RESULTS

Results of the experiments conducted in the laboratory and in the field are presented below:

4.1 GENETIC VARIABILITY AMONG THE GENOTYPES FOR THE VIGOR TRAITS

(A) Laboratory Studies:

The harvested seeds of the forty genotypes of pea (Table 1) grown in the field at Mountain Research Centre for Field Crops (MRCFC) Khudwani Anantnag, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir i.e., location I and that at Kisan (PG) College, Simbhaoli Hapur, Uttar Pradesh (KPGC) i.e., location II were tested in the laboratory to determine the extent of genetic variability for various seed and seedling vigor traits. Results of the analysis of variance, coefficient of variation, ranges and means for twelve seed and seedling vigor traits at two different locations are presented in Tables 4.1(a), 4.1(b) and 4.1(c), 4.1(d) for location I and location II respectively. Varietal differences were highly significant for all the traits studied, indicating wide spectrum of variation among the genotypes.

The 100 seed weight varied from 8.52 grams to 17.19 with mean = 12.35 grams for seeds from location I, and from 5.93 grams to 16.26 grams with mean= 11.95 grams for those from location II. Rate of germination index ranged from 6.92 to 15.25 with mean = 10.95 for seeds from location I, and from 6.96 to 14.99 with mean =10.90 for those from location II.

Seedling root length measured on the 8^{th} day after germination ranged from 1.90 cm to 10.87 cm with mean = 4.36 cm for seeds from location I, and 1.53 cm to 11.47cm with mean = 4.46 cm for those from location II. Seedling shoot length which was also measured on the 8^{th} day after germination ranged from 2.11 cm to 24.21 cm with mean = 8.32 cm for seeds from location I, and 2.60 cm to 24.50 cm with mean = 7.66 cm for those from location II.

Seedling fresh weight ranged from 1.82 gm to 6.80 gm with mean = 2.78 for seeds from location I, and 1.65gms to 6.41 with mean = 2.81gms for those from location II. Dry seedling weight varied from 146.67 mg to 566.66 mg for seeds from location I, with a mean of 347mg, where as in seeds from location II, it ranged from 130.37mg to 880.73 mg with a mean of 341.59 mg.

Table No: 4.1 (a) **Analysis of variance, coefficient of variation, ranges and means for seed and seedling vigor traits in 40 genotypes of pea raised at location I during 2009-2010**

Vigor traits	df		MS		CV (%)	Range	Mean
	Genotype	Error	Genotype	Error			
1	39	78	10.11**	0.06	2.14	8.52-17.19	12.35
2	39	78	275.64**	3.59	2.46	52.67-86.67	76.77
3	39	78	8.33**	0.78	8.14	6.92-15.25	10.95
4	39	78	14.11**	1.20	25.09	1.90-10.87	4.36
5	39	78	72.86**	2.48	18.93	2.11-24.21	8.32
6	39	78	142.93**	2.81	13.29	4.01-35.08	12.63
7	39	78	3.73**	0.02	5.66	1.82-6.80	2.78
8	39	78	38412.30**	1426.26	10.88	146.67-566.66	347.00
9	39	78	114238.45**	18763.53	13.67	286.03-2837.47	1002.02
10	39	78	2464379.70.**	111267.71	12.46	10480.07-49247.07	26760.00
11	39	78	158.29**	1.04	5.18	5.43-37.27	19.73
12	39	78	123.75**	0.88	1.11	73.22-96.40	84.35

*, ** :- Significant at 5% and 1% probability respectively

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm
12= Viability percentage

Table No: 4.1 (b) **Analysis of variance for seed and seedling vigor traits in 40 genotypes of pea raised at location I during 2009-2010**

		Characters											
Source of variation	df	1	2	3	4	5	6	7	8	9	10	11	12
Replication	2	0.002	2.28	30.07	0.14	9.82	8.97	0.11	10188.50	73100.00	41971712.0	2.01	0.187
Treatment	39	10.11**	275.64**	8.33	14.11**	72.86**	142.93**	3.73**	38412.30**	1142384.5**	246437970.0**	158.29**	123.75**
Error	78	0.069	3.59	0.78	1.20	2.48	2.81	0.024	14262.69	18763.5	11126771.0	1.04	0.88

*, ** :- Significant at 5% and 1% probability respectively

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm
12= Viability percentage

Table No: 4.1 (c) **Analysis of variance, coefficient of variation, ranges and means for seed and seedling vigor traits in 40 genotypes of pea raised at location II during 2009-2010**

Vigor traits	df		MS		CV (%)	Range	Mean
	Genotype	Error	Genotype	Error			
1	39	78	10.29**	0.007	0.70	5.93-16.26	11.95
2	39	78	291.67**	0.22	0.61	51.67-89.67	76.82
3	39	78	8.79**	0.68	7.55	6.96-14.99	10.90
4	39	78	13.30**	0.43	14.85	1.53-11.47	4.46
5	39	78	58.34**	0.72	11.11	2.60-24.50	7.66
6	39	78	118.71**	1.07	8.54	4.39-33.37	12.10
7	39	78	3.53**	0.03	8.54	1.65-6.41	2.81
8	39	78	58287.77**	135.08	3.40	130.37-880.73	341.59
9	39	78	93322.01**	6304.10	8.34	318.35-2974.2	951.88
10	39	78	4126790.10**	895724.31	3.606	9386.33-73401.00	26240.25
11	39	78	148.40**	0.77	4.64	5.63.39.13	18.96
12	39	78	143.21**	0.29	0.64	69.83-97.70	84.29

*, ** :- Significant at 5% and 1% probability respectively

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm
12= Viability percentage

Table No: 4.1 (d) **Analysis of variance for seed and seedling vigor traits in 40 genotypes of pea raised at location II during 2009-2010**

	Characters												
Source of variation	d. f.	1	2	3	4	5	6	7	8	9	10	11	12
Replication	2	0.01	3.21	0.34	0.20	1.83	2.21	0.76	77.00	9620.00	1499136.0	0.542	0.062
Treatment	39	10.29**	291.67**	8.79**	13.30**	58.34**	118.71**	3.53**	58287.77**	932201.0**	412679010.0**	148.40**	143.21**
Error	78	0.007	0.22	0.68	0.43	0.72	1.07	0.03	135.08	6304.10	895724.31	0.77	0.29

*, ** :- Significant at 5% and 1% probability respectively

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm
12= Viability percentage

Vigor index I varied from 286.03 to 2837.47 with a mean of 1002.02 in seeds from location I, and from 318.35 to 2974.2 with a mean of 951.88 in seeds from location II. Vigor Index II varied from 10480.07 to 49247.07 with a mean of 26760.00 in seeds from location I, and 9386.33 to 73401.00 with a mean of 26240.25 in seeds from location II.

Electrical conductivity varied from 5.43 µs/gm to 37.27 µs/gm with a mean of 19.73 µs/gm in seeds from location I, and from 5.63 µs/gm to 39.13 µs/gm with a mean of 18.96 µs/gm in seeds from location II. The seed viability percentages varied from 73.22 % to 96.40 % with mean = 84.35 for seeds from location I, and from 69.83% to 97.7% with mean = 84.29% for those from location II.

The data on different seed and seedling vigor traits along with the estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance for both the seed sources viz. location I and location II are presented in Table 4.1(e) and 4.1(f) respectively. In general the estimates of PCV were higher than the estimates of GCV for all the characters, which indicate the presence of environmental influence. The genotypic coefficient of variation ranged from 7.59 for seed viability to 61.08 for vigor index I, whereas PCV ranged from 7.67 to 62.59 for the same characters respectively, for seeds from location I. However, for the seeds raised at location II, the GCV ranged from 8.19 for seed viability to 58.39 for vigor index I, whereas PCV ranged from 8.21 to 58.99 for the same characters respectively. The estimates of GCV and PCV were high/moderate in order of their magnitude for the characters; vigor index I, seedling shoot length, total seedling length, seedling root length, fresh seedling weight and electrical conductivity for the seeds raised at both the sites. Low estimate of GCV and PCV were recorded for the characters seed viability, germination percentage, hundred seed weight and speed of germination for the seeds raised at location I as well as location II.

The heritability was estimated for all the twelve characters and the criterion of considering low, moderate and high heritability was adopted as suggested by Hanson et al., (1956). 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.

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.

Table No: 4.1 (e) **Mean, range, coefficient of variation, heritability and genetic advance for laboratory characters in 40 genotypes of pea raised location I during 2009-2010**

Characters		1	2	3	4	5	6	7	8	9	10	11	12
Mean		12.35	76.77	10.90	4.36	8.32	12.63	2.78	347.00	1002.02	26760.00	19.73	84.35
Range	**Maximum**	17.19	86.67	15.25	10.87	24.21	35.08	6.80	566.67	2837.47	10480.07	37.27	96.40
	Minimum	8.52	52.67	6.92	1.90	2.11	4.01	1.82	146.67	286.03	49247.07	5.43	73.22
Genotypic coefficient of variation (GCV)		14.81	12.40	14.54	47.50	58.20	54.10	40.01	32.00	61.08	33.10	36.69	7.59
Phenotypic coefficient of variation(PCV)		14.96	12.65	16.66	53.72	61.20	55.71	40.41	33.80	62.59	35.37	37.05	7.67
Heritability (h2)		0.980	0.962	0.761	0.782	0.904	0.943	0.980	0.896	0.952	0.876	0.980	0.979
Genetic advance		3.73	19.24	2.85	3.78	9.49	13.67	2.27	216.55	1230.27	17073.49	14.77	13.04

1=100 seed weight (gm) 7= Fresh seedling weight (gm)
2= Germination percentage 8= Dry seedling weight (mg)
3= Speed of germination 9= Vigor index I
4= Seedling root length (cm) 10= Vigor index II
5= Seedling shoot length (cm) 11= Electrical conductivity (µs/gm
6= Total seedling length (cm) 12= Viability percentage

Table No: 4.1 (f) **Mean, range, coefficient of variation, heritability and genetic advance for laboratory characters in 40 genotypes of pea raised at location II during 2009-2010**

Characters		1	2	3	4	5	6	7	8	9	10	11	12
Mean		11.95	76.82	10.90	4.46	7.66	12.10	2.81	341.59	951.88	26240.25	18.96	84.29
Range	Maximum	16.26	89.67	14.99	11.47	24.50	33.73	6.41	880.73	2974.22	73401.00	39.13	97.70
	Minimum	5.93	51.67	6.96	1.53	2.60	4.39	1.65	130.37	318.35	9386.33	5.63	69.83
Genotypic coefficient of variation (GCV)		15.50	12.83	15.07	46.42	57.15	51.74	38.38	40.76	58.39	44.65	36.99	8.19
Phenotypic coefficient of variation(PCV)		15.53	12.84	16.86	48.74	58.22	52.44	38.97	40.90	58.99	44.79	37.28	8.21
Heritability (h2)		0.998	0.998	0.799	0.907	0.964	0.973	0.970	0.993	0.980	0.994	0.984	0.994
Genetic advance		3.81	20.28	3.03	4.06	8.86	12.73	2.19	285.81	1133.55	24056.28	14.34	14.17

1=100 seed weight (gm) 7= Fresh seedling weight (gm)
2= Germination percentage 8= Dry seedling weight (mg)
3= Speed of germination 9= Vigor index I
4= Seedling root length (cm) 10= Vigor index II
5= Seedling shoot length (cm) 11= Electrical conductivity (µs/gm
6= Total seedling length (cm) 12= Viability percentage

(B) Field Studies:

Twenty-three parents selected as lines and testers were raised at the experimental field of Department of Agri. Botany (Genetics and Plant Breeding) Kisan (PG) College Simbhaoli, Hapur (KPGC), i.e., location II and observations were recorded to determine the extent of genetic variability for various field characters. Results of the analysis of variance, coefficient of variation, ranges and means for five field characters are presented in the Table 4.1 (g) and 4.1 (h). All the 23 genotypes of pea exhibited highly significant differences for all the characters, indicating wide spectrum of variation among the genotypes. The estimates of PCV were higher than the estimates of GCV for all the characters under study, indicating the presence of environmental influence as presented in Table 4.1 (i). The GCV ranged from 12.29 for seeds per pod to 43.95 for number of pods per plant, whereas PCV ranged from 19.69 for seeds per pod to 47.22 for number of pods per plant.

The 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.

Testing of 40 pea genotypes for different seed and seedling vigor traits have revealed the presence of sufficient genetic variability for the vigor traits among the genotypes. IC-208375, EC-398602, NBP-82, EC-538008, IC-417878, IC-208366, IC-267127, DMR-7, IC-424886, IC-267162, IC-417586, IC-267151, IC-208364, EC-398599, IC-424895, DMR-11, IC-208385, EC-342007, EC-538004, IC-424896, IC-267181, IC-208368 and EC-538005 possessed higher values among most of the vigor traits. Some significant and positive correlations were also observed among the important vigor traits. These results indicated the possibility of utilizing these genotypes as parents in improving seed and seedling vigor traits in pea.

Table No: 4.1 (g) Analysis of variance, coefficient of variation, ranges and means for agronomic traits in 23 parents of pea raised at location II during 2010-2011

Characters		1	2	3	4	5
df	**Genotype**	22	22	22	22	22
	Error	44	44	44	44	44
MS	**Genotype**	44.26**	2.16**	0.31*	0.81**	0.48*
	Error	146.50	12.66	0.20	0.54	0.51
C.V. (%)		12.92	17.26	7.89	15.39	4.48
Range	**Max**	170.73	46.53	8.47	5.87	26.70
	Min	49.97	5.70	3.90	3.53	6.57
Mean		93.67	20.61	5.61	4.79	15.90

*, ** :- Significant at 5% and 1% probability respectively

1= Plant height (cm)
2= Pods per plant
3= Pod length (cm)
4= Seeds per pod
5= Seed yield per plant (gm)

Table No: 4.1 (h) Analysis of variance for field characters in 23 parents of pea raised at location II during 2010-2011

Characters						
Source of variation	d.f.	1	2	3	4	5
Replication	2	44.26	2.16	0.31	0.81	0.48
Treatment	22	2652.48**	258.95**	4.37**	1.59*	90.51**
Error	44	146.50	12.66	0.20	0.54	0.51

*, ** :- Significant at 5% and 1% probability respectively

Table No: 4.1 (i) Mean, range, coefficient of variation, heritability and genetic advance for field characters in 23 parents of pea raised at location II during 2010-2011

Characters		1	2	3	4	5
Mean		93.68	20.62	5.61	4.80	15.91
Range	Maximum	170.73	46.53	8.47	5.87	26.70
	Minimum	49.97	5.70	3.90	3.53	6.57
Genotypic coefficient of variation (GCV)		30.85	43.95	21.01	12.29	34.43
Phenotypic coefficient of variation(PCV)		33.45	47.22	22.44	19.69	34.72
Heritability (h2)		0.85	0.86	0.87	0.38	0.98
Genetic advance		54.92	17.37	2.27	0.76	11.19

1= Plant height (cm)
2= Pods per plant
3= Pod length (cm)
4= Seeds per pod
5= Seed yield per plant (gm)

4.2 CORRELATION AND PATH COFFICIENT AMONG THE GENOTYPES FOR THE VIGOR TRAITS

(A) Laboratory Studies :

The correlation coefficients among the seed and seedling vigor traits were computed in both the seed sources and are shown in Tables 4.2 (a) and 4.2 (b). In general, the genotypic correlation coefficients were higher than the phenotypic correlation coefficients.

Speed of germination had significant and positive phenotypic correlation with vigor index I, total seedling length and fresh seedling weight in seeds from location I as well as location II. Highly significant and positive phenotypic correlation was also observed between total seedling length and fresh seedling weight and vigor index I from both seed sources. The seed viability also exhibited highly significant and significant positive phenotypic correlation with 100 seed weight and seedling root length along with vigor index I respectively in seeds from location I. However, in the seeds produced at location II this relationship could not touch the significant limits. 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.

The electrical conductivity possessed highly significant negative phenotypic correlation with speed of germination, total seedling length, fresh seedling weight and vigor index I and vigor index II in seeds produced from location I. In the seeds produced at location II, although electrical conductivity showed similar negative phenotypic correlation with, speed of germination, total seedling length, fresh seedling weight and vigor index I, it showed non significant phenotypic relationship with vigor index II.

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.

Table No: 4.2 (a) **Estimates of phenotypic correlation coefficient (P) and genotypic correlation coefficient (G) among seed and seedling vigor traits in 40 pea genotypes of pea raised at location I during 2009-2010**

		Characters											
S.No	Characters	1	2	3	4	5	6	7	8	9	10	11	12
1	P G		0.311* 0.331*	0.349* 0.401**	0.381** 0.441**	0.399** 0.430**	0.416** 0.440**	0.458** 0.467**	0.184 0.204	0.443** 0.469**	0.320* 0.350*	-0.216 -0.219	0.430** 0.441**
2	P G			0.613** 0.698**	0.430** 0.506**	0.481** 0.509**	0.480** 0.500**	0.402** 0.416**	-0.126 -0.142	0.581** 0.597**	0.292* 0.299*	-0.066 -0.071	0.209 0.215
3	P G				0.481** 0.566**	0.475** 0.583**	0.498** 0.573**	0.479** 0.566**	0.003 0.032	0.555** 0.639**	0.315* 0.384**	-0.425** -0.487**	0.258 0.291*
4	P G					0.764** 0.974**	0.882** 0.991**	0.742** 0.843**	0.286* 0.377**	0.874** 0.984**	0.492** 0.672**	-0.285* -0.297*	0.317* 0.352*
5	P G						0.974** 0.996**	0.767** 0.821**	0.262* 0.265*	0.966** 0.987**	0.471** 0.507**	-0.248 -0.279**	0.310* 0.330*
6	P G							0.802** 0.837**	0.298* 0.315*	0.989** 0.991**	0.512** 0.556**	-0.285* -0.299*	0.334* 0.345*
7	P G								0.366* 0.393**	0.803** 0.835**	0.536** 0.585**	-0.413** -0.420**	0.308* 0.316*
8	P G									0.255 0.267*	0.895** 0.897**	-0.201 -0.223	0.029 0.035
9	P G										0.513** 0.550**	-0.291* 0.304*	0.352* 0.363*
10	P G											-0.261* -0291*	0.142 0.153
11	P G												-0.367* -0.373**
12	P G												

*, ** :- Significant at 5% and 1% probability respectively

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm
12= Viability percentage

Table No: 4.2 (b) **Estimates of phenotypic correlation coefficient (P) and genotypic correlation coefficient (G) among seed and seedling vigor traits in 40 genotypes of pea raised at location II during 2009-2010**

Characters													
S.No	Characters	1	2	3	4	5	6	7	8	9	10	11	12
1	P G		0.283* 0.283*	0.272* 0.306*	0.299* 0.314*	0.381** 0.387**	0.368* 0.372**	0.455** 0.463**	0.238 0.240	0.400** 0.403**	0.309* 0.311*	-0.257 -0.259	0.153 0.153
2	P G			0.602** 0.675**	0.210 0.222	0.385** 0.394**	0.346* 0.352*	0.342* 0.349*	-0.002 -0.002	0.493** 0.499**	0.312* 0.313*	-0.113 -0.114	0.193 0.195
3	P G				0.369* 0.440**	0.470** 0.531**	0.459** 0.516**	0.411** 0.466**	0.070 0.072	0.546** 0.616**	0.277* 0.307*	-0.424** -0.477**	0.104 0.105
4	P G					0.804** 0.871**	0.903** 0.938**	0.725** 0.768**	0.305* 0.322*	0.862** 0.896**	0.359* 0.380**	-0.414** -0.437**	-0.139 -0.146
5	P G						0.980** 0.987**	0.774** 0.803**	0.369* 0.379**	0.975** 0.982**	0.478** 0.490**	-0.407** 0.413**	0.043 -0.044
6	P G							0.794** 0.819**	0.368* 0.376**	0.983** 0.983**	0.464** 0.473**	-0.425** -0.432**	-0.075 -0.077
7	P G								0.363* 0.372**	0.805** 0.828**	0.457** 0.467**	-0.374** -0.383**	0.023 0.023
8	P G									0.350* 0.356*	0.945** 0.945**	0.068 0.070	-0.109 -0.109
9	P G										0.494** 0.501**	-0.430** -0.436**	-0.016 -0.016
10	P G											0.013 0.014	-0.038 -0.038
11	P G												-0.007 -0.008
12	P G												

*, ** :- Significant at 5% and 1% probability respectively

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm
12= Viability percentage

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 location I origin while negative and non-significant in seeds from location II.

The genotypic correlation coefficients were partitioned in order to know the direct and indirect effects of eleven characters towards vigor index II, which are presented in Table 4.2 (c) and 4.2 (d) for seeds produced at location I and location II respectively.

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.

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).

100 seed weight contributed high positive direct effect (0.182 & 0.236) on vigor index II and its indirect negative effects were recorded via, electrical conductivity (-0.074 & -0.036) from the seeds produced at location I and location II respectively.

Speed of germination contributed low positive direct effect (0.79 & 0.57) on vigor index II and its positive indirect effects via, germination percentage (0.55 &

0.38),total seedling length (0.45 & 0.29),fresh seedling weight (0.45 & 0.26) and vigor index I (0.51 & 0.27). However, it had negative indirect effect on vigor index II via, electrical conductivity (-0.24 & -0.04) from the seeds of both sites.

Total seedling length contributed high positive direct effect on vigor index II (36.06 & 5.62) and its positive indirect effects were recorded via, seedling root length, (35.71 & 5.27), seedling shoot length (35.94 & 5.55), fresh seedling weight (30.21 & 4.60), vigor index I (35.74 & 2.42), speed of germination (20.68 & 2.90) and 100 seed weight (15.85 & 2.09) for seeds from location I and location II respectively.

Seed viability percentage contributed low positive direct effect (0.59 & 0.47) on vigor index II and its positive indirect effect was recorded via electrical conductivity (0.51 & 0.42), however its negative indirect effect was recorded via total seedling length (-0.18 & -0.46), vigor index I (-0.21 & -0.05) and speed of germination (-0.17 & -0.28).

Residual effect was negligible (0.004), indicating that the characters in the present study controlled most of the variations for vigor index II.

Table No: 4.2 (c) **Estimates of genotypic direct (in bold letters) and indirect effect on vigor index II for 11 laboratory characters in 40 genotypes of pea raised at location I during 2009-2010**

Characters	1	2	3	4	5	6	7	8	9	10	11	r = Vigor index II
1	**0.182**	0.637	0.320	0.072	-8.609	15.853	-0.184	-0.126	-8.022	0.452	-0.265	0.350
2	0.060	**1.923**	0.557	0.083	-1.018	18.033	-0.164	0.087	-1.005	0.024	-0.119	0.299
3	0.073	1.342	**0.799**	0.093	-1.167	20.684	-0.223	-0.019	-1.078	0.345	-0.170	0.384
4	0.080	0.970	0.451	**0.165**	-1.948	35.712	0.333	-0.233	-1.636	-0.138	-0.181	0.672
5	0.078	0.979	0.466	0.161	**-2.000**	35.946	-0.324	-0.163	-1.652	0.092	-0.183	0.507
6	0.080	0.961	0.458	0.163	-1.993	**36.068**	-0.331	-0.194	-1.659	0.093	-0.189	0.556
7	0.085	0.800	0.452	0.139	-1.642	30.210	**-0.395**	-0.242	-1.398	0.146	-0.174	0.585
8	0.037	-0.272	0.025	0.062	-5.293	11.354	0.155	**-0.618**	-4.633	0.436	-0.037	0.897
9	0.087	1.149	0.514	0.161	-1.973	35.745	-0.330	-0.171	**-1.674**	0.114	-0.214	0.550
10	-0.074	-0.042	-0.247	0.020	1.651	-3.038	0.052	0.242	1.725	**-1.114**	0.517	-0291
11	0.080	0.383	0.227	0.050	-6.103	11.415	-0.114	-0.039	-5.978	0.962	**0.599**	-0.373

Residual effect = 0.004

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Electrical conductivity (µs/gm)
11= Viability percentage

Table No: 4.2 (d) **Estimates of genotypic direct (in bold letters) and indirect effect on vigor index II for 11 laboratory characters in 40 genotypes of pea raised at location II during 2009-2010**

Characters	1	2	3	4	5	6	7	8	9	10	11	r = Vigor index II
1	**0.236**	0.061	0.175	-0.645	-1.370	2.093	0.193	0.146	0.056	-0.066	-0.179	0.311
2	-0.067	**0.215**	0.387	-0.456	-1.394	1.978	0.145	-0.001	0.024	-0.084	-0.258	0.313
3	0.072	0.145	**0.574**	-0.906	-1.879	2.901	0.195	0.044	0.103	-0.045	-0.289	0.307
4	0.074	0.047	0.253	**-2.057**	-3.085	5.274	0.321	0.197	0.094	0.062	-0.383	0.380
5	0.091	0.084	0.304	-1.792	**-3.541**	5.551	0.335	0.231	0.089	0.091	-0.484	0.490
6	0.088	0.075	0.296	-1.929	-3.496	**5.622**	0.342	0.229	0.093	0.033	-0.466	0.473
7	0.109	0.075	0.267	-1.579	-2.843	4.602	**-0.418**	0.227	0.082	-0.010	-0.394	0.467
8	0.056	0.00	0.041	-0.663	-1.340	2.114	0.155	**-0.610**	-0.015	0.047	-0.171	0.945
9	0.061	-0.024	0.274	0.899	1.464	2.428	-0.160	0.042	**-0.216**	0.003	-0.056	0.501
10	-0.036	-0.042	-0.060	0.299	0.156	-0.431	0.009	-0.006	0.001	**-0.432**	0.042	0.014
11	-0.089	0.116	0.349	-1.655	-3.599	5.498	0.345	0.219	0.025	-0.038	**0.477**	-0.038

Residual effect = 0.004

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Electrical conductivity (µs/gm)
11= Viability percentage

(B) Field Studies of Parents:

All the possible genotypic and phenotypic coefficients between seed yield per plant and other four characters of parents are presented in Table 4.2 (e). In general, the genotypic correlation coefficient was higher than phenotypic correlation coefficients.

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. A non significant negative phenotypic correlation was found between seeds per pod and plant height, pods per plant as well as pod length. Pod length possessed non significant positive correlation with plant height as well as pods per plant.

Positive and high genotypic correlation was found between seed yield and pods per plant, seeds per pod as well as pod length. Seed yield also exhibited significant positive genotypic correlation with plant height. 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.

The genotypic correlation coefficients were partitioned in order to know the direct and indirect effect of four characters towards seed yield which are presented in Table 4.2 (f). 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). Residual effect was negligible (0.004), indicating that the characters in the present study controlled most of the variations for seed yield.

Table No: 4.2 (e) **Estimates of phenotypic correlation coefficient (P) and genotypic correlation coefficient (G) among agronomic traits in 23 parents of pea raised at location II during 2010-2011**

Characters	1	2	3	4	5
1 P		0.188 ns	0.197 ns	-0.013 ns	0.291 ns
G		0.360*	0.250 ns	0.008 ns	0.370 *
2 P			0.083 ns	-0.300 ns	0.383*
G			0.098 ns	-0.544 **	0.426**
3 P				-0.089 ns	0.35*
G				-0.112 ns	0.42**
4 P					0.40**
G					0.82**
5 P					
G					

*, ** :- Significant at 5% and 1% probability respectively
NS: Non significant

1= Plant height (cm) 4= Seeds per pod
2= Pods per plant 5= Seed yield per plant (gm)
3= Pod length (cm)

Table No: 4.2 (f) **Estimates of genotypic direct (in bold letters) and indirect effect on seed yield per plant for 4 agronomic characters in 23 parents of pea raised at location II during 2010-2011**

Characters	1	2	3	4	r = seed yield per plant
1	**0.146**	0.168	-0.006	0.001	0.310
2	0.052	**0.467**	-0.002	-0.091	0.426
3	0.036	0.039	**-0.245**	-0.018	0.032
4	0.001	-0.254	0.002	**0.168**	-0.082

1= Plant height (cm) 3= Pod length (cm)
2= Pods per plant 4= Seeds per pod

4.3 LINE X TESTER ANALYSIS

4.3.1 Analysis of variance

Analysis of variance due to crosses, females, males, female x male are presented in Table 4.3 (a) and 4.3 (b) for field and laboratory studies respectively.

(A) Field studies:

4.3.1.1 Variance due to crosses

Variances within the crosses were highly significant for all the characters.

4.3.1.2 Variance due to lines

The highly significant variances were observed for all the characters studied.

4.3.1.3 Variance due to tester

Variance due to tester was found significant for all the characters.

4.3.1.4 Variance due to line x tester

Variance due to line x tester was significant for plant height and pods per plant, however it was non significant for pod length, seeds per pod and seed yield per plant.

(B) Laboratory studies:

4.3.1.5 Variance due to crosses

Variances within the crosses were highly significant for all the characters, except for fresh seedling weight.

4.3.1.6 Variance due to lines

The highly significant variances were observed for all the characters studied.

4.3.1.7 Variance due to tester

Variance due to tester was significant for all characters except, 100 seed weight, speed of germination and seedling root length.

4.3.1.8 Variance due to line x tester

Variance due to line x tester was found significant for all the characters.

4.3.2 Mean performance of parents and their hybrids

The mean values of parents and their hybrids for 5 field characters and 12 laboratory characters under study were averaged over replication and are presented in Table 4.3 (c) and 4.3 (d) respectively.

Table No: 4.3 (a) **ANOVA for line x tester analysis in pea for field characters carried out at location II during 2011-2012**

Characters	d.f.	1	2	3	4	5
Replication	2	11.95	4.69	0.07	0.43	1.12
Crosses	59	3394.07**	416.04**	2.57**	3.31**	164.69**
Line effect	19	2412.38**	274.03**	4.71**	1.34	100.32**
Tester effect	2	2843.03**	228.93**	3.14*	4.34*	42.46**
Line x tester effect	1	5206.93**	32.48**	0.15	0.65	0.15
Error	164	3.49	3.87	0.86	0.19	0.81

*, ** :- Significant at 5% and 1% probability respectively

1= Plant height (cm)
2= Pods per plant
3= Pod length (cm)
4= Seeds per pod
5= Seed yield per plant (gm)

Table No: 4.3 (b) **ANOVA for line x tester analysis in pea for laboratory characters carried out at location II during 2011-2012**

Characters	df	1	2	3	4	5	6	7	8	9	10	11	12
Replication	2	0.85	1.70	13.74	1.31	1.64	5.71	0.01	2634.53	18859.70	580500.68	042	2.69
Crosses	59	5.99b	537.34b	7.57b	8.78b	2.69b	55.74b	1.21	25962.35b	716979.80b	14195184.0b	146.30b	167.95b
Line effect	19	4.42b	337.85b	2.65b	5.65b	20.3.5b	43.56b	1.12	25496.10b	409158.80b	11288735.0b	112.80b	127.94b
Tester effect	2	2.79	3.04a	0.17	1.91	61.35b	85.61b	6.27b	46493.77b	665457.30b	21187721.0b	3.64a	9.00b
Line x tester effect	1	81.25b	884.93b	197.01b	229.15b	955.23b	2139.84b	61.27b	71069.12b	1950968.00b	19321570.0b	1617.56b	790.43b
Error	164	0.20	5.97	0.57	0.74	2.26	3.16	0.19	16.56	113.30	1471.20	2.47	0.77

a, b :- Significant at 5% and 1% probability respectively

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm
12= Viability percentage

(A) Field studies:

4.3.2.1 Plant height (cm)

The highest plant height was exhibited by IC-267127 followed by NBP-82 among the parents. The hybrid EC-538008 x IC-208375 showed highest plant height followed by EC-398599 x IC-208375.

4.3.2.2 Pods per plant

The parent IC-267181 recorded maximum number of pods per plant followed by IC-424896. Among crosses IC-208368 x EC-398602 registered maximum number of pods per plant (64.37), whereas it was minimum for the cross IC-424886 x NBP-82 (8.53).

4.3.2.3 Pod length (cm)

Pod length was maximum in DMR-11 parent (8.47), whereas minimum in IC-267162 (3.90). Crosses IC-267151 x EC-398602 (9.13) and EC-398599 x IC-208375 recorded maximum pod length, while IC-267127 x IC-208375 had lowest pod length (5.10).

4.3.2.4 Seeds per pod

The parent (IC-424886) registered more number of seeds per pod (5.87) followed by IC-208375 (5.60).Maximum number of seeds per pod was recorded in cross EC-538008 x IC-208375 (8.80) and minimum in IC-424886 x NBP-82 (4.10).

4.3.2.5 Seed yield per plant (grams)

The parents EC-398599 (26.70) and IC-424896 (25.33) had maximum seed yield per plant. Among the hybrids IC-208364 x IC-208375 (35.17) andIC-208364 x NBP-82 (33.32) exhibited maximum seed yield per plant, where as it was minimum for IC-208368 x NBP-82 (7.07).

(B) Laboratory studies:

4.3.2.6 100 seed weight (grams)

The highest 100 seed weight was recorded by parents IC-208375 (16.24) and EC-398602 (15.08) and minimum by EC-538008 (9.51). Among hybrids, crosses EC-538005 x IC-208375 and DMR-11 x EC-398602 exhibited highest 100-seed weight (14.60), whereas it was lowest for IC-417586 x NBP-82 (9.24).

4.3.2.7 Germination percentage

The parents IC-267162 and EC-398602 (88.67) recorded maximum germination percentage followed by NBP-82 (87.67). For hybrids maximum germination percentage was receded by IC-208368 x IC-208375 (100.0), however it was lowest for the IC-267151 x NBP-82 (57.00) cross.

Table No: 4.3 (c) **Mean performance of parents (line x testers) and hybrids for the field characters in pea**

Characters / Treatments	1	2	3	4	5
Parents					
Lines					
EC-538008	51.97	10.67	6.33	5.00	6.73
IC-417878	87.40	25.07	4.53	4.83	13.30
IC-208366	49.97	19.13	5.67	4.23	19.53
IC-267127	170.73	28.60	7.70	5.50	22.17
DMR-7	98.77	33.20	6.70	3.53	18.43
IC-424886	77.70	19.47	4.23	5.87	19.83
IC-267162	100.87	16.67	3.90	5.40	18.47
IC-417586	105.90	20.27	4.77	4.17	6.57
IC-267151	56.20	11.27	5.53	3.90	15.70
IC-208364	55.83	19.33	5.53	5.50	16.40
EC-398599	113.40	21.27	4.80	4.73	26.70
IC-424895	102.93	14.03	5.27	5.20	14.90
DMR-11	113.77	13.73	8.47	5.07	12.03
IC-208385	109.40	15.07	5.33	5.40	10.43
EC-342007	80.20	19.80	8.13	5.50	17.07
EC-538004	108.23	5.70	4.83	5.53	11.97
IC-424896	106.03	36.87	4.97	4.77	25.33
IC-267181	92.43	46.53	5.73	3.93	15.87
IC-208368	85.67	18.63	5.33	4.23	20.53
EC-538005	67.83	22.33	4.83	4.37	6.60
Testers					
IC-208375	113.50	17.93	4.40	5.60	13.63
EC-398602	89.00	10.60	5.63	4.80	13.60
NBP-82	150.17	28.00	6.43	3.23	20.13
Hybrids					
EC-538008 x IC-208375	185.50	19.07	7.23	8.80	11.02
IC-417878 x IC-208375	173.97	12.60	7.77	6.50	11.77
IC-208366 x IC-208375	158.63	47.57	7.07	4.20	11.46
IC-267127 x IC-208375	126.50	32.23	5.10	6.77	16.04
DMR-7 x IC-208375	101.63	29.27	7.47	5.77	11.13
IC-424886 x IC-208375	153.37	39.07	6.67	5.33	15.00
IC-267162 x IC-208375	97.93	23.77	6.75	8.33	22.11
IC-417586 x IC-208375	86.50	19.00	7.73	6.03	21.70
IC-267151 x IC-208375	142.57	20.87	7.07	6.87	20.41
IC-208364 x IC-208375	168.13	34.43	8.03	8.60	35.17
EC-398599 x IC-208375	182.20	29.63	9.10	6.73	24.93
IC-424895 x IC-208375	166.63	30.77	8.00	7.67	27.72
DMR-11 x IC-208375	106.03	21.60	7.13	7.30	30.75
IC-208385 x IC-208375	95.27	21.53	8.43	5.73	20.77
EC-342007 x IC-208375	78.30	21.03	6.90	7.27	23.23
EC-538004 x IC-208375	97.60	22.77	5.23	6.33	26.17
IC-424896 x IC-208375	85.83	19.50	6.73	5.87	21.64
IC-267181 x IC-208375	70.07	38.73	7.23	5.93	24.04
IC-208368 x IC-208375	106.57	21.87	5.43	6.10	30.57
EC-538005 x IC-208375	97.33	24.93	7.63	6.30	20.07

Characters / Treatments	1	2	3	4	5
EC-538008 x EC-398602	96.678	47.73	7.03	6.93	20.98
IC-417878 x EC-398602	112.10	23.13	6.37	4.77	10.36
IC-208366 x EC-398602	98.67	17.00	7.60	4.70	8.80
IC-267127 x EC-398602	85.50	28.87	8.07	5.67	11.78
DMR-7 x EC-398602	93.73	25.00	6.83	5.97	20.76
IC-424886 x EC-398602	74.80	19.57	7.93	5.40	16.44
IC-267162 x EC-398602	156.63	18.10	8.10	4.93	23.36
IC-417586 x EC-398602	90.03	23.93	7.23	7.00	20.19
IC-267151 x EC-398602	87.87	20.97	9.13	6.80	21.51
IC-208364 x EC-398602	153.67	29.47	7.67	6.13	21.95
EC-398599 x EC-398602	118.57	20.47	6.03	5.33	32.61
IC-424895 x EC-398602	92.60	28.73	7.53	5.07	32.68
DMR-11 x EC-398602	130.07	26.40	6.40	5.53	32.56
IC-208385 x EC-398602	119.40	10.60	5.70	7.83	16.76
EC-342007 x EC-398602	91.87	12.17	6.93	6.10	16.11
EC-538004 x EC-398602	148.57	14.20	5.67	6.30	22.36
IC-424896 x EC-398602	168.40	22.97	6.80	6.00	9.33
IC-267181 x EC-398602	165.23	15.90	8.07	5.63	11.21
IC-208368 x EC-398602	145.00	64.37	7.07	7.20	11.59
EC-538005 x EC-398602	125.00	22.97	6.47	7.67	11.63
EC-538008 x NBP-82	106.20	21.23	8.40	6.43	11.20
IC-417878 x NBP-82	156.53	17.23	8.00	7.60	16.51
IC-208366 x NBP-82	152.40	29.33	8.67	6.43	26.96
IC-267127 x NBP-82	173.63	25.00	6.83	6.60	19.75
DMR-7 x NBP-82	160.37	37.77	5.20	6.10	15.02
IC-424886 x NBP-82	111.10	8.53	5.97	4.10	17.97
IC-267162 x NBP-82	102.40	9.73	6.97	4.53	17.41
IC-417586 x NBP-82	84.67	10.50	6.80	5.30	20.30
IC-267151 x NBP-82	99.80	50.20	6.30	6.23	29.84
IC-208364 x NBP-82	89.37	40.70	8.57	5.10	33.32
EC-398599 x NBP-82	69.70	45.90	7.83	5.03	25.60
IC-424895 x NBP-82	104.07	51.63	6.87	5.30	20.45
DMR-11 x NBP-82	92.57	49.00	7.90	4.93	13.93
IC-208385 x NBP-82	81.43	45.70	6.40	5.17	29.56
EC-342007 x NBP-82	161.23	24.33	6.10	6.40	30.21
EC-538004 x NBP-82	166.07	21.57	7.50	5.10	28.94
IC-424896 x NBP-82	160.03	32.27	7.17	5.13	28.40
IC-267181 x NBP-82	112.13	25.70	6.67	5.73	11.83
IC-208368 x NBP-82	101.93	23.80	7.10	4.90	7.07
EC-538005 x NBP-82	151.20	21.63	7.03	6.40	14.35
S.Em±	3.49	3.87	0.86	0.19	0.81

1= Plant height (cm)
2= Pods per plant
3= Pod length (cm)
4= Seeds per pod
5= Seed yield per plant (gm)

4.3.2.8 Speed of Germination index

Speed of germination index was maximum in IC-208375 (15.25) parent, where as minimum in EC-538005 (6.92) parent. Crosses EC-538008 x IC-208375 (16.90) and IC-267127 x IC-208375 (13.56) recorded maximum speed of germination index, while cross EC-538005 x NBP-82 (7.41) had lowest germination index.

4.3.2.9 Seedling root length (cm)

The parent NBP-82 recorded maximum seedling root length (9.83) followed by EC-398602 (8.59). Among crosses EC-417878 x IC-208375 registered maximum seedling root length (9.61), whereas EC-398599 x NBP-82 exhibited minimum value of seedling root length (2.06).

4.3.2.10 Seedling shoot length (cm)

Maximum seedling shoot length was exhibited by parent NBP-82 (22.52) and minimum by IC-424886 (2.11). The cross EC-417878 x IC-208375 (16.83) registered maximum seedling shoot length and minimum was shown by cross IC-267181 x IC-208375 (3.42).

4.3.2.11 Total seedling length (cm)

The parent NBP-82 exhibited maximum total seedling length (32.35) followed by EC-398602 (23.30). Among crosses, the maximum total seedling length was recorded by EC-538008 x IC-208375 (23.07) and minimum by IC-267151 x NBP-82 (5.59).

4.3.2.12 Fresh seedling weight (gm)

The parents EC-398602 (6.80) recorded maximum fresh seedling weight followed by NBP-82 (4.52). Among the hybrids, EC-538008 x IC-208375 (4.47) and EC-538005 x IC-208375 (4.11) exhibited maximum fresh seedling weight.

4.3.2.13 Dry seedling weight (mg)

The highest dry seedling weight was recorded by parents IC-208375 (566.67) followed by DMR-11 (540.0).While as hybrids IC-424896 x EC-398602 (571.67) and EC-538004 x EC-398602 (188.0) recorded highest and lowest dry seedling weight respectively.

4.3.2.14 Vigor index I

EC-538008 (1627.53) and IC-267181 (369.67) registered highest and lowest vigor index I respectively among parents. The cross EC-538008 x IC-208375 (2206.30) exhibited highest vigor index I and lowest was recorded by IC-267151 x NBP-82 (318.83).

4.3.2.15 Vigor index II

IC-208375 (49247.07) and IC-424895 (4937.07) registered highest and lowest vigor index II respectively among parents. The cross IC-424896 x NBP-82 (40558.33) exhibited highest vigor index II and lowest was recorded by IC-417586 x IC-208375 (15095.0).

4.3.2.16 Electrical conductivity (µs/gm)

The parents IC-208385 (36.17) and IC-424895 (28.20) recorded maximum electrical conductivity and minimum was in NBP-82 (5.43). Hybrid IC-267162 x IC-208375 recorded maximum electrical conductivity (31.71).

4.3.2.17 Viability percentage

The highest viability percentage was recorded by parents EC-538008 (96.40) and IC-208375 (95.11), while hybrids IC-208366 x IC-208375 (100.0) and EC-538008 x IC-208375 (99.80) exhibited viability percentage.

Table No: 4.3 (d) **Mean performance of parents (line x testers) and hybrids for the laboratory characters in pea**

Characters / Treatments	1	2	3	4	5	6
Parents						
Lines						
EC-538008	12.60	86.33	10.73	6.47	12.40	18.87
IC-417878	10.63	67.33	10.50	2.38	6.83	9.21
IC-208366	12.60	70.00	10.49	2.01	6.77	8.79
IC-267127	11.84	72.67	10.45	4.11	5.20	9.31
DMR-7	12.46	77.33	10.44	5.36	10.41	15.60
IC-424886	11.57	71.33	10.36	1.90	2.11	4.01
IC-267162	13.82	88.67	10.34	5.89	11.35	17.25
IC-417586	11.83	68.67	10.17	3.47	5.73	8.47
IC-267151	11.87	76.00	10.17	3.17	5.05	8.21
IC-208364	11.28	75.33	10.01	3.79	7.51	11.29
EC-398599	13.87	85.67	9.84	3.78	7.41	11.19
IC-424895	11.05	81.67	9.63	2.90	3.80	6.27
DMR-11	11.89	60.33	9.43	2.21	4.12	6.33
IC-208385	13.80	79.67	9.39	5.69	6.40	11.85
EC-342007	12.85	65.33	9.33	2.73	4.27	7.00
EC-538004	9.51	61.67	9.27	3.67	5.23	8.90
IC-424896	10.23	84.33	9.06	1.93	3.73	6.17
IC-267181	12.24	52.67	8.97	2.53	4.74	6.93
IC-208368	13.25	62.67	8.01	3.10	6.00	9.10
EC-538005	10.67	54.00	6.92	3.13	6.00	8.34
Testers						
IC-208375	16.24	86.67	15.25	8.35	14.57	22.91
EC-398602	15.08	88.67	14.65	8.59	14.81	23.30
NBP-82	14.33	87.67	14.18	9.83	22.52	32.35
Hybrids						
EC-538008 x IC-208375	13.04	94.67	16.90	7.83	14.59	23.07
IC-417878 x IC-208375	13.06	91.67	12.91	9.61	16.83	20.49
IC-208366 x IC-208375	11.98	97.33	10.46	8.79	13.64	22.44
IC-267127 x IC-208375	12.73	66.67	13.56	4.15	9.51	13.66
DMR-7 x IC-208375	12.79	87.67	9.53	3.38	9.16	12.54
IC-424886 x IC-208375	11.59	84.33	9.96	3.15	9.04	10.49
IC-267162 x IC-208375	12.04	66.00	9.25	3.76	4.97	8.73
IC-417586 x IC-208375	12.06	60.00	9.06	2.70	6.16	8.86
IC-267151 x IC-208375	11.52	68.00	8.64	2.34	5.07	7.41
IC-208364 x IC-208375	12.41	71.33	11.17	5.22	6.55	11.77
EC-398599 x IC-208375	12.94	74.33	9.37	5.53	7.08	12.61
IC-424895 x IC-208375	13.91	84.00	9.58	4.74	6.32	11.06
DMR-11 x IC-208375	14.22	76.67	10.73	4.81	11.09	15.90
IC-208385 x IC-208375	13.42	75.00	10.31	4.86	11.58	16.44
EC-342007 x IC-208375	14.31	98.67	11.11	5.48	8.41	17.68
EC-538004 x IC-208375	13.96	74.00	11.87	2.79	4.96	7.75
IC-424896 x IC-208375	12.76	69.67	10.76	2.91	7.58	10.49
IC-267181 x IC-208375	12.99	70.00	12.26	2.72	3.42	6.14
IC-208368 x IC-208375	13.76	100.0	10.91	8.18	13.04	21.23
EC-538005 x IC-208375	14.60	95.33	11.17	5.80	13.20	19.01

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Characters / Treatments	1	2	3	4	5	6
EC-538008 x EC-398602	14.35	97.67	10.63	7.43	12.67	20.11
IC-417878 x EC-398602	13.94	69.33	12.95	3.84	6.37	10.21
IC-208366 x EC-398602	12.85	68.33	8.03	3.44	7.26	10.69
IC-267127 x EC-398602	12.94	68.00	9.84	5.40	7.10	12.50
DMR-7 x EC-398602	12.20	97.00	11.40	5.21	5.78	11.92
IC-424886 x EC-398602	12.47	76.33	11.32	4.87	6.00	10.88
IC-267162 x EC-398602	13.52	95.33	11.21	4.01	5.57	9.58
IC-417586 x EC-398602	11.79	75.33	10.46	3.51	7.81	12.88
IC-267151 x EC-398602	12.49	93.67	9.70	4.96	9.96	14.92
IC-208364 x EC-398602	12.04	92.33	10.35	5.34	9.23	14.57
EC-398599 x EC-398602	14.33	95.67	10.43	4.69	8.17	12.85
IC-424895 x EC-398602	14.03	94.33	8.47	3.85	7.61	11.47
DMR-11 x EC-398602	14.60	93.67	10.93	6.15	8.60	14.75
IC-208385 x EC-398602	11.80	95.33	10.34	5.01	6.96	11.97
EC-342007 x EC-398602	11.19	82.33	11.39	5.40	6.66	12.06
EC-538004 x EC-398602	11.09	92.00	10.85	2.16	4.04	6.20
IC-424896 x EC-398602	12.38	66.67	9.45	3.25	6.55	9.81
IC-267181 x EC-398602	11.98	65.67	10.51	4.34	5.45	9.78
IC-208368 x EC-398602	12.06	66.33	10.57	3.44	4.75	8.19
EC-538005 x EC-398602	14.34	94.00	9.24	8.26	10.46	18.72
EC-538008 x NBP-82	14.26	92.00	10.94	6.22	9.57	15.78
IC-417878 x NBP-82	14.51	97.67	10.21	5.28	5.43	10.71
IC-208366 x NBP-82	13.66	67.67	9.92	4.11	5.13	9.24
IC-267127 x NBP-82	13.29	68.67	10.64	4.23	5.31	9.55
DMR-7 x NBP-82	12.91	86.00	9.32	3.80	5.17	8.97
IC-424886 x NBP-82	9.31	62.67	7.51	3.15	3.80	6.95
IC-267162 x NBP-82	9.31	61.33	7.73	3.62	5.04	8.96
IC-417586 x NBP-82	9.24	66.33	7.78	2.65	4.39	7.04
IC-267151 x NBP-82	10.12	57.00	8.83	2.08	3.51	5.59
IC-208364 x NBP-82	10.01	57.67	9.16	2.59	4.64	7.23
EC-398599 x NBP-82	9.99	70.00	9.09	2.06	3.57	5.63
IC-424895 x NBP-82	13.18	69.67	9.46	4.19	5.10	9.29
DMR-11 x NBP-82	12.49	57.67	9.08	2.61	3.90	6.51
IC-208385 x NBP-82	13.07	70.33	9.22	2.45	4.46	6.91
EC-342007 x NBP-82	14.46	77.67	10.56	3.52	5.73	9.25
EC-538004 x NBP-82	13.45	75.33	11.31	4.19	6.91	11.09
IC-424896 x NBP-82	13.43	85.00	9.78	2.88	8.06	10.94
IC-267181 x NBP-82	11.30	68.67	8.33	3.99	6.36	10.35
IC-208368 x NBP-82	10.69	57.67	8.20	3.36	5.83	9.19
EC-538005 x NBP-82	11.03	66.00	7.41	4.66	5.74	10.40
S.Em±	0.20	5.97	0.57	0.74	2.26	3.16

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)

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Characters / Treatments	7	8	9	10	11	12
Parents						
Lines						
EC-538008	3.84	320.00	1627.53	27570.33	21.63	96.40
IC-417878	1.98	440.00	621.10	29710.20	26.20	76.07
IC-208366	2.07	266.67	614.97	18666.90	11.40	77.29
IC-267127	2.02	300.00	675.00	21840.33	16.00	83.74
DMR-7	2.32	380.00	1207.90	29430.53	22.10	93.11
IC-424886	1.84	391.00	286.03	27823.50	24.43	79.18
IC-267162	3.84	386.67	1529.33	34580.36	20.03	81.33
IC-417586	1.88	423.33	557.23	29057.07	16.03	76.51
IC-267151	2.44	264.00	623.37	20073.80	16.47	91.22
IC-208364	2.49	306.67	849.67	23173.43	13.13	93.70
EC-398599	2.67	300.00	958.40	25707.03	24.23	78.18
IC-424895	2.00	183.33	512.37	14937.07	28.20	73.74
DMR-11	3.27	540.00	382.73	32583.33	13.63	77.14
IC-208385	1.87	255.33	942.03	20380.33	36.17	86.29
EC-342007	2.15	370.00	459.93	24163.80	23.43	84.82
EC-538004	2.08	296.67	550.83	18320.33	13.53	81.48
IC-424896	1.96	448.33	474.70	37817.33	24.07	83.49
IC-267181	2.19	320.00	369.67	16787.30	20.17	83.22
IC-208368	1.84	454.00	611.40	28460.33	26.50	90.04
EC-538005	2.15	510.33	481.07	27580.63	21.50	85.08
Testers						
IC-208375	4.11	566.67	976.86	49247.07	6.63	95.11
EC-398602	6.80	472.67	927.19	41963.57	7.63	91.74
NBP-82	4.52	320.00	948.46	32226.80	5.43	94.11
Hybrids						
EC-538008 x IC-208375	4.47	356.00	2206.30	34058.67	15.07	99.80
IC-417878 x IC-208375	3.97	326.67	1938.47	31028.00	16.53	97.67
IC-208366 x IC-208375	4.03	336.33	2185.17	32738.33	12.43	100.0
IC-267127 x IC-208375	2.71	481.00	895.17	32063.33	21.67	80.23
DMR-7 x IC-208375	2.36	458.33	1100.20	40184.67	22.47	81.10
IC-424886 x IC-208375	2.07	458.67	877.33	38659.33	18.63	86.07
IC-267162 x IC-208375	2.39	283.00	576.10	18680.67	31.70	71.77
IC-417586 x IC-208375	2.39	251.33	533.73	15095.00	31.67	70.90
IC-267151 x IC-208375	1.95	242.00	503.87	16468.00	26.60	74.63
IC-208364 x IC-208375	2.78	349.33	840.03	24916.00	12.47	86.77
EC-398599 x IC-208375	2.69	303.00	937.17	22523.00	13.57	82.73
IC-424895 x IC-208375	2.18	323.33	928.43	27159.33	7.00	89.40
DMR-11 x IC-208375	3.37	399.33	1219.33	30616.00	18.00	95.20
IC-208385 x IC-208375	2.84	387.00	1233.43	29024.33	17.97	93.37
EC-342007 x IC-208375	2.56	391.33	1745.30	38609.00	10.33	99.33
EC-538004 x IC-208375	2.43	401.33	574.13	29697.33	21.30	93.30
IC-424896 x IC-208375	2.46	396.33	734.73	27744.33	21.10	92.03
IC-267181 x IC-208375	1.94	406.67	429.67	28462.67	13.77	98.43
IC-208368 x IC-208375	3.88	392.33	2122.67	39233.33	15.07	85.50
EC-538005 x IC-208375	4.11	395.00	1819.23	37789.67	16.73	82.83

Continued.....

Characters / Treatments	7	8	9	10	11	12
EC-538008 x EC-398602	3.93	399.67	1967.03	39038.00	11.17	88.17
IC-417878 x EC-398602	2.14	448.00	705.93	30916.00	15.10	79.87
IC-208366 x EC-398602	2.20	434.00	735.33	29797.67	16.23	78.70
IC-267127 x EC-398602	2.00	444.00	849.73	30197.33	10.13	83.10
DMR-7 x EC-398602	2.67	292.00	1154.87	28311.67	10.57	95.60
IC-424886 x EC-398602	2.78	270.33	833.63	20724.00	13.77	93.63
IC-267162 x EC-398602	2.61	277.00	913.47	26402.33	9.33	99.13
IC-417586 x EC-398602	3.33	335.33	969.83	25255.33	9.43	96.17
IC-267151 x EC-398602	3.10	313.67	1402.43	29481.33	11.33	94.97
IC-208364 x EC-398602	2.59	322.00	1345.33	29736.33	7.27	98.30
EC-398599 x EC-398602	2.75	371.00	1258.17	36698.00	16.37	81.83
IC-424895 x EC-398602	2.92	316.67	1084.00	29872.00	18.43	80.63
DMR-11 x EC-398602	2.79	325.33	1379.90	30472.67	10.23	82.13
IC-208385 x EC-398602	2.23	192.33	1141.53	18332.00	25.87	77.60
EC-342007 x EC-398602	2.57	189.67	993.00	15621.67	28.43	78.53
EC-538004 x EC-398602	2.15	188.00	571.03	17297.33	21.77	82.03
IC-424896 x EC-398602	3.54	571.67	655.00	37910.67	10.87	79.43
IC-267181 x EC-398602	3.57	551.67	642.10	36232.67	13.07	78.40
IC-208368 x EC-398602	3.23	550.67	542.77	36527.33	7.87	84.30
EC-538005 x EC-398602	2.17	269.67	1763.67	25372.00	27.47	91.00
EC-538008 x NBP-82	2.24	263.00	1214.13	24194.00	29.00	91.23
IC-417878 x NBP-82	2.02	265.00	1049.50	25875.33	22.53	92.40
IC-208366 x NBP-82	2.55	392.33	625.20	26547.67	25.57	82.20
IC-267127 x NBP-82	2.54	374.33	652.53	25701.67	28.40	80.70
DMR-7 x NBP-82	1.96	385.33	769.67	33128.67	24.77	85.50
IC-424886 x NBP-82	2.42	270.67	435.90	16951.67	24.70	80.53
IC-267162 x NBP-82	2.36	291.33	531.30	17872.67	23.40	78.60
IC-417586 x NBP-82	1.82	282.00	466.20	18718.67	19.43	83.30
IC-267151 x NBP-82	2.30	426.00	318.83	24288.00	28.77	79.77
IC-208364 x NBP-82	1.86	431.67	416.63	24885.67	29.67	79.07
EC-398599 x NBP-82	1.60	424.67	392.47	29718.00	24.73	81.73
IC-424895 x NBP-82	2.67	344.00	446.90	23973.33	12.73	89.63
DMR-11 x NBP-82	2.46	329.33	375.63	18995.00	14.10	86.93
IC-208385 x NBP-82	2.37	335.33	433.63	21236.00	8.17	95.33
EC-342007 x NBP-82	2.23	468.67	716.03	37024.67	25.63	88.50
EC-538004 x NBP-82	2.04	463.67	835.77	34931.67	28.47	87.10
IC-424896 x NBP-82	2.10	477.00	930.63	40558.33	21.47	93.80
IC-267181 x NBP-82	2.76	533.67	711.67	36622.00	17.90	88.77
IC-208368 x NBP-82	2.44	513.33	530.30	29603.00	19.87	86.57
EC-538005 x NBP-82	2.34	526.33	688.10	34728.67	13.93	91.23
S.E m±	0.19	16.56	113.30	1471.20	2.47	0.778

7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm)
12= Viability percentage

4.3.3 Heterosis

Heterosis (per cent) over mid parental value (heterosis) and the better parent (heterobeltiosis) was computed for all the yield components in field studies and for vigor index in case of laboratory studies. The results are depicted in Tables 4.3 (e) and 4.3 (f) for field and laboratory characters respectively.

(A) Field studies:

4.3.3.1 Plant height

The significant positive and negative heterosis was observed for mid parent as well as better parent. The heterosis over mid parent ranged from -38.50 to 146.82 of which (IC-417878 x IC-208375) had the highest positive heterosis, whereas hybrid (IC-267181 x IC-208375) had the highest negative heterosis. Thirty three cross combinations showed significant heterosis over mid parent with seven of them in the negative direction. The heterosis over better parent ranged from -34.27 to 256.96 of which hybrid (EC-538008 x IC-208375) had the maximum positive heterosis. Forty two cross combinations showed significant heterosis over better parent with five of them in the negative direction.

4.3.3.2 Pods per plant

Both heterosis over mid parent and better parent were highly significant for most of the hybrids. The maximum positive heterosis percentage over mid parent was observed in hybrid IC-208368 x EC-398602 (208.47) and maximum negative heterosis percentage was observed in hybrid IC-417586 x NBP-82 (-37.69). Forty two cross combinations showed significant heterosis over mid parent with five of them in the negative direction. The highest heterosis percentage over better parent was exhibited by hybrid IC-208368 x EC-398602 (368.69) and DMR-11 x NBP-82 (362.26). Fifty cross combinations showed significant heterosis over better parent with six of them in the negative direction.

4.3.3.3 Pod length

F1 hybrids for the maximum number of crosses showed significant heterosis over mid parent and better parent for pod length. However, the highest positive heterosis over mid parent was noticed in the hybrid IC-267151 x EC-398602 (63.58) and the hybrid DMR-7 x NBP-82 (-28.60) exhibited maximum negative heterosis. Fifty four cross combinations showed significant heterosis over mid parent with only one of them in the negative direction. The maximum positive and negative heterosis over better parent was noticed in the hybrids IC-208366 x NBP-82 (96.97) and DMR-

11 x NBP-82 (-19.17) respectively. Sixty cross combinations showed significant heterosis over better parent with one of them in the negative direction.

4.3.3.4 Seeds per pod

Heterosis over both mid and better parent was found to be highly significant. The hybrids EC-342007 x IC-208375 (114.78) and IC-424895 x IC-208375 (137.11), recorded maximum positive heterosis over mid and better parent respectively. While, the hybrids IC-424886 x NBP-82 (-26.35) and IC-424886 x NBP-82 (-25.90) was found to exhibit maximum negative heterosis over mid and better parent respectively. Fifty seven cross combinations showed significant heterosis over mid parent with two of them in the negative direction. Sixty cross combinations showed significant heterosis over better parent with two of them in the negative direction.

4.3.3.5 Seed yield per plant

Significant mid parent heterosis and heterobeltiosis were observed in most of the hybrids. The highest positive heterosis over mid (96.47) and better parent (157.95) was exhibited in the hybrid IC-208364 x IC-208375. However, the maximum negative heterosis over mid parent was observed in the hybrid IC-208368 x NBP-82 (-30.0).The hybrid IC-424896 x EC-398602 (-22.49) exhibited maximum, negative heterosis over better parent. Fifty three cross combinations showed significant heterosis over mid parent with ten of them in the negative direction. Fifty seven cross combinations showed significant heterosis over better parent with four of them in negative the direction.

Table No: 4.3 (e) **Heterosis (%) over mid parent (MP) and better parent (BP) for the field characters in pea**

Crosses	1		2		3		4		5	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
EC-538008 x IC-208375	124.21b	256.96b	33.33a	78.75b	34.78a	64.39b	66.04b	76.00b	8.22a	63.66b
IC-417878 x IC-208375	146.82b	234.77b	18.50a	18.13a	29.81a	37.87b	32.65b	35.42b	15.77a	74.80b
IC-208366 x IC-208375	56.96a	205.26b	146.03b	345.94b	10.70a	11.58a	2.02	29.90b	-14.71a	70.15b
IC-267127 x IC-208375	25.93a	44.74a	49.92a	79.74b	14.18a	15.91a	29.71b	40.00b	19.13a	20.63a
DMR-7 x IC-208375	15.23	16.29a	64.11a	176.10b	46.89b	64.71b	19.72a	20.14b	-17.27a	-16.34a
IC-424886 x IC-208375	29.11a	75.48b	47.24a	55.85a	21.58a	47.06b	32.23b	64.95b	-10.25a	12.81a
IC-267162 x IC-208375	19.82a	96.00b	28.24a	32.53a	34.04a	53.33b	69.49b	96.85b	33.31a	62.15b
IC-417586 x IC-208375	24.49a	73.12b	27.80a	79.25b	36.87a	37.28b	33.58b	42.52b	30.97a	59.53b
IC-267151 x IC-208375	42.47a	185.32b	-11.46	9.06	16.80a	24.71a	83.93b	112.37b	2.89	1.36
IC-208364 x IC-208375	18.31a	48.14a	47.99a	20.40a	32.78a	82.58b	54.95b	56.36b	96.46b	157.95b
EC-398599 x IC-208375	40.30a	104.72b	51.19a	179.56b	36.50a	61.54b	30.74b	40.28b	39.38a	83.28b
IC-424895 x IC-208375	3.85	10.97	8.72	9.88	13.21a	24.35a	75.57b	137.11b	31.05a	37.67b
DMR-11 x IC-208375	-0.09	7.36	-15.51	20.45a	28.53a	62.12b	59.85b	106.60b	91.79b	125.55b
IC-208385 x IC-208375	1.47	7.04	-1.67	103.14b	36.76a	49.70b	37.60b	62.26b	29.66a	52.70b
EC-342007 x IC-208375	-37.09a	-20.72a	-31.26a	-24.88a	5.08	7.25a	114.78b	124.74b	20.48a	15.40a
EC-538004 x IC-208375	2.09	25.61a	21.75a	26.95a	21.74a	23.62a	10.47a	13.10a	56.39b	91.96b
IC-424896 x IC-208375	2.98	10.47	29.71a	83.96b	36.49a	59.06b	10.00a	22.22b	29.43a	59.09b
IC-267181 x IC-208375	-38.50a	-9.82	63.20a	98.97b	35.63a	70.87b	30.40b	83.51b	20.32a	21.23a
IC-208368 x IC-208375	-0.58	5.65	26.40a	31.20a	30.92a	39.32b	10.91a	12.96a	90.49b	124.25b
EC-538005 x IC-208375	2.53	9.36	82.89a	135.22b	60.14b	95.73b	23.53b	31.25b	25.16a	47.55b
EC-538008 x EC-398602	-22.98a	-4.16	113.73b	186.40b	36.13a	80.34b	60.62b	114.43b	8.70a	13.61a
IC-417878 x EC-398602	2.19	5.85	21.12a	29.00a	38.91a	44.70b	-2.39	14.40a	2.61	57.82b
IC-208366 x EC-398602	1.25	10.86	10.15	60.38a	46.15b	59.44b	4.83a	12.80a	-12.73a	34.01b
IC-267127 x EC-398602	-33.22a	-19.26a	19.61a	42.43a	44.05b	69.23b	53.15b	75.26b	-11.76a	79.39b
DMR-7 x EC-398602	10.47	66.79a	71.23a	121.89b	37.58a	55.30b	25.61b	52.99b	41.55b	52.27b
IC-424886 x EC-398602	3.03	33.10a	78.96a	84.59b	42.09b	43.37b	24.14b	38.46b	12.20a	20.86a
IC-267162 x EC-398602	51.80a	178.71b	-7.81	60.65a	35.38a	46.39b	38.32b	52.58b	30.40a	48.81b
IC-417586 x EC-398602	6.34	61.25a	28.44a	33.46a	45.64b	64.39b	26.13b	27.27b	34.45a	48.09b
IC-267151 x EC-398602	21.33a	57.37a	40.09a	97.80a	63.58b	65.06b	32.04b	41.67b	43.40b	58.16b
IC-208364 x EC-398602	49.19a	175.22b	24.51a	52.41a	28.13a	38.55b	40.46b	89.69b	20.15a	33.82b

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Crosses	1		2		3		4		5	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
EC-398599 x EC-398602	4.51	4.56	4.42	14.13	31.16a	37.12b	3.23	12.68a	61.70b	139.19b
IC-424895 x EC-398602	-8.50	-18.34a	80.33a	171.07b	44.41b	56.94b	6.29a	7.04a	62.20b	140.32b
DMR-11 x EC-398602	-1.30	14.70a	7.17	24.14a	13.95a	33.33a	38.91b	71.13b	39.03a	61.71b
IC-208385 x EC-398602	10.33	16.00a	-33.68a	-24.47a	17.93a	29.55a	45.06b	50.64b	17.50a	22.96a
EC-342007 x EC-398602	-4.27	-10.75	-1.22	14.78a	27.22a	31.65a	22.00b	27.08b	13.08a	18.48a
EC-538004 x EC-398602	17.40a	44.33a	-32.43a	11.9	-3.13	7.59a	49.41b	94.85b	27.67a	50.09b
IC-424896 x EC-398602	48.20a	48.37a	45.05a	67.23a	5.70	54.55b	12.50a	18.42b	-27.32a	-22.49a
IC-267181 x EC-398602	62.98a	85.66b	30.68a	50.00a	14.42a	43.20b	14.19a	17.36b	-12.54a	-6.84a
IC-208368 x EC-398602	9.88	27.45a	208.47b	368.69b	-5.15	9.84a	73.49b	122.68b	-27.94a	-3.68
EC-538005 x EC-398602	12.16	14.26a	39.19a	52.43a	32.88a	46.97b	39.39b	41.98b	-3.35	11.47a
EC-538008 x NBP-82	7.06	19.33a	65.45a	100.31b	53.19b	57.50b	26.14b	34.03b	-6.77	7.38a
IC-417878 x NBP-82	20.61a	43.08a	-20.43a	13.72	35.98a	50.00b	76.06b	135.05b	8.05	58.27b
IC-208366 x NBP-82	57.36a	90.02b	55.48a	63.57a	38.30a	96.97b	15.92a	16.97b	75.64b	97.75b
IC-267127 x NBP-82	105.24b	116.50b	64.47a	135.85b	-0.73	21.30a	28.16b	37.50b	28.78a	45.20b
DMR-7 x NBP-82	39.23a	99.96b	58.02a	90.74b	-28.60a	-19.17a	39.69b	88.66b	-19.23a	-11.97a
IC-424886 x NBP-82	0.21	2.65	-27.79a	49.71a	29.24a	35.61b	-26.35b	-25.90b	40.36a	50.14b
IC-267162 x NBP-82	3.84	15.06a	19.43a	70.76a	33.12a	44.14b	-12.26a	-5.56a	36.17a	45.46b
IC-417586 x NBP-82	-34.47a	-21.77a	-37.69a	84.21b	20.71a	40.69b	20.91b	63.92b	26.50a	69.67b
IC-267151 x NBP-82	-9.08	-5.88	83.21a	179.93b	34.52a	43.18b	20.26b	30.77b	53.14b	118.85b
IC-208364 x NBP-82	-8.36	0.41	71.49a	283.96b	61.64b	72.48b	6.62a	6.99a	71.15b	144.98b
EC-398599 x NBP-82	-45.59a	-34.27a	41.52a	63.93a	37.43a	57.72b	25.83b	55.67b	12.60a	27.14a
IC-424895 x NBP-82	1.07	12.59	60.19a	187.92b	35.53a	56.06b	11.19a	34.75b	38.62a	49.98b
DMR-11 x NBP-82	2.04	4.01	71.53a	362.26b	39.00a	40.24b	12.98a	25.42b	-5.48	2.40
IC-208385 x NBP-82	-32.87a	-11.90	22.63a	63.21a	5.21	11.63a	44.19b	59.79b	64.20b	46.80b
EC-342007 x NBP-82	61.91a	88.21b	33.09a	35.69a	25.34a	38.64b	30.17b	51.18b	76.86b	121.61b
EC-538004 x NBP-82	90.15a	93.85b	47.55a	103.46b	36.78a	40.62b	12.92a	20.47b	69.59b	122.82b
IC-424896 x NBP-82	35.72a	86.81b	38.38a	73.17b	21.81a	34.37b	37.50b	58.76b	39.66a	41.04b
IC-267181 x NBP-82	23.68a	65.31a	27.65a	43.31a	44.40b	51.52b	15.05a	31.30b	16.90a	79.19b
IC-208368 x NBP-82	29.99a	50.27a	44.53a	124.53b	35.67a	46.90b	6.91a	12.21a	-30.00a	7.12a
EC-538005 x NBP-82	38.72a	122.90b	-14.04	-3.13	24.85a	45.52b	68.42b	97.94b	7.38	117.47b
C.D at 5%	16.76	13.58	17.66	14.35	8.25	6.82	3.97	3.23	8.08	6.61
C.D at 1%	84.03	68.11	88.48	71.93	41.37	33.73	19.92	16.23	40.61	33.10

a, b :- Significant at 5% and 1% probability respectively

1= Plant height (cm) 3= Pod length (cm) 5= Seed yield per plant (gm)
2= Pods per plant 4= Seeds per pod

(B) Laboratory studies:

4.3.3.6 100 Seed weight

Significant mid parent heterosis and heterobeltiosis were observed in most of the crosses. The highest positive heterosis over mid and better parent was noticed in the hybrid IC-424886 x NBP-82 (27.72) and EC-538004 x IC-208375 (20.66) respectively. Whereas the maximum negative heterosis was observed in the hybrid EC-538008 x IC-208375 (-9.58) and EC-267151 x IC-208375 (-8.57) respectively. Forty two cross combinations showed significant heterosis over mid parent with nineteen of them in the negative direction. Forty one cross combinations showed significant heterosis over better parent with four of them in the negative direction. [Table 4.3 (f)]

4.3.3.7 Germination percentage

Majority of the hybrids exhibited significant heterosis over mid and better parent for this trait. The hybrid IC-267151 x NBP-82 (33.33) and DMR-7 x IC-208375 (30.20) exhibited the highest positive significant heterosis over mid and better parent respectively. While, the hybrid IC-208375 x IC-208375 (-9.64) and IC-208364 x NBP-82 (-31.00) gave the maximum significant negative heterosis over mid and better parent respectively. Forty-eight cross combinations showed significant heterosis over mid parent with three of them in the negative direction. Forty cross combinations showed significant heterosis over better parent with twenty-six of them in the negative direction.

4.3.3.8 Speed of germination

Heterosis over both mid and better parent was found to be highly significant. The hybrid IC-424886 x NBP-82 (38.76) and EC-538008 x IC-208375 (57.47) was recorded maximum positive heterosis over mid and better parent respectively. While, the hybrids EC-342007 x IC-208375 (-9.72) and IC-208366 x EC-398602 (-21.01) was noticed maximum negative heterosis over mid and better parent respectively. Fifty-four cross combinations showed significant heterosis over mid parent with eight of them in the negative direction. Fifty-five cross combinations showed significant heterosis over better parent with eleven of them in the negative direction

4.3.3.9 Seedling root length

Majority of the F1 hybrids showed significant heterosis over mid and better parent for seedling root length. However, maximum positive heterosis over mid (66.07) and better (96.53) parent was exhibited in the hybrids EC-538004 x EC-

398602 and IC-267181 x EC-398602 respectively. While highest negative heterosis was noticed in the hybrids DMR-11 x EC-398602 and IC-417586 x NBP-82 over mid (-9.60) and better (-27.95) parent respectively. Fifty-seven cross combinations showed significant heterosis over mid parent with two of them in the negative direction. Fifty-three cross combinations showed significant heterosis over better parent with eight of them in the negative direction

4.3.3.10 Seedling shoot length

Majority of the hybrids noticed significant heterosis over mid and better parent for this trait. Maximum positive heterosis was recorded over mid parent (72.77) and better parent (258.83) in the hybrids EC-398599 x NBP-82 and IC-424896 x IC-208375 respectively. Whereas, the hybrid IC-424886 x NBP-82 noticed maximum negative heterosis better parent (-27.33). Fifty-four cross combinations showed significant heterosis over mid parent with none of them in the negative direction. Forty-seven cross combinations showed significant heterosis over better parent with eight of them in the negative direction.

4.3.3.11 Total seedling length

Both heterosis over mid and better parent noticed highly significant for most of the hybrids. The hybrids EC-398599 x NBP-82 and IC-424896 x IC-208375 noticed positive heterosis over mid parent (70.75) and better parent (161.46) respectively. Whereas the hybrids EC-538005 x IC-208375 and IC-267127 x IC-208375 exhibited negative heterosis over mid (-6.25) and better (-15.64) parent respectively. Only thirteen cross combinations showed significant heterosis over mid parent with one of them in the negative direction. Nineteen cross combinations showed significant heterosis over better parent with six of them in the negative direction.

4.3.3.12 Fresh seedling weight

Heterosis over both mid and better parent was found highly significant. The maximum positive heterosis over mid parent (12.36) and better parent (45.61) was registered in the hybrids EC-538008 x IC-208375 and DMR-11 x IC-208375 respectively. Whereas, the hybrids IC-208364 x NBP-82 and EC-398599 x NBP-82 recorded the highest negative heterosis over mid (-57.50) and better (-18.40) parent respectively. Fifty-eight cross combinations showed significant heterosis over mid parent with two of them in the negative direction. Sixty cross combinations showed significant heterosis over better parent with six of them in the negative direction.

4.3.3.13 Dry seedling weight

Significant negative and positive heterosis was observed for mid and better parent for this trait. The hybrids IC-208368 x EC-398602 noticed maximum positive heterosis over mid (28.06) and better (72.08) parent. The highest negative heterosis over mid (-48.71) and better (-9.25) parent was noticed in the hybrids IC-208385 x EC-398602 and IC-267151 x IC-208375 respectively. Forty cross combinations showed significant heterosis over mid parent with ten of them in the negative direction. Twenty-three cross combinations showed significant heterosis over better parent with two of them in the negative direction.

4.3.3.14 Vigor Index I

Mid parent heterosis and heterobeltiosis was highly significant for this trait. Among all the hybrids maximum positive heterosis over mid (22.18) and better (156.87) parent were noticed in the hybrids EC-538008 x IC-208375 and IC-424896 x IC-208375 respectively. However, the highest negative heterosis over mid (-76.30) and better (-32.83) parent was exhibited in the hybrids EC-398599 x NBP-82 and IC-267151 x NBP-82 respectively. Fifty-one cross combinations showed significant heterosis over mid parent with three of them in the negative direction. Forty-seven cross combinations showed significant heterosis over better parent with five of them in the negative direction.

4.3.3.15 Vigor Index II

Some of the F1 hybrids showed significant heterosis over mid and better parent for vigor index II. The maximum positive heterosis over better parent (42.81) was exhibited in the hybrid IC-424895 x NBP-82, while highest negative heterosis was noticed in the hybrids IC-417586 x IC-208375 and IC-267151 x NBP-82 over mid (-50.21) and better (-35.78) parent respectively. Seven cross combinations showed significant heterosis over mid parent with none of them in the positive direction. Thirteen cross combinations showed significant heterosis over better parent with two of them in the negative direction.

4.3.3.16 Electrical conductivity (µs/gm)

Significant negative and positive heterosis was observed for mid and better parent for this trait. The hybrids IC-267162 x IC-208375 and IC-267151 x IC-208375 noticed maximum positive heterosis over mid (251.57) and better (389.57) parent respectively. The highest negative heterosis over mid (-36.20) parent was noticed in the hybrid IC-208385x NBP-82. Fifty-seven cross combinations showed significant

heterosis over mid parent with thirteen of them in the negative direction. All cross combinations showed significant heterosis over better parent.

4.3.3.17 Viability percentage

Mid parent heterosis and heterobeltiosis was highly significant for this trait. Among all the hybrids maximum positive heterosis over mid (13.60) and better (24.31) parent were noticed in the hybrid IC-267181 x IC-208375. However, the highest negative heterosis over mid (-29.70) and better (-15.64) parent was exhibited in the hybrids IC-208364 x IC-208375 and IC-267127 x IC-208375 respectively. Thirteen cross combinations showed significant heterosis over mid parent with one of them in the negative direction. Nineteen cross combinations showed significant heterosis over better parent with six of them in the negative direction.

Table No: 4.3 (f) **Heterosis (%) over mid parent (MP) and better parent (BP) for the laboratory characters in pea**

Crosses	1		2		3		4		5		6	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
EC-538008 x IC-208375	-9.58a	3.49a	9.44a	9.65a	30.06a	57.47b	5.67	21.03a	8.18	17.63a	10.42a	2.26
IC-417878 x IC-208375	-5.65a	3.62a	4.76	6.18a	1.71	20.29a	27.64a	48.56b	23.66a	35.70a	-2.81	8.60a
IC-208366 x IC-208375	10.99a	-4.89a	11.88a	12.74a	16.01a	-2.52	7.89a	35.98b	21.86a	10.03a	12.39a	18.92b
IC-267127 x IC-208375	-5.27a	19.76b	13.42a	-0.99	5.32	29.13b	22.56a	74.51b	11.09a	39.31a	14.92b	48.41b
DMR-7 x IC-208375	-0.45	20.39b	12.39a	30.20b	24.20a	-9.24a	38.30a	42.16b	15.37a	34.13a	22.85b	36.21b
IC-424886 x IC-208375	-7.08a	9.10a	8.82a	25.25b	19.26a	-5.14	48.47b	32.21b	38.39a	32.42a	49.53b	13.90b
IC-267162 x IC-208375	16.54a	-4.47a	15.74a	-5.71	28.11a	-11.79a	27.48a	86.59b	53.42b	-26.62a	44.94b	-0.68
IC-417586 x IC-208375	12.87a	-4.31a	24.37b	-14.29b	27.92a	-13.63a	49.06b	34.11b	42.90a	-9.01a	44.75b	0.87
IC-267151 x IC-208375	14.43a	-8.57a	13.74a	-2.86	29.97a	-17.67a	60.55b	16.06a	65.38b	-25.15a	63.99b	-15.71b
IC-208364 x IC-208375	11.65a	4.76a	10.46a	-1.83	13.07a	6.89a	16.22a	27.03a	33.73a	25.96a	26.96b	26.43b
EC-398599 x IC-208375	-3.86	9.26a	-7.85a	2.29	25.38a	-10.40a	12.92a	34.58b	29.25a	36.15a	22.67b	35.46b
IC-424895 x IC-208375	6.33a	17.48b	4.78	15.60b	22.18a	-8.32a	32.04a	15.34a	54.38b	21.60a	46.90b	18.84b
DMR-11 x IC-208375	-0.91	14.16a	-6.50	-0.86	16.49a	2.78	29.82a	-10.26a	11.16a	6.60	17.41b	1.94
IC-208385 x IC-208375	-2.52	7.73a	-9.64a	-3.02	17.78a	-1.18	30.31a	-9.33a	-8.17	11.27a	15.48b	5.38a
EC-342007 x IC-208375	6.88a	14.91a	19.60b	27.59b	-9.72a	6.45a	27.91a	2.18	48.90a	-19.15a	26.25b	13.35b
EC-538004 x IC-208375	0.3.7	20.66b	-6.33	3.74	-7.28a	14.64a	45.48b	47.02b	40.53a	134.70b	42.41b	93.19b
IC-424896 x IC-208375	-4.19a	10.35a	12.92a	-2.34	13.97a	3.86	44.50b	53.16b	10.40a	258.83b	23.16b	161.46b
IC-267181 x IC-208375	0.33	12.31a	11.95a	-1.87	-0.03	18.41a	53.64b	43.16b	72.26b	61.67b	66.25b	52.91b
IC-208368 x IC-208375	-8.45a	-0.43	14.07a	15.38b	14.74a	5.51	14.93a	38.86b	0.64	14.89a	5.71a	23.08b
EC-538005 x IC-208375	1.01	5.59a	7.52a	7.52a	10.60a	8.03a	19.84a	-1.53	0.92	16.29a	-6.25a	10.20b
EC-538008 x EC-398602	1.98	3.83a	10.78a	11.41a	13.28a	2.80	-5.47	26.13a	25.17a	11.63a	18.92b	16.58b
IC-417878 x EC-398602	-0.70	17.80b	10.73a	-17.33b	1.90	27.37a	35.03a	10.56a	37.19a	11.29a	34.91b	20.63b
IC-208366 x EC-398602	-4.52a	8.56a	13.14a	-20.33b	35.27b	-21.01a	43.01b	-1.06	29.34a	26.72a	32.68b	26.30b
IC-267127 x EC-398602	-1.07	9.35a	13.01a	-19.67b	19.14a	-3.21	18.79a	55.57b	49.73a	23.98a	38.74b	47.68b
DMR-7 x EC-398602	13.22a	2.78	19.26b	10.33a	10.31a	12.13a	-9.44a	64.63b	41.09a	14.46a	23.41b	45.13b
IC-424886 x EC-398602	-7.41a	5.11a	-7.29	-12.33a	-8.80a	11.31a	17.07a	53.89b	39.54a	18.96a	30.97b	32.43b
IC-267162 x EC-398602	3.26	13.96a	16.50a	7.67a	-7.90a	10.23a	38.31a	26.63a	59.61b	10.30a	52.79b	16.60b
IC-417586 x EC-398602	14.35a	4.49a	-7.00	-11.33a	17.18a	4.49	42.09b	-7.22a	29.24a	4.04	24.69b	14.05b
IC-267151 x EC-398602	-5.25a	10.70a	14.23a	5.00	21.31a	-3.10	19.83a	30.99a	10.72a	32.73a	13.72b	32.14b
IC-208364 x EC-398602	-5.96a	6.74a	13.29a	4.67	14.46a	3.33	21.59a	41.02b	38.54a	22.91a	33.25b	28.98b

Crosses	1		2		3		4		5		6	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
EC-398599 x EC-398602	-4.81a	3.32	11.03a	9.00a	16.85a	5.99a	22.70a	23.99a	25.67a	10.26a	24.61b	14.90b
IC-424895 x EC-398602	-3.10	1.11	8.22a	5.67	30.87a	-13.99a	37.68a	1.94	31.47a	2.79	33.50b	2.50
DMR-11 x EC-398602	3.52	5.21a	8.08a	6.00	-9.02a	11.01a	-9.60a	62.79b	42.53a	16.11a	32.23b	31.88b
IC-208385 x EC-398602	13.54a	6.76a	13.27a	8.67a	16.93a	7.30a	10.91a	72.76b	24.17a	83.25b	17.93b	91.06b
EC-342007 x EC-398602	14.38a	1.21	-3.33	-6.33a	-6.22	18.20a	-5.98	86.21b	28.40a	75.35b	18.40b	92.50b
EC-538004 x EC-398602	12.61a	0.33	8.66a	4.33	-8.86a	12.63a	66.07b	-25.22a	69.30b	6.32	67.89b	-1.06
IC-424896 x EC-398602	11.99a	4.12a	-9.30a	-20.00b	23.43a	0.21	38.34a	47.43b	29.86a	59.06b	32.92b	55.01b
IC-267181 x EC-398602	11.17a	0.73	11.86a	-23.00b	12.71a	11.45a	19.64a	96.53b	42.46a	32.20a	33.96b	54.64b
IC-208368 x EC-398602	-8.00a	1.43	10.36a	-21.33b	10.48a	12.05a	42.91b	55.74b	64.31b	15.37a	57.65b	29.45b
EC-538005 x EC-398602	-4.51a	3.96a	13.03a	7.33a	25.04a	-1.63	17.72a	45.25b	-0.25	63.39b	7.67a	57.90b
EC-538008 x NBP-82	-1.22	3.36a	9.31a	3.33	-8.99a	16.51a	12.89a	9.32a	-9.81	49.48b	10.20a	33.16b
IC-417878 x NBP-82	3.21	5.19a	16.73a	10.00a	13.32a	8.77a	32.00a	-7.21a	62.43b	-15.10a	51.55b	-9.65a
IC-208366 x NBP-82	-6.12a	6.28a	10.96a	-19.00b	19.27a	6.36a	25.81a	50.37b	45.52a	20.23a	38.22b	32.00b
IC-267127 x NBP-82	-4.85a	3.40a	10.82a	-20.00b	11.23a	14.08a	25.21a	54.88b	44.30a	24.53a	36.99b	36.38b
DMR-7 x NBP-82	-5.02a	0.44	12.42a	-1.67	20.73a	-0.14	39.47b	39.15b	61.42b	21.09a	54.41b	28.14b
IC-424886 x NBP-82	27.72b	-2.14	15.51a	-24.00b	38.76b	-19.02a	47.59b	-14.25a	61.57b	-27.23a	56.29b	-21.87b
IC-267162 x NBP-82	24.30b	-2.14	18.40b	-27.33b	35.40b	-16.68a	41.00b	-1.54	49.67a	-3.51	44.35b	0.67
IC-417586 x NBP-82	22.50b	-2.87	11.16a	-21.33b	33.62a	-16.07a	60.81b	-27.95a	68.33b	-15.94a	65.87b	-20.90b
IC-267151 x NBP-82	23.56b	-1.11	33.33b	-29.67b	27.34a	-2.50	59.44b	8.13a	61.66b	-5.90	61.55b	-9.35a
IC-208364 x NBP-82	20.90b	-2.18	33.33b	-31.00b	22.70a	1.14	50.67b	34.60b	49.98b	24.42a	50.93b	17.24b
EC-398599 x NBP-82	18.68a	-2.41	18.60b	-17.67b	21.73a	0.37	64.97b	6.92a	72.77b	-4.11	70.75b	-8.65a
IC-424895 x NBP-82	-7.47a	7.65a	0.00	-17.00b	21.92a	5.43	22.92a	65.53b	47.20a	7.52	37.73b	34.12b
DMR-11 x NBP-82	-8.57a	2.01	18.40b	-31.00b	23.09a	1.26	53.12b	2.89	60.08b	-17.65a	56.93b	-6.02a
IC-208385 x NBP-82	-1.64	6.72a	0.24	-17.33b	20.36a	2.75	60.43b	-3.42	67.68b	-5.91	64.83b	0.29
EC-342007 x NBP-82	-1.94	9.13a	4.02	-9.00a	-9.23a	31.85b	38.50a	13.55a	44.25a	-4.44	41.19b	1.68
EC-538004 x NBP-82	-5.06a	1.48	-0.44	-13.33a	-0.16	41.26b	28.35a	35.05b	33.63a	15.11a	31.52b	21.90b
IC-424896 x NBP-82	-2.60	1.36	13.08a	-2.67	11.83a	22.15b	55.46b	-7.10a	43.48a	34.33a	47.22b	20.22b
IC-267181 x NBP-82	16.00a	5.94a	-2.37	-18.00b	24.88a	20.32a	30.49a	27.34a	38.18a	5.94	33.79b	24.06b
IC-208368 x NBP-82	16.99a	0.16	19.16b	-31.00b	24.01a	18.39a	42.72b	7.13a	43.95a	-2.78	41.91b	10.19b
EC-538005 x NBP-82	11.77a	3.34a	-6.82	-21.67b	29.73a	7.08a	28.07a	48.83b	59.75b	-4.33	48.87b	24.74b
C.D at 5%	4.09	3.34	7.42	6.06	6.78	5.54	7.73	6.31	9.93	8.11	5.40	4.41
C.D at 1%	20.49	16.76	17.31	13.99	33.99	27.75	38.76	31.63	49.78	40.69	12.47	10.18

a, b :- Significant at 5% and 1% probability respectively

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)

Continued……..

Crosses	7		8		9		10		11		12	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
EC-538008 x IC-208375	12.36b	16.31b	-19.70b	11.25a	22.18a	35.56b	-11.33	23.53	6.60a	127.14b	4.22	4.93
IC-417878 x IC-208375	-25.38b	3.30a	-17.58b	2.08	4.98	19.10a	-10.75	12.54	12.98b	116.59b	3.82	6.46a
IC-208366 x IC-208375	-3.71a	4.77a	5.10	5.10	-2.12	34.26b	9.50	18.74	-8.13a	128.83b	4.98	6.26
IC-267127 x IC-208375	-11.00b	37.10b	-4.44	9.32a	-31.28b	44.13b	-18.78	7.92	31.98b	226.63b	-6.26	-15.64a
DMR-7 x IC-208375	-46.28b	19.22b	0.44	4.17	-18.09b	77.14b	12.13	35.26a	32.81b	194.32b	-3.34	-11.59a
IC-424886 x IC-208375	-36.17b	4.89a	20.70b	43.33b	-49.27b	41.25b	24.83	30.12a	17.81b	242.94b	1.15	-8.55a
IC-267162 x IC-208375	-22.74b	15.27b	-32.08b	6.13	-55.67b	-6.32	-44.99a	0.07	251.57b	377.89b	-16.74a	-7.15a
IC-417586 x IC-208375	-46.04b	15.43b	-32.01b	-5.75	-60.17b	-13.21	50.21a	19.13	232.75b	314.85b	-16.11a	-8.27a
IC-267151 x IC-208375	-40.85b	-5.95b	-17.50b	-9.25a	-70.81b	-18.07a	-35.28	-11.78	216.04b	389.57b	-12.91a	-3.44
IC-208364 x IC-208375	-9.51b	37.23b	-19.38b	16.44b	-36.82b	24.45b	-29.90	14.08	10.16a	87.94b	-29.7a	3.62
EC-398599 x IC-208375	-39.00b	32.95b	-21.57b	1.00	-31.60b	38.84b	-29.40	3.13	14.81b	77.73b	-5.70	-1.20
IC-424895 x IC-208375	-33.47b	7.58b	4.30	7.78a	-47.13b	37.55b	0.47	24.35	-34.68b	28.83a	0.54	6.76a
DMR-11 x IC-208375	4.92a	45.61b	-15.63b	5.09	-23.60b	0.95	-22.17	4.03	25.39b	171.36b	1.16	2.24
IC-208385 x IC-208375	-37.67b	22.59b	-9.23a	1.84	-24.64b	2.11	-18.69	-1.38	20.85b	135.37b	1.02	1.78
EC-342007 x IC-208375	-25.01b	10.65b	11.81a	22.29b	-13.71	44.49b	55.24a	31.19a	-24.94b	90.18b	6.11	6.68a
EC-538004 x IC-208375	-18.52b	31.65b	-16.19a	2.64	-49.42b	100.72b	-22.93	6.73	37.12b	221.11b	7.06	17.83a
IC-424896 x IC-208375	-43.13b	33.27b	-8.22	1.36	-37.51b	156.87b	-20.49	-0.28	31.60b	176.42b	7.69	16.23a
IC-267181 x IC-208375	-39.03b	5.24b	14.39a	27.08b	-72.49b	50.22b	-5.20	2.30	-7.81a	153.37b	13.60a	24.31a
IC-208368 x IC-208375	-2.31a	1.22a	-17.69b	1.47	20.83a	6.98	-6.40	13.46	13.00b	127.14b	-3.08	5.13
EC-538005 x IC-208375	-22.76b	7.04b	-8.07	2.16	1.22	18.96a	-1.26	9.28	20.96b	119.21b	-4.28	1.85
EC-538008 x EC-398602	-6.02	2.35a	13.11a	24.90b	-9.91	28.62b	16.87	21.14	-12.30b	105.52b	0.51	8.41a
IC-417878 x EC-398602	-28.59b	13.83b	-9.49a	5.83	-44.44b	26.69b	-21.04	6.40	33.24b	127.64b	-6.93	4.38
IC-208366 x EC-398602	-49.37b	16.84b	-3.12	2.52	-43.92b	31.96b	-16.09	2.55	37.18b	112.66b	-6.45	2.86
IC-267127 x EC-398602	-37.40b	6.56b	19.46b	38.75b	-49.94b	52.49b	-1.45	3.92	-5.59a	86.50b	-2.59	8.61a
DMR-7 x EC-398602	-18.41b	9.56b	-29.70b	10.61a	-11.42	85.26b	-18.32	41.04a	-8.51a	59.30b	2.61	4.80
IC-424886 x EC-398602	-39.73b	14.07b	-26.61b	2.40	-37.99b	33.73b	-33.19	3.24	14.25b	80.35b	2.36	2.65
IC-267162 x EC-398602	-25.00b	6.97b	-5.14	4.92	-47.21b	46.54b	0.96	31.53a	-14.76b	71.78b	6.98	8.67a
IC-417586 x EC-398602	0.81	33.78b	-23.21b	9.35a	-31.55b	14.14	-30.25	8.98	-4.55	42.21a	1.87	2.64
IC-267151 x EC-398602	-33.21b	24.66b	-19.50b	2.28	-3.78	65.06b	-9.48	27.22	9.15a	48.47a	2.43	1.36
IC-208364 x EC-398602	-26.17b	4.02a	2.77	5.00	-27.03b	58.34b	7.35	28.32	-21.72b	33.74a	4.68	4.91

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Crosses	7		8		9		10		11		12	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
EC-398599 x EC-398602	-18.88b	3.12a	-14.38a	23.67b	-14.48	31.28b	-2.08	42.75a	6.05a	146.73b	-5.56	4.67
IC-424895 x EC-398602	-38.29b	9.50b	-18.03b	5.56	-28.30b	13.11	-11.71	16.20	15.69b	141.48b	-5.09	3.13
DMR-11 x EC-398602	-22.36b	4.62a	4.95	8.44a	-27.29b	43.98b	5.20	18.54	-31.01b	88.34b	-4.66	5.05
IC-208385 x EC-398602	-27.11b	11.52b	-48.71b	4.91	-8.55	122.80b	-42.88a	22.73	48.52b	289.95b	-8.08a	5.24
EC-342007 x EC-398602	-41.47b	28.88b	-42.17b	3.45	-22.96a	93.81b	-45.09a	4.58	58.70b	272.49b	-5.08	6.51a
EC-538004 x EC-398602	-33.91b	7.85b	-25.30b	2.55	-65.91b	11.45	-26.65	15.80	29.44b	300.61b	-2.25	11.25a
IC-424896 x EC-398602	-4.11a	8.26b	3.31	5.86	-44.65b	71.14b	-7.34	16.35	7.24a	63.82b	-7.77	2.97
IC-267181 x EC-398602	-29.01b	9.28b	8.95	16.71b	-47.54b	67.77b	-2.79	11.20	22.88b	71.18b	-7.15	1.63
IC-208368 x EC-398602	-17.07b	-1.22a	28.06b	72.08b	-66.29b	41.81b	12.72	13.34	-17.48b	44.79a	-1.55	9.28a
EC-538005 x EC-398602	-27.62b	15.66b	-34.39b	5.61	20.54a	87.22b	-27.12	24.49	28.35b	314.07b	0.33	5.45
EC-538008 x NBP-82	-48.40b	19.40b	-27.75b	3.00	-19.26a	28.88b	-22.39	18.71	32.42b	279.91b	2.49	5.72
IC-417878 x NBP-82	-36.70b	8.01b	-7.88	3.79	-44.46b	11.41	-1.63	26.96	8.33a	314.72b	2.44	7.08a
IC-208366 x NBP-82	-18.72b	18.27b	-16.23a	6.04	-48.84b	35.93b	-27.67	9.87	70.07b	285.43b	-8.63a	-3.09
IC-267127 x NBP-82	-43.24b	17.96b	-11.16a	1.17	-48.32b	41.88b	-22.27	6.36	82.83b	272.05b	-8.58a	-4.86
DMR-7 x NBP-82	-41.36b	-9.13b	11.69a	20.42b	-53.32b	67.34b	17.50	37.10a	71.59b	355.83b	-4.43	0.80
IC-424886 x NBP-82	-21.70b	16.69b	-37.30b	-8.76	-65.61b	-20.87a	-49.82a	-7.47	144.96b	272.36b	-8.79a	-11.60a
IC-267162 x NBP-82	-46.81b	13.64b	-24.26b	-1.80	-59.38b	-3.55	-40.71a	-2.44	121.10b	206.55b	-9.25a	-3.53
IC-417586 x NBP-82	-44.82b	-12.36b	-8.54	-4.94	-72.48b	-15.36a	-25.94	2.17	104.92b	257.67b	-5.12	2.23
IC-267151 x NBP-82	-24.22b	17.55b	-16.06a	-4.98	-74.07b	-32.83b	44.21a	35.78a	87.41b	333.67b	-10.68a	-4.46
IC-208364 x NBP-82	-57.50b	-4.94a	-6.26	-3.72	-67.20b	-12.23	-37.61	-34.20a	87.17b	288.65b	-9.76a	-5.30
EC-398599 x NBP-82	-50.69b	-18.40b	10.54a	-5.28	-76.30b	-17.32a	-15.14	-21.42	67.68b	355.21b	-7.96a	-2..11
IC-424895 x NBP-82	-15.43b	21.58b	-22.41b	7.50a	-45.03b	75.00b	-27.39	42.81a	-4.98a	-91.96b	0.53	7.71a
DMR-11 x NBP-82	-45.27b	12.16b	-16.90b	2.92	-69.15b	1.61	-35.34	13.15	1.44	84.72b	-0.62	1.16
IC-208385 x NBP-82	-29.49b	7.90b	4.79	4.79	-72.96b	17.30a	-13.35	26.50	-36.20b	50.31a	7.52	14.56a
EC-342007 x NBP-82	-25.13b	20.98b	-8.16	3.23	-44.83b	17.11a	-4.71	30.09a	54.73b	286.43b	-4.40	-1.71
EC-538004 x NBP-82	-52.85b	10.49b	0.07	2.13	-37.55b	36.70b	-0.80	22.74	66.80b	272.93b	-4.17	-3.26
IC-424896 x NBP-82	-33.89b	14.10b	23.26b	49.06b	-46.03b	52.21b	33.66	42.51a	34.45b	295.09b	1.88	4.18
IC-267181 x NBP-82	-11.81b	28.33b	-0.90	-5.82	-42.26b	47.94b	-4.66	32.78a	27.25b	169.85b	-1.47	4.34
IC-208368 x NBP-82	-45.40b	13.47b	4.44	8.60a	-58.35b	10.23	-14.87	7.33	36.38b	160.26b	-2.08	1.75
EC-538005 x NBP-82	-29.87b	8.67b	26.78b	64.48b	-58.53b	43.04b	16.13	25.92	3.47	156.44b	1.83	7.24a
C.D at 5%	1.23	1.00	9.12	7.44	17.29	14.49	40..59	30.84	4.79	11.43	7.87	6.35
C.D at 1%	6.17	5.06	16.76	13.66	25.26	21.49	54.85	52.21	11.06	57.29	39.46	31.83

a, b :- Significant at 5% and 1% probability respectively

7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm)
12= Viability percentage

4.3.4 Combining Ability

4.3.4.1 Analysis of variance

Analysis of variance for combining ability was carried out for all the characters and results are presented in Table 4.3 (g) and 4.3 (h) for field and laboratory characters respectively.

(A) Field studies:

The variance due to female was significant for all the characters. The variance due to male was also significant for all the characters.

The variance due to line x tester was highly significant for four characters. The estimates of *gca* effects for parents and *sca* effects of hybrids are presented in Table 4.3 (i) and Table 4.3 (j) respectively. The genotypes which showed significant and positive *gca* effects are considered as good combiners and which showed negative *gca* effects are considered as poor combiners.

(B) Laboratory studies:

The variance due to female was significant for all twelve characters. The variance due to male was significant for nine characters.

The variance due to line x tester was highly significant for ten characters. The estimates of *gca* effects for parents and *sca* effects of hybrids are presented in Table 4.3 (k) and Table 4.3 (L) respectively for laboratory characters. The genotypes which showed significant and positive *gca* effects are considered as good combiners and which showed negative *gca* effects are considered as poor combiners except electrical conductivity where it is considered as good general combiner.

Table No: 4.3 (g) Analysis of variance for combining ability for the field characters

Characters	df	1	2	3	4	5
Replication	2	2.48	3.16	0.03	0.10	1.30
Lines (females)	19	7711.92**	792.43**	2.59**	5.87**	426.59**
Testers (males)	2	3134.25**	1227.42**	22.51**	10.72**	148.89**
Line x Tester	38	1248.82**	185.14**	1.33	1.64*	34.57**
Error	118	2.13	0.64	0.04	0.06	0.93

*, ** - Significant at 5% and 1% probability respectively

1= Plant height (cm)
2= Pods per plant
3= Pod length (cm)
4= Seeds per pod
5= Seed yield per plant (gm)

Table No: 4.3 (h) Analysis of variance for combining ability for the laboratory characters

Characters	df	1	2	3	4	5	6	7	8	9	10	11	12
Replication	2	0.10	0.57	4.74	1.61	2.30	2.53	0.003	101.68	3345.06	11359.57	0.75	4.73
Lines (females)	19	17.24b	1368.62b	14.61b	22.50b	75.44b	156.07b	3.34b	79614.13b	204555.80b	4165554.0b	393.57b	478.31b
Testers (males)	2	0.99	828.71b	9.63b	1.65	16.69bb	16.70b	2.31	3946.66b	37265.07b	1151107.0b	515.91b	339.08b
Line x tester	38	0.63	106.37b	3.94b	2.29b	3.17b	7.62b	0.08	295.17b	88464.85b	1781073.0b	3.22b	3.76b
Error	118	0.24	6.70	0.39	0.54	2.33	3.48	0.01	94.49	30045.84	107918.60	2.99	1.25

a, b :- Significant at 5% and 1% probability respectively.

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm)
12= Viability per

4.3.4.2 Estimation of *gca* and *sca*

(A) Field studies:

4.3.4.1 Plant height

The parents E538008 (51.50), IC-267127 (51.31), IC-208368 (41.25),EC-342007 (40.94), DMR-11 (38.35), IC-2.8385 (8.05), NBP-82 (6.28), and IC-417878 (5.97) recorded positive but significant *gca* effects for plant height and remaining parents showed negative significant *gca* effects. Out of sixty crosses as many as twenty-nine crosses showed positive and significant *sca* effects. The hybrid IC-267162 x EC-398602 recorded maximum positive significant *sca* effects (41.96).

4.3.4.2 Pods per plant

Significant positive *gca* and *sca* effects were noted in eight parents and twenty-one hybrids, respectively for pods per plant. The maximum positive *gca* effects were observed in parents IC-267181 (21.87), IC-424896 (18.69), DMR-11 (7.50), IC-417878 (6.62), NBP-82 (5.0), IC-267127 (4.70), IC-267162 (4.60) and EC-342007 (3.79), while the hybrids IC-208368 x EC-398602 (24.96) and IC-267181 x EC-398602 (-14.70) registered highest positive and negative significant *sca* effects for this trait respectively.

4.3.4.3 Pod length

The parents IC-267127 (1.25) and EC-398602 (0.64) observed positively significant *gca* effects, whereas parent IC-424895 (-1.30) registered negative significant *gca* effect for this trait. Seven crosses had significant positive *sca*, whereas ten crosses had significant negative *sca* effects. Out of these cross IC-208366 x NBP-82 (2.35) and cross DMR-7 x NBP-82 (-1.64) had the highest positive and negative estimates respectively.

4.3.3.4 Seeds per pod

Significant positive *gca* effects was observed in parents IC-267127 (1.57), IC-208375 (1.13), IC-208366 (0.98), DMR-7 (0.67), IC-424895 (0.65), IC-208364 (0.55), EC-538008 (0.40), IC-267162 (0.35) EC-342007 (0.28) and DMR-11 (0.18). While as, negatively significant *gca* was observed in remaining parents.

Ten and nine crosses showed positive and negative significant *sca* for seeds per pod. The highest positive and negative *sca* observed in hybrids EC-538008 x IC-208375 and IC-208366 x IC-208375 respectively.

4.3.3.5 Seed yield per plant

Parents emerged as good general combiners for this trait. The parents EC-398599 (12.33), IC-424896 (9.30), IC-267127 (8.98), IC-208368 (8.90), DMR-7 (4.63), IC-208366 (1.12), IC-267162 (3.59), and IC-208364 (0.93) recorded maximum significant positive *gca* effects and the other parents showed it in negative direction. Fourteen cross combinations resulted in high order positive *sca* effects and twelve crosses in negative sca effects. The highest *sca* effects were observed in hybrids IC-208385 x NBP-82 (7.73) and negative in DMR-7 x NBP-82 (-6.07).

Table No: 4.3 (i) **Estimates of general combining ability effects of lines and testers for the field characters in pea**

Parents	1	2	3	4	5
Lines					
EC-538008	51.50**	-0.50	0.23	0.40**	-8.87**
IC-417878	5.97**	6.62**	-0.72	-0.14**	-6.23**
IC-208366	-12.20**	-5.70**	0.06	0.98**	1.12**
IC-267127	51.31**	4.70**	1.25*	1.57**	8.98**
DMR-7	-28.00**	-5.52**	0.36	0.67**	4.63**
IC-424886	-36.70**	0.09	-0.73	-0.05	3.66**
IC-267162	-21.01**	4.60**	-0.43	0.35**	3.59**
IC-417586	-22.44**	-3.91**	0.22	-1.05**	-9.97**
IC-267151	-12.81**	-6.02**	0.50	-0.67**	-0.10
IC-208364	-10.67**	-2.12**	0.88	0.55**	0.93**
EC-398599	-7.45**	-1.71**	-0.47	-0.79**	12.33**
IC-424895	-1.25**	-14.58**	-1.03*	0.65**	-1.87**
DMR-11	38.35**	7.50**	0.18	0.18**	-9.58**
IC-208385	8.05**	-6.46**	0.50	1.13**	-7.17**
EC-342007	40.94**	3.79**	-0.23	0.28**	0.29
EC-538004	-21.81**	-17.32**	-0.55	-1.45**	-1.73**
IC-424896	-34.91**	18.69**	0.44	-0.64**	9.30**
IC-267181	-28.51**	21.87**	-0.07	-0.97**	1.02**
IC-208368	41.25**	-0.85	-0.20	-0.55**	8.90**
EC-538005	0.56	-3.20**	-0.19	-0.42**	-9.20**
Testers					
IC-208375	1.62	-1.18*	-0.58	0.45**	1.25**
EC-398602	-7.90*	-3.82**	0.64*	-0.39	-1.77
NBP-82	6.28*	5.00**	-0.06	-0.06	0.52

*, ** :- Significant at 5% and 1% probability respectively

1= Plant height (cm)
2= Pods per plant
3= Pod length (cm)
4= Seeds per pod
5= Seed yield per plant (gm)

Table No: 4.3 (j) **Estimates of specific combining ability effects of hybrids for the field characters in pea**

Hybrids	1	2	3	4	5
EC-538008 x IC-208375	11.18**	-6.16**	0.46**	1.85**	-1.64
IC-417878 x IC-208375	9.17**	-10.00**	-0.23	0.39	2.12*
IC-208366 x IC-208375	-20.35**	16.16**	-0.23	-2.24**	-0.48
IC-267127 x IC-208375	-2.28	-0.11	-0.73**	0.36	0.74
DMR-7 x IC-208375	-17.63**	-0.44	0.42*	0.20	-1.16
IC-424886 x IC-208375	19.92**	0.55	0.31	-0.56*	0.42
IC-267162 x IC-208375	-12.68**	3.74**	0.15	0.80**	-0.55
IC-417586 x IC-208375	-14.60**	1.60	-0.09	-0.66**	2.06*
IC-267151 x IC-208375	27.28**	-5.34**	-0.06	-0.15	-1.52
IC-208364 x IC-208375	-5.80**	4.00**	0.24	0.48*	4.65**
EC-398599x IC-208375	17.78**	1.84*	0.08	-0.55*	-2.57*
IC-424895 x IC-208375	-11.97**	-5.84**	-0.32	0.06	-2.07*
DMR-11 x IC-208375	11.22**	1.39	0.23	0.08	4.58**
IC-208385 x IC-208375	9.97**	3.96**	0.30	-0.65**	-2.38*
EC-342007 x IC208375	-21.18**	-5.35**	-0.53*	0.56*	-2.20*
EC-538004 x IC208375	11.48**	-3.05**	-0.59**	-0.16	0.97
IC-424896 x IC-208375	9.23**	-3.68**	-0.31	0.21	-0.54
IC-267181 x IC-208375	-20.72**	6.74**	0.89**	-0.05	-0.43
IC-208368 x IC-208375	4.76**	-8.46**	-0.69**	-0.80**	5.45**
EC-538005x IC-208375	5.04**	-2.76**	0.29	0.24	-2.04*
EC-538008x EC398602	-9.81**	11.23**	0.39	0.55*	-3.41**
IC-417878x EC-398602	11.73**	1.31	-0.40	-0.73**	-1.20
IC-208366x EC-398602	7.81**	-2.18**	-0.38	0.04	0.26
IC-267127x EC-398602	-19.54**	0.87	0.78**	0.69**	0.94
DMR-7 x EC-398602	-16.27**	5.29**	-0.21	0.08	-0.68
IC-424886x EC-398602	-25.69**	2.49**	-0.33	0.35	-1.98*
IC-267162x EC-398602	41.96**	-7.79**	-0.54*	-0.44	2.66**
IC-417586x EC-398602	-22.10**	0.32	-0.20	-0.10	-2.27*
IC-267151x EC-398602	-14.76**	-0.01	0.48*	0.54*	2.06*
IC-208364x EC-398602	36.86**	-0.32	-0.29	-0.45	0.21

Hybrids	1	2	3	4	5
EC-398599x EC398602	3.21*	-3.55**	-0.04	-0.43	-1.26
IC-424895x EC-398602	-13.24**	7.35**	0.24	0.14	1.84
DMR-11 x EC-398602	10.04**	-3.80**	-0.20	0.29	-0.58
IC-208385x EC-398602	-2.16	-0.54	0.18	0.64**	-2.90**
EC-342007x EC398602	-20.18**	3.66**	0.19	-0.26	-0.53
EC-538004x EC398602	22.34**	-3.12**	-0.37	-0.38	3.43**
IC-424896x EC-398602	7.24**	-10.26**	0.07	-0.73**	-2.63**
IC-267181x EC-398602	13.59**	-14.70**	0.12	-0.26	2.27*
IC-208368x EC-398602	-20.83**	24.96**	-0.19	0.99**	0.36
EC-538005x EC398602	-5.86**	3.70**	-0.57**	-0.02	-2.73**
EC-538008 x NBP-82	-15.14**	4.60**	0.14	-0.41	-0.14
IC-417878 x NBP-82	21.01**	-8.31**	0.44*	0.43	2.88**
IC-208366 x NBP-82	-11.35**	-0.19	2.35**	-0.40	5.13**
IC-267127 x NBP-82	19.40**	-1.88*	-0.71	0.61*	0.94
DMR-7 x NBP-82	-8.05**	2.07*	-1.64**	-0.21	-6.07**
IC-424886 x NBP-82	10.10**	0.12	-0.03	-1.00**	-1.84
IC-267162 x NBP-82	10.91**	3.96**	-0.25	0.28	0.62
IC-417586 x NBP-82	-21.01**	-4.09**	0.28	0.72**	1.22
IC-267151 x NBP-82	11.90**	5.78**	-0.69**	0.33	-1.00
IC-208364 x NBP-82	10.98**	-1.08	0.36	0.03	5.50**
EC-398599 x NBP-82	-22.87**	-4.70**	0.33	-0.36	-4.51**
IC-424895 x NBP-82	9.76**	4.04**	0.39	-0.28	-2.11*
DMR-11 x NBP-82	7.78**	4.04**	0.20	0.19	-5.61**
IC-208385 x NBP-82	-17.54**	-8.07**	-0.60**	0.10	7.73**
EC-342007 x NBP-82	-2.83	-0.54	-0.24	0.40	-0.22
EC-538004 x NBP-82	11.52**	-0.67	-0.06	-0.06	1.53
IC-424896 x NBP-82	-8.69**	1.21	0.30	-0.35	-1.31
IC-267181 x NBP-82	-11.24**	3.17**	0.31	-0.40	-0.51
IC-208368 x NBP-82	-11.92**	3.90**	-0.47*	-0.39	-2.24*
EC-538005 x NBP-82	23.16**	-7.07**	0.16	0.79**	2.75**

*, ** :- Significant at 5% and 1% probability respectively.

1= Plant height (cm)
2= Pods per plant
3= Pod length (cm)
4= Seeds per pod
5= Seed yield per plant (gm)

(B) Laboratory studies:

4.3.3.6 100 Seed weight

The parents IC-208385 (1.77), EC-398599 (1.72), IC-267162 (1.64), DMR-7 (1.38), IC-208368 (1.18), EC-342007 (0.68), IC-417586 (0.64), IC-424886 (0.63), IC-267127 (0.48) and IC-267181 (0.31) recorded significant and positive *gca* effects. Two hybrids viz. IC-424895 x IC-208375 (0.87) and IC-267162 x EC-398602 (0.84) showed significant and positive *sca* effects for this trait.

4.3.3.7 Germination percentage

Out of twenty-three parents, nine parents exhibited significant positive *gca* effects for germination percentage. The maximum *gca* effects were observed in parents IC-267162 (19.34), EC-538008, EC-398599, IC-208385 (16.23), IC-424895 (11.56), IC-267151 (11.23), IC-208364 (8.78), DMR-7 (5.12), and IC-417878 (1.23), while seven crosses showed significant positive *sca* effects, the highest being in DMR-7 x IC-208375 T3 (11.21), and EC-342007 x IC-208375 (11.10) crosses.

4.3.3.8 Speed of germination

Eight parents were observed to be good general combiners for speed of germination as they showed significant and positive *gca* effects. The highest *gca* effects were registered by parents EC-538008 (3.22), IC-424886 (1.43) and IC-267151 (1.11).

Three cross combinations registered significant and positive *sca* effects of these, the crosses EC-538008 x IC-208375 (3.01) and IC-417878 x EC-398602 (2.21) recorded the highest *sca* effects for speed of germination.

4.3.3.9 Seedling root length

Parent EC-538008 (4.33) registered highest positive significant *gca* effects followed by IC-267162 (2.72) and IC-208385 (2.17), whereas, highest significant negative *gca* effects were observed in IC-424896 (-2.17) for this trait.

Cross EC-538005 x EC-398602 (1.51) registered highest significant positive *sca* for seedling root length, while, it was highest and significantly negative in hybrid EC-538005 x IC-208375 (-1.34).

4.3.3.10 Seedling shoot length

Seven parents were observed to be good combiners as they recorded significantly positive *gca* effects. The highest *gca* effects were exhibited by parents EC-538008 (7.74), IC-267162 (5.69), DMR-7 (3.08) and IC-417878 (1.95).

Fourteen cross combinations recorded significantly positive *sca* effects. Of these the crosses EC-538005 x EC-398602 (1.93), IC-424896 x IC-208375 (1.76), and IC-424896 x NBP-82 (1.71) showed the highest *sca* effects for seedling shoot length.

4.3.3.11 Total seedling length

Parent EC-538008 (10.31) had high positive and significant *gca*, while parent IC-424896 (-5.54) had negative and significant *gca*. Fourteen crosses of the total twenty-eight crosses had significantly positive *sca*. Of these cross EC-538005 x EC-398602 (3.28) and cross IC-417878 x NBP-82 (-3.76) had the highest positive and negative estimates respectively.

4.3.3.12 Fresh seedling weight

Parents EC-538008 (1.52), IC-267162 (1.34), DMR-11 (0.82), IC-208364 (0.37), DMR-7 (0.29), EC-398599 (0.19), and IC-267151 (0.06), had positive and significant *gca* and remaining parents had negative and significant *gca*.

Cross DMR-11 x IC-208375 (0.29) registered highest significant *sca* whereas, cross IC-417878 x IC-208375 (-0.25) showed highest significant negative *sca*.

4.3.3.13 Dry seedling weight

Ten parents were observed to be good combiners as they recorded significantly positive *gca* effects. Parents DMR-11 (188.02), EC-538005 (154.47), IC-208368 (99.80), IC-417878 (96.02), IC-417586 (72.02) and IC-424896 (57.47) had highest positive and significant *gca* among them.

Out of the sixty crosses, six crosses had significantly positive *sca* and nine crosses had significantly negative *sca*. Of these cross EC-398599 x EC-398602 (24.43) and cross IC-424886 x NBP-82 (-19.57) recorded the highest positive and negative estimates respectively.

4.3.3.14 Vigor Index I

Parents EC-538008 (1159.14), and IC-424896 (-574.86) had significant highest, positive and negative *gca* respectively. Out of sixty crosses, cross EC-538005 x EC-398602 (395.21) and cross EC-538004 x EC-398602 (-328.45) had highest significant positive and negative *sca* respectively

4.3.3.15 Vigor Index II

The parents IC-267162 (10111.97), IC-208368 (8929.86), IC-417878 (8394.08), DMR-11 (8315.19) and EC-538005 (5076.19) recorded highest significant positive *gca* effects for vigor index II. Twenty-one hybrids showed significant and positive *sca* effects, whereas, the twenty-four hybrids exhibited the highest negative

significant *sca* effect for this trait. The highest positive and negative significant *sca* effects was exhibited by DMR-7 x IC-208375 (4725.49) and IC-267127 x IC-208375 (-5204.16) respectively.

4.3.3.16 Electrical conductivity (µs/gm)

Eleven parents were observed to be good combiners as they recorded significantly negative *gca* effects. Parents IC-208364 (-9.02), DMR-11 (-7.77), IC-267127 (-7.36), IC-267151 (-7.14), and IC-267181 (-6.70) had highest negative and significant *gca* among them, while, remaining parents had positive and significant *gca* for this trait.

Out of sixty crosses, thirteen crosses had significantly negative *sca* and fifteen crosses had significant positive *sca.* Among these, cross DMR-7 x NBP-82 (1.81) and cross EC-342007 x IC-208375 (-1.81) had the highest positive and negative estimates respectively.

4.3.3.17 Viability percentage

Out of twenty-three parents, nine parental lines displayed significant and positive *gca* effects and fifteen hybrids showed significant and positive *sca* effects for this trait.

The highest significant and positive *gca* and *sca* effects were recorded by parents EC-538008 (12.36), IC-208364 (9.69), IC-267151 (9.33), DMR-7 (9.18), and IC-424886 (7.80), and the hybrids IC-208385 x NBP-82 (2.08), IC-424896 x NBP-82 (1.38) and EC-538008 x IC-2.8375 (1.26) respectively.

Table No: 4.3 (k) **Estimates of general combining ability effects of lines and testers for the laboratory characters in pea**

Parents	1	2	3	4	5	6
Lines						
EC-538008	0.09	16.23**	3.22**	4.33**	7.74**	10.31**
IC-417878	-0.23*	1.23*	0.82**	-0.85**	1.95**	0.54
IC-208366	-0.73**	-13.66**	-1.22**	-1.48**	-1.88**	-3.36**
IC-267127	0.48**	-1.77**	-0.16	0.74**	-0.63	0.12
DMR-7	1.38**	5.12**	0.52**	0.63**	3.08**	4.99**
IC-424886	0.63**	-7.11**	1.43**	-1.61**	-1.96**	-3.56**
IC-267162	1.64**	19.34**	0.70**	2.72**	5.69**	8.42**
IC-417586	0.64**	-9.77**	0.08	-0.19	-0.37	-0.55
IC-267151	0.13	11.23**	1.11**	0.28	-1.50**	-0.90*
IC-208364	-0.50**	8.78**	-0.03	0.19	1.72**	2.43**
EC-398599	1.72**	16.23**	-0.26	0.48**	0.85**	1.33**
IC-424895	-1.24**	11.56**	0.66**	-0.23	-1.39**	-1.61**
DMR-11	-0.46**	-12.11**	-0.03	-0.74**	-1.70**	-2.43**
IC-208385	1.77**	16.23**	-0.07	2.17**	1.20**	3.38**
EC-342007	0.68**	-4.22**	-0.24	-0.37*	-2.08**	-2.44**
EC-538004	-3.32**	-14.88**	-2.53**	-1.28**	-2.87**	-4.04**
IC-424896	-2.56**	-16.77**	-1.17**	-2.17**	-3.38**	-5.54**
IC-267181	0.31**	-12.44**	-0.95**	-1.33**	-2.79**	-4.12**
IC-208368	1.18**	1.01	0.35*	-0.89**	-0.38	-1.26**
EC-538005	-1.60**	-14.22**	-2.22**	-0.41*	-1.30**	-1.71**
Testers						
IC-208375	0.15*	-1.03	0.46*	0.16	0.04	0.37
EC-398602	-0.10	-3.09**	-0.22	0.01	0.51	0.24
NBP-82	-005	4.12**	-0.24	-0.17	-0.55	-0.60

*, ** :- Significant at 5% and 1% probability respectively.

1=100 seed weight (gm) 4= Seedling root length (cm)
2= Germination percentage 5= Seedling shoot length (cm)
3= Speed of germination 6= Total seedling length (cm)

Parents	7	8	9	10	11	12
Lines						
EC-538008	1.52**	-30.31**	1159.14**	4033.30**	-3.69**	12.36**
IC-417878	-0.25**	96.02**	6.73	8394.08**	2.56**	-4.32**
IC-208366	-0.39**	-11.20**	-412.94**	-11827.14**	11.62**	-14.36**
IC-267127	-0.08**	-44.76**	-48.96	-3708.92**	-7.36**	-0.49
DMR-7	0.29**	22.58**	448.52**	41.74	-2.93**	9.18**
IC-424886	-0.36**	31.47**	-371.33**	59.74	0.36	7.80**
IC-267162	1.34**	25.69**	1018.81**	10111.97**	-4.04**	-1.29**
IC-417586	-0.52**	72.02**	-187.17**	1728.63**	-4.54**	-6.24**
IC-267151	0.06**	-90.20**	16.48	-3429.03**	-7.14**	9.33**
IC-208364	0.37**	-46.31**	288.36**	-417.37**	-9.02**	9.69**
EC-398599	0.19**	-32.31**	289.85**	3772.52**	-3.36**	-5.26**
IC-424895	-0.31**	-179.98**	-48.98	-11491.37**	6.99**	-7.40**
DMR-11	0.82**	188.02**	-337.55**	8315.19**	-7.77**	-6.08**
IC-208385	-0.49**	-104.09**	391.60**	-3427.92**	7.97**	4.75**
EC-342007	-0.28**	14.02**	-268.37**	-115.70	7.88**	-3.99**
EC-538004	-0.43**	-88.64**	-473.04**	-10727.37**	4.14**	-5.98**
IC-424896	-0.71**	57.47**	-574.86**	-2277.81**	9.36**	-6.60**
IC-267181	-0.13**	-33.76**	-465.45**	-7173.59**	-6.70**	3.84**
IC-208368	-0.51**	99.80**	-123.36**	8929.86**	6.82**	3.01**
EC-538005	-0.12**	154.47**	-307.48**	5076.19**	-1.13**	2.06**
Testers						
IC-208375	0.16**	8.91**	26.03	298.38*	0.94	-0.62
EC-398602	0.06**	-6.96*	-23.65	-1509.93**	2.34**	-2.01**
NBP-82	-0.22	-1.94	-2.38	1211.55**	-3.29**	2.62**

*, ** :- Significant at 5% and 1% probability respectively
7= Fresh seedling weight (gm) 10= Vigor index II
8= Dry seedling weight (mg) 11= Electrical conductivity (µs/gm)
9= Vigor index I 12= Viability percentage

Table No: 4.3 (l) **Estimates of specific combining ability effects of hybrids for the laboratory characters in pea**

Hybrids	1	2	3	4	5	6
EC-538008 x IC-208375	0.20	1.14	3.01**	-1.08	-0.47	0.70
IC-417878 x IC-208375	0.46	0.21	-0.29	0.86	1.30*	-1.75*
IC-208366 x IC-208375	-0.66	-1.34	-2.72**	0.22	-0.83	1.04*
IC-267127 x IC-208375	0.21	-11.86**	2.08**	0.43	0.23	1.07*
DMR-7 x IC-208375	0.52	11.21**	-1.26*	-0.19	-0.58	0.07
IC-424886 x IC-208375	-0.73	0.66	-0.82	-0.24	0.35	-1.14*
IC-267162 x IC-208375	0.02	2.36	-0.19	0.66	-0.47	0.03
IC-417586 x IC-208375	0.28	-1.57	0.30	-0.24	0.26	0.29
IC-267151 x IC-208375	-0.30	-0.79	-0.11	-0.42	0.22	-0.32
IC-208364 x IC-208375	-0.83**	-4.19	0.67	-0.11	-0.14	-0.41
EC-398599x IC-208375	-0.05	0.87	-0.45	0.36	-0.08	0.56
IC-424895 x IC-208375	0.87**	3.32	-0.22	-0.25	0.22	-0.15
DMR-11 x IC-208375	0.09	-5.75*	-0.45	-0.40	0.69	-1.14*
IC-208385 x IC-208375	-0.47	-5.35*	-0.18	-0.20	0.71	-0.47
EC-342007 x IC208375	0.38	11.10**	0.63	0.60	-1.40*	1.61*
EC-538004 x IC208375	0.57	3.81	-0.22	-0.18	-0.40	-0.74
IC-424896 x IC-208375	-0.38	1.54	-0.65	0.09	1.76*	2.13**
IC-267181 x IC-208375	-0.20	-5.34*	0.87	0.08	-1.36*	-1.39*
IC-208368 x IC-208375	-0.62	3.36	-0.46	0.88	0.03	0.75
EC-538005x IC-208375	0.46	0.76	0.49	-1.34*	-0.28	-1.34*
EC-538008x EC398602	0.16	-4.12	-0.03	0.46	0.25	0.60
IC-417878x EC-398602	0.55	1.81	2.21**	-0.55	-0.58	-1.29*
IC-208366x EC-398602	-0.30	2.87	-2.02**	-0.80	-0.16	-0.68
IC-267127x EC-398602	-0.25	-4.68	-0.19	1.35*	0.74	1.97*
DMR-7 x EC-398602	-0.68	8.47**	-0.37	0.35	-0.05	0.76
IC-424886x EC-398602	-0.16	-10.13**	0.23	0.17	-0.28	-0.15
IC-267162x EC-398602	0.84**	1.66	0.14	-0.52	0.33	-0.61
IC-417586x EC-398602	-0.46	-10.75**	-0.17	-1.25*	-1.23*	-1.61*
IC-267151x EC-398602	0.48	9.65**	-0.25	0.35	0.46	0.56
IC-208364x EC-398602	-0.02	1.10	0.42	0.91	0.77	1.05*

Hybrids	1	2	3	4	5	6
EC-398599x EC398602	-0.13	2.14	0.03	-0.37	0.00	-0.54
IC-424895x EC-398602	-0.20	2.87	-1.25*	-1.05	-1.02*	-1.80*
DMR-11 x EC-398602	0.33	-5.01	1.23	1.43*	1.02*	2.33*
IC-208385x EC-398602	0.30	6.47*	-0.98	0.66	1.03*	1.53*
EC-342007x EC398602	-0.08	-4.46	0.75	1.20*	0.27	1.75*
EC-538004x EC398602	-0.22	-2.01	0.23	-1.86*	-1.30*	-3.27**
IC-424896x EC-398602	0.10	1.47	-1.19	-0.58	0.93	0.18
IC-267181x EC-398602	-0.07	2.54	0.56	0.65	-0.64	0.29
IC-208368x EC-398602	-0.03	-4.01	0.63	-0.07	-0.28	-0.47
EC-538005x EC398602	-0.17	0.47	-1.36*	1.51*	1.93**	3.28**
EC-538008 x NBP-82	-0.02	0.54	1.03	-0.38	0.58	0.48
IC-417878 x NBP-82	0.19	-1.01	0.32	-1.14*	-2.51**	-3.76**
IC-208366 x NBP-82	0.23	-5.42*	-0.50	-0.10	-0.11	-0.38
IC-267127 x NBP-82	0.10	-2.35	0.90	0.18	-0.40	0.06
DMR-7 x NBP-82	-0.33	7.77**	-0.40	-0.08	0.51	0.32
IC-424886 x NBP-82	-0.12	0.25	-0.63	-0.15	-0.65	-1.06*
IC-267162 x NBP-82	0.12	0.98	0.28	0.47	0.12	1.07*
IC-417586 x NBP-82	0.00	-1.23	0.35	-0.32	0.53	-0.01
IC-267151 x NBP-82	-0.06	-3.53	-0.66	-0.32	-0.44	-0.93
IC-208364 x NBP-82	0.07	-0.79	0.36	0.34	0.23	0.84
EC-398599 x NBP-82	0.00	4.32	0.30	-0.02	0.21	0.09
IC-424895 x NBP-82	0.12	4.81	-0.26	0.95	0.57	1.35*
DMR-11 x NBP-82	-0.03	-5.13	0.05	-0.48	-1.09*	-1.30*
IC-208385 x NBP-82	0.20	0.32	0.21	-0.47	0.52	-0.06
EC-342007 x NBP-82	0.54	-0.64	-0.45	-0.17	-1.21*	-1.54*
EC-538004 x NBP-82	-0.24	-0.91	0.98	0.65	-0.50	0.43
IC-424896 x NBP-82	-0.30	1.54	-0.53	-0.48	1.71*	1.12*
IC-267181 x NBP-82	0.15	5.58*	-0.11	-0.18	0.34	0.00
IC-208368 x NBP-82	-0.22	-3.35	0.44	-0.65	-0.65	-1.03*
EC-538005 x NBP-82	0.07	-2.23	-0.33	0.83	0.31	1.03*

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)

Hybrids	7	8	9	10	11	12
EC-538008 x IC-208375	0.16	7.43	70.30	1151.95**	-0.56	1.26**
IC-417878 x IC-208375	-0.25*	-6.04	-147.86*	-70.40	-0.49	0.52
IC-208366 x IC-208375	0.09	-1.39	77.57	-1081.55**	1.04*	-1.78**
IC-267127 x IC-208375	0.17	6.09	-88.43	-5204.16**	-0.20	-1.61**
DMR-7 x IC-208375	-0.09	-0.71	166.28*	4725.49**	-0.80	0.64*
IC-424886 x IC-208375	-0.09	-5.39	-77.86	478.67	1.00*	0.98*
IC-267162 x IC-208375	-0.01	15.32*	12.17	1634.39**	0.77*	-0.05
IC-417586 x IC-208375	0.09	-0.48	19.48	-142.96	-0.67*	0.47
IC-267151 x IC-208375	-0.07	-14.83*	-31.66	-1491.44**	-0.10	-0.43
IC-208364 x IC-208375	0.07	15.21*	-87.87	-248.49	0.51	1.08*
EC-398599x IC-208375	0.08	-15.26*	58.94	-833.18**	0.21	-1.56**
IC-424895 x IC-208375	-0.15	0.06	28.93	1081.67**	-0.72*	0.47
DMR-11 x IC-208375	0.29*	-2.13	-206.05**	-2432.16**	1.62**	-0.15
IC-208385 x IC-208375	-0.15	1.41	-142.27*	-2215.51**	0.19	-0.59
EC-342007 x IC208375	-0.14	0.72	248.32**	4647.67**	-1.81**	0.74*
EC-538004 x IC208375	0.00	-9.02*	-31.40	764.17*	1.63**	-0.67*
IC-424896 x IC-208375	0.12	1.85	178.87*	619.49*	0.03	-0.55
IC-267181 x IC-208375	-0.11	7.17	-147.47*	-1383.66**	-1.67**	1.22**
IC-208368 x IC-208375	-0.25*	-12.24*	127.00*	247.95	-0.20	0.62*
EC-538005x IC-208375	0.07	6.29	-126.76*	612.60*	0.07	-0.66*
EC-538008x EC398602	0.17	5.94	-0.24	-860.55**	0.13	0.04
IC-417878x EC-398602	-0.13	-2.91	-83.76	303.95	0.33	-0.07
IC-208366x EC-398602	0.02	-1.04	-4.68	1003.93**	0.07	0.15
IC-267127x EC-398602	0.11	3.94	88.44	-1317.88**	-0.40	-0.08
DMR-7 x EC-398602	-0.17	3.32	161.52*	1867.28**	-1.60**	0.10
IC-424886x EC-398602	0.03	-2.48	-110.04*	-2912.07**	0.20	-0.48
IC-267162x EC-398602	0.14	-0.83	-51.48	44.78	1.40**	0.39
IC-417586x EC-398602	0.17	2.76	-295.39**	-3200.71**	-0.86*	0.31
IC-267151x EC-398602	0.03	-3.04	186.88*	2833.60**	-0.35	0.50
IC-208364x EC-398602	-0.20*	0.28	108.51*	367.12	1.21**	-0.80*

Hybrids	7	8	9	10	11	12
EC-398599x EC398602	-0.23*	24.43**	-8.55	4052.06**	0.41	0.92*
IC-424895x EC-398602	0.04	-14.04*	-133.04*	-965.62**	1.08*	1.11**
DMR-11 x EC-398602	0.19	-10.39*	141.59*	-3086.44**	-1.49**	-2.03**
IC-208385x EC-398602	-0.25*	-6.75	213.65**	949.95**	-0.43	-1.17**
EC-342007x EC398602	0.19	6.63	114.79*	47.93	0.73	1.15**
EC-538004x EC398602	0.06	-0.06	-328.45**	-997.88**	-0.30	0.02
IC-424896x EC-398602	-0.06	4.76	15.69	722.06*	-0.68*	-0.66*
IC-267181x EC-398602	0.06	0.63	52.46	852.38**	0.12	-0.30
IC-208368x EC-398602	0.00	-5.39	-68.15	-1574.44**	0.56	0.96*
EC-538005x EC398602	-0.13	-5.13	395.21**	-73.49	0.19	0.07
EC-538008 x NBP-82	0.03	4.07	-104.65*	556.82	0.32	1.07*
IC-417878 x NBP-82	0.10	1.06	-290.56**	-483.33	-0.51	-1.77**
IC-208366 x NBP-82	0.04	-0.57	-83.29	-2210.05**	-1.62**	0.02
IC-267127 x NBP-82	0.13	-2.71	-6.28	-1247.73**	-0.19	-0.09
DMR-7 x NBP-82	-0.17	3.28	89.58	3457.78**	1.81**	0.07
IC-424886 x NBP-82	0.07	-19.57*	-67.93	-1194.38**	1.24**	0.34
IC-267162 x NBP-82	0.10	16.96*	77.15	1534.93**	-1.45**	-0.20
IC-417586 x NBP-82	-0.16	2.61	-9.22	-340.55	0.21	-0.14
IC-267151 x NBP-82	0.22*	-10.35*	-83.17	-2307.61**	0.10	0.20
IC-208364 x NBP-82	-0.12	11.18*	64.31	98.38	-0.40	0.88*
EC-398599 x NBP-82	-0.10	-0.83	18.86	2209.23**	0.30	-1.08*
IC-424895 x NBP-82	0.01	-1.13	135.49*	2273.51**	0.12	-0.38
DMR-11 x NBP-82	-0.10	0.07	-86.11	-896.51**	0.09	-1.69**
IC-208385 x NBP-82	0.09	1.06	-49.38	-1377.00**	-0.21	2.08**
EC-342007 x NBP-82	-0.05	-10.02*	-137.47*	-778.61*	-0.50	-0.68*
EC-538004 x NBP-82	-0.15	0.85	31.94	-1063.29**	0.93*	-0.69*
IC-424896 x NBP-82	0.20*	9.17*	105.53*	1841.89**	-0.43	1.38**
IC-267181 x NBP-82	0.09	0.32	42.29	2672.39**	-0.28	0.53
IC-208368 x NBP-82	-0.14	-4.15	-89.41	-2538.29**	0.29	-0.28
EC-538005 x NBP-82	0.04	3.83	47.12	-134.11	-0.01	-0.25

*, ** :- Significant at 5% and 1% probability respectively.

7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm)
12= Viability percentage

4.3.5 Gene action

The mean sum of squares due to *gca* and *sca* were used to estimate the variances for *gca* and *sca* respectively, based on which additive and dominance components were worked out and presented in Table 4.3 (m) and Table 4.3 (n) for field and laboratory characters respectively.

(A) Field studies:

The estimated variances due to *sca* (s^2*sca*) were magnitudinaly high and greater than estimated values of *gca* variances (s^2*gca*) for all characters studied. The magnitude of dominance gene action was greater than that of additive gene action for all the characters except pod length and seed yield per plant. The additive and dominance ratio ranged from 0.58 for plant height to 1.50 for pod length.

(B) Laboratory studies:

The estimated variances due to *gca* (s^2*gca*) were magnitudinally high and greater than estimated values of *sca* variances (s^2*sca*) for all most all characters studied with the exception of germination percentage, speed of germination and seedling root length. In contrast to the field characters here the magnitude of additive gene action was greater than that of dominance gene action for all the characters except speed of germination and seedling root length. The additive and dominance ratio ranged from 0.25 for vigor index II to 327.25 for electrical conductivity.

Table No: 4.3 (m) Components of genetic variance for 5 field characters in pea

Characters	1	2	3	4	5
σ^2 gca	120.99**	23.90**	0.33*	0.19	7.33**
σ^2 sca	415.56**	61.50**	0.43*	0.53*	11.22**
σ^2 additive	241.99	47.81	0.66	0.39	14.68
σ^2 dominance	415.56	61.50	0.43	0.53	11.22
$\sqrt{D/\ }$	1.31	1.13	0.80	1.16	0.87
A.D. ratio	0.58	0.77	1.50	0.73	1.30
^{2} gca/σ sca ratio	0.291	0.388	0.767	0.363	0.654

*, ** :- Significant at 5% and 1% probability respectively

1= Plant height (cm)
2= Pods per plant
3= Pod length (cm)
4= Seeds per pod
5= Seed yield per plant (gm)

Table No: 4.3 (n) Components of genetic variance for 12 laboratory characters in pea

Characters	1	2	3	4	5	6	7	8	9	10	11	12
σ^2 gca	0.24*	28.76**	0.23*	0.28*	1.24**	2.28**	0.07	1202.47**	27621.65**	718905.30**	13.08**	11.73**
σ^2 sca	0.13*	33.23**	1.18**	0.58*	0.28	1.38**	0.02	66.90**	19473.00**	557718.15**	0.08	0.84*
σ^2 additive	0.49	57.52	0.47	0.57	2.49	4.57	0.16	2404.94	55243.30	143781.06	26.18	23.47
σ^2 dominance	0.13	33.23	1.18	0.58	0.28	1.38	0.02	66.90	19473.00	557718.15	0.08	0.84
$\sqrt{D/A}$	0.51	0.76	1.58	1.00	0.33	0.54	0.35	0.16	0.59	1.96	0.05	0.18
A.D. ratio	3.76	1.73	0.39	0.98	8.89	3.31	8.0	35.94	2.83	0.25	327.25	27.94
^{2} gca/σ^2 sca ratio	1.84	0.86	0.19	0.48	4.42	1.65	3.50	17.97	1.41	1.28	163.5	13.96

*, ** :- Significant at 5% and 1% probability respectively

1=100 seed weight (gm)
2= Germination percentage
3= Speed of germination
4= Seedling root length (cm)
5= Seedling shoot length (cm)
6= Total seedling length (cm)
7= Fresh seedling weight (gm)
8= Dry seedling weight (mg)
9= Vigor index I
10= Vigor index II
11= Electrical conductivity (µs/gm
12= Viability percentage