towards seed yield at genotypic level. Pankaj et al., (2003) (pea), Satyawan et al., (2004), Mohan et al., (2005), Singh and Yadav (2005), Kumar and Sharma (2006), Usmani and Dubey (2007) (pea), Kanade et al., (2010) (pigeon pea), Saumya et al., (2011) (pea) also reported the similar results.

5.3 HETEROSIS

The genetic improvement of a crop depends upon the correct choice of parents from available gene pool. Such a selection is not an easy task, since phenotypic expression is determined not only by genotype but is influenced by environment and interaction between genotype and environment. It is therefore, necessary for the critical assessment of the material. In this respect, statistical tools are of immense help in plant breeding programme based on a sound biometrical background. The understanding of gene action of complex quantitative characters is essential for formulating effective procedure for improvement. The estimates of gene effects and genetic variance help in understanding the genetic potential of the breeding material.

In the present investigation, twenty lines and three testers were used to study the extent of heterosis. The degree of heterosis for quantitative characters such as yield and its components is largely due to divergent nature of parents. The exploitation of heterosis for commercial purpose is very common in cross pollinated crops. However, its scope in self pollinated crops seems to be limited owing to the difficulty in the production of hybrid seed.

In the present study, the expression of heterosis is presented in the Table 4.3 (a) and Table 4.3 (e) for field characters and Table 4.3 (b) and Table 4.3 (f) for laboratory characters. From the genetic analysis, it may be observed that there was appreciable heterosis in almost all field characters studied. The case was same for laboratory characters as well except for fresh seedling weight.

The degree of heterosis varied considerably for every vigor character. For laboratory characters, the maximum values of heterosis over mid parent and better parent respectively was recorded for 100 seed weight (27.72 & 20.66), germination percentage (33.33 & 30.20), speed of germination (38.76 & 57.47), seedling root length (66.07 & 96.53), seedling shoot length (72.77 & 258.83), total seedling length (70.75 & 161.46), fresh seedling weight (12.36 & 45.61), dry seedling weight (28.06 & 72.08), vigor index I (22.18 & 156.87), vigor index II (42.81 & non significant value), electrical conductivity (-36.20 & -91.96) and viability percentage(13.60 & 24.31). For field characters, the maximum values of heterosis over mid parent and better parent respectively was recorded for plant height (146.82 & 256.96), pods per plant (208.47 & 368.69), pod length (63.58 & 96.67), seeds per pod (114.78 & 137.11) and seed yield per plant (96.47 & 157.95). Our results are in accordance with the earlier findings of Borah, H. K. (2009) who studied combining ability and heterosis in field pea and concluded that days to maturity, protein content and 100 seed weight were having high heterotic effects, while as moderate heterosis was found for days to flowering, number of seeds per pod, and plant height. Similar results were reported earlier by Sing et al., (1994), Sarwat et al., (1994) in pea, Aher et al.,(2000) in moongbean, Espinosa and Ligarreto (2005), Harinder et al., (2005), Raju and Muthiah (2007), Ganesh et al., (2008), Saumya et al., (2009), and Lila et al., (2009) in pea. Our findings are in confirmation to their results.

The best five cross combinations involved in each character on the basis of their performance over mid and better parent is summarized in Table 5.3.

Table No. 5.3 Best five cross combinations in heterosis.

S No	Character involved	Best five cross combinations
1	Plant height	EC-538008 x IC-208375, IC-417878 x IC-208375, IC-267181 x EC-398602, EC-342007 x NBP-82, EC-538008 x NBP-82.
2	Pods per plant	IC-208366 x IC-208375,EC-538008 x EC-398602, EC-538005 x IC-208375, IC-208368 x EC-398602, EC-538004 x NBP-82.
3	Pod length	DMR-7 x IC-208375, EC-538005 x IC-208375, IC-208366 x EC-398602, IC-267151 x EC-398602, IC-208364 x NBP-82.
4	Seeds per pod	IC-267162 x IC-208375, IC-424895 x IC-208375, EC-342007 x IC-208375, IC-417878 x NBP-82, EC-538005 x NBP-82.
5	Seed yield per plant	IC-208364 x IC-208375, EC-538004 x IC-208375, IC-208368 x IC-208375, IC-424895 x EC-398602, EC-342007 x NBP-82.
6	100 seed weight	DMR-7 x EC-398602, IC-417586 x EC-398602, IC-208385 x EC-398602, IC-424896 x EC-398602, IC-424886 x NBP-82.
7	Germination percentage	DMR-7 x IC-208375, EC-342007 x IC-208275, EC-538008 x EC-398602, IC-267162 x EC-398602, EC-398599 x EC-398602.
8	Speed of germination	EC-538008 x IC-208375, IC-267181 x EC-398602, IC-208368 x EC-398602, IC-417878 x NBP-82, IC-424896 x NBP-82.
9	Total seedling length	EC-538004 x IC-208375, IC-267127 x EC-398602, DMR-7 x EC-398602, IC-208364 x EC-398602, IC-267181 x EC-398602.
10	Fresh seedling weight	EC-538008 x IC-208375, IC-208366 x NBP-82
11	Dry seedling weight	IC-424886 x IC-208375, EC-342007 x IC-208375, IC-267181 x IC-208375, EC-538008 x EC-398602, IC-208368 x EC-398602.
12	Vigor index I	EC-538008 x IC-208375, EC-538005 x EC-398602.
13	Vigor index II	IC-417586 x IC-208375, EC-342007 x IC-208375, IC-267151 x NBP-82.
14	Electrical conductivity	IC-424895 x IC-208375, EC-342007 x IC-208375, IC-267162 x EC-398602, IC-208368 x EC-398602, IC-208385 x NBP-82.
15	Viability percentage	IC-267181 x IC-208375, IC-417878 x NBP-82.

5.4 COMBINING ABILITY

Among the self pollinated crops, the example of commercial exploitation of heterosis is scanty. However, the information collected on the basis of heterotic effects of crosses could be useful in deciding the crosses, which needs to be carried for further selection in segregating generation. Therefore, under such a situation it is not only heterosis which can be considered as a criterion for further selection, but their mean values and specific combining ability effects should also be considered, so that crosses with high mean, high *sca* effects or heterosis value should not be left out. In a systemic breeding programme, the knowledge of parents with desirable characters and good general combining abilities are not only needed, but high estimates of sca effects and high heterotic effects over the parents are also desired for selecting the transgressive segregants.

Joshi and Dhawan (1966) and Dhaliwal and Singh (1970) discussed the importance of combining ability analysis in selecting the parental lines in self pollinating crops. From the genetic analysis, {Table 4.3 (g) & Table 4.3 (h)} it may be revealed that variance due to female and male were significant for almost all field characters. Like wise the variance due to male and female was also significant for all laboratory characters.

The good general combiners for most of the field characters include EC-538008, IC-267127, IC-267162, DMR-11, IC-208385, EC-342007, IC-424896, IC-208368 and NBP-82. The parents EC-398599, IC-424896, IC-267127, IC-208368, DMR-7, IC-208366, IC-267162, and IC-208364 were good general combiners for seed yield per plant where the others were poor combiners.

The good general combiners for most of the laboratory characters include EC-538008, IC-417878, DMR-7, IC-267162, EC-398599, IC-208385, IC-208385, DMR-11, IC-208368, IC-417586, EC-538005 and IC-208364. The good general combiners for vigor index include EC-538008, IC-267162, IC-208368, IC-417878, DMR-11 and EC-538005 and the other parents were poor combiners for this trait. Our results coincide with the findings of earlier workers who reported good and poor general combiners of pea germplasm on the basis of their *gca* effects viz**.** Singh and Singh (1991), Singh et al.,(1994), Vikas and Singh (1999), Lohithaswa and Dharmaraj (2003), Jahagirdar, J. E. (2003), Pandey N. (2004), Baskaran and Muthiah (2007) and Sarode et al., (2009).

The hybrids which showed significant and positive *sca* effects for most of the field characters includes EC-538008 x IC-208375, IC-127162 x IC-208375, IC-208364 x IC-208375, EC-398599 x IC-208375, DMR-11 x IC-208375, IC-208375 x IC-208375, IC-267181 x IC-208375, IC-208368 x IC-208375, EC-538008 x EC-398602, IC-267127 x EC-398602, IC-127151 x EC-398602, EC-538004 x EC-398602, IC-417878 x NBP-82, IC-267127 x NBP-82, IC-267162 x NBP-82, IC-267151 x NBP-82, IC-424895 x NBP-82, and EC-538005 x NBP-82.

The hybrids which showed significant and positive *sca* effects for most of the laboratory characters includes IC-424896 x IC-208375, IC-267127 x EC-398602, DMR-11 x EC-398602, IC-208385 x EC-398602, EC-342007 x EC-398602, EC-538005 x EC-398602, IC-417878 x NBP-82, IC-424896 x NBP-82, EC-538008 x IC-208375, DMR-7x IC-208375, IC-267162 x IC-208375, IC-208364 x IC-208375, IC-424895 x IC-208375, EC-342007 x IC-208375, IC-267181 x IC-208375, IC-208368 x IC-208375, DMR-7 x EC-398602, IC-267151 x EC-398602, EC-398599 x EC-398602, IC-208385 x EC-398602, IC-424896 x EC-398602, IC-267127 x NBP-82, IC-208364 x NBP-82 and IC-424895 x NBP-82.

The desired best four cross combinations with high *sca* effects and their parents are presented in Table 5.4. The cross combinations as indicated in Table 5.4, where both the parents were poor general combiners, desirable combining ability of such crosses seems to be mainly due to complementation of genes. (Whitehead, 1962 and Lather, 1985). The good general combiners indicated that the high *sca* effects of these crosses were attributed to the cumulative effects of the additional gene action. The parents involved in the crosses that showed higher *sca* effects were mostly divergent in origin and involvement of good general combiners as their parents was not so necessary in these crosses.

Table No: 5.4 Best four cross combinations and their respective parents.

S No	Character	Crosses with higher *sca* effects	*gca* of parents involved in cross
1	Plant height	IC-267151 x IC-208375 IC-267162 x EC-398602 IC-267151 x IC-208375 IC-208364 x EC-398602	Low x Average Low x Low Low x Average Low x Low
2	Pods per plant	IC-208366 x IC-208375 IC-267181 x IC-208375 EC-538008 x EC-398602 IC-208368 x EC-398602	Low x Low High x Low Low x Low Low x Low
3	Pod length	IC-267181 x IC-208375 IC-267127 x EC-398602 DMR-7 x EC-398602 IC-208366 x NBP-82	Low x Low High x High Average x High Average x Low
4	Seeds per pod	EC-538008 x IC-208375 IC-267127 x EC-398602 IC-417586 x NBP-82 EC-538005 x NBP-82	High x High High x Low Low x Low Low x Low
5	Seed yield per plant	IC-208364 x IC-208375 IC-208368 x IC-208375 IC-208364 x NBP-82 IC-208385 x NBP-82	Average x High High x High Average x Average Low x Average
6	100 seed weight	IC-424895 x IC-208375 IC-267162 x EC-398602 EC-342007 x NBP-82	Low x Average High x Low Average x Low
7	Germination percentage	DMR-7 x IC-208375 EC-342007 x IC-208375 DMR-7 x EC-398602 IC-267151 x EC-398602	High x Low Low x Low High x Low High x Low
8	Speed of germination	EC-538008 x IC-208375 IC-267127 x IC-208375 IC-417878 x EC-398602	High x Average Low x Average Average x Low
9	Total seedling length	IC-267127 x EC-398602 DMR-11 x EC-398602 IC-267127 x EC-398602 EC-538005 x EC-398602	Low x Low Low x Low Low x Low Low x Low
10	Fresh seedling weight	DMR-11 x IC-208375 IC-267151 x NBP-82 IC-424896 x NBP-82	High x High Average x Low Low x Low
11	Dry seedling weight	IC-267127 x IC-208375 EC-398599 x EC-398602 IC-267162 x NBP-82 IC-208364 x NBP-82	Low x High Low x Low Average x Low Low x Low
12	Vigor index I	DMR-7 x IC-208375 EC-342007 x IC-208375 IC-208385 x EC-398602 EC-538005 x EC-398602	High x Low Low x Low High x Low Low x Low
13	Vigor index II	DMR-7 x IC-208375 EC-342007 x IC-208375 EC-398599 x EC-398602 DMR-7 x NBP-82	Low x Average Low x Average High x Low Low x High
14	Electrical conductivity	DMR-11 x IC-208375 EC-538004 x IC-208375 IC-267162 x EC-398602 DMR-7 x NBP-82	High x Average High x High Low x High Low x Low
15	Viability percentage	IC-267181 x IC-208375 EC-342007 x EC-398602 IC-208385 x NBP-82 IC-424896 x NBP-82	Average x Low Low x Low Average x High Low x High

5.5 GENE ACTION

The magnitude of additive and dominance gene effects for field and laboratory characters is presented in Table 4.3 (m) and Table 4.3 (n) respectively. In field studies, the dominance effect was found to be predominant for all characters except for pod length and seed yield per plant. Moreover, it is clear, that plant height, pods per plant and seeds per pod had relatively higher magnitude of dominance variances as compared to other characters, whereas additive variances were higher for pod length and seed yield per plant. The estimates of dominance components in order of their magnitude were found high for plant height, pods per plant and seeds per pod. It is evident from the results that these characters were also governed by additive component of variances.

In laboratory studies, the additive effect was found to be predominant for all characters except speed of germination, seedling root length, and vigor index II. Moreover, it is clear, that vigor index I and dry seedling weight had relatively higher magnitude of additive variances as compared to other characters, whereas dominances variances were higher for speed of germination, seedling root length and vigor index II. The estimates of additive components in order of their magnitude were found high for vigor index II, vigor index I, seedling dry weight, germination percentage, electrical conductivity and viability percentage. It is evident from the results that these characters were also governed by dominant component of variances.

Degree of dominance was worked out for all characters which indicated over dominance for all characters mostly in plant height, pods per plant and seeds per pod for field studies. In laboratory studies, the magnitude of degree of dominance was higher in vigor index II followed by speed of germination and seedling root length.

On the basis of above findings, it may be concluded that seed yield and seed vigor and their components are controlled either by additive or dominance components or by both. Heterosis breeding is recommended for the characters which were controlled by non-additive components of variances. However, in self pollinated crops like pea this approach may be utilized for selecting the best segregates to develop the new varieties. Similar results were found by Meena et al., (2004) who studied the inheritance of seed shape and vigor in chickpea and concluded that seed shape and seed vigor inheritance is under digenic control. Our results are in conformity of the earlier findings of Singh and Singh (1991), Naidu and Satyanaryana (1993), Vikas and Singh (1999), Sawicki and Boros (2000), Sachan et al.,(2001), Tyagi and Srivastava (2001), Singh et al., (2006), Jyothula and Guttala (2009) and Vinod et al., (2011).