GENETIC VARIABILITY AND CORRELATION STUDIES IN PIGEONPEA GERMPLASM LINES

By

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B.Sc. (Agri.)

MASTER OF SCIENCE

(Agriculture)

IN

AGRICULTURAL BOTANY

(GENETICS AND PLANT BREEDING)

DEPARTMENT OF AGRICULTURAL BOTANY

COLLEGE OF AGRICULTURE, LATUR

MARATHWADA AGRICULTURAL UNIVERSITY, PARBHANI

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DISSERTATION

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MARATHWADA AGRICULTURAL UNIVERSITY,
PARBHANI

2006

AFFECTIONATELY

DEDICATED TO MY

BELOVED PARENTS

FOR BUILDING UP

MY EDUCATIONAL

CAREER AND

EXCELLENT WISHES

THROUGHOUT MY LIFE

CANDIDATE'S DECLARATION

I hereby declare that the
dissertation or part thereof
has not been previously submitted
by me to any other University
or Institution for a
degree or diploma

Place : Latur

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CERTIFICATE – I

This is to certify that the dissertation entitled "**GENETIC VARIABILITY AND CORRELATION STUDIES IN PIGEONPEA GERMPLASM LINES**" submitted by **Shri. KODALE SHANKAR VISHWANATH** to the Marathwada Agricultural University, Parbhani in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **AGRICULTURAL BOTANY (GENETICS AND PLANT BREEDING)** is record of original and bonafide research work carried out by him under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree.

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

Place : Latur
Date : 19 /01 /2006

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Research Guide
&
Chairman

CERTIFICATE – II

This is to certify that the dissertation entitled "**GENETIC VARIABILITY AND CORRELATION STUDIES IN PIGEONPEA GERMPLASM LINES**" submitted by **Shri. KODALE SHANKAR VISHWANATH** to the Marathwada Agricultural University, Parbhani in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **AGRICULTURAL BOTANY (GENETICS AND PLANT BREEDING)** has been approved by the student's advisory committee after viva-voce examination in collaboration with the external examiner.

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ABBRIVATIONS

%	-	per cent
*	-	Significant at 5 per cent
**	-	Significant at 1 per cent
d.f.	-	Degrees of freedam
et al.,	-	and other co-workers
g	-	gram
GCV	-	Genotypic coefficient of variation
ha	-	hectare
M S S	-	Mean sum of squares
No.	-	Number (s)
PCV	-	Phenotypic coefficient of variation
r	-	Correlation coefficient
viz.,	-	Namely
vs	-	versus

INTRODUCTION

Chapter I

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Millsp) is the second most widely grown legume in India only after chickpea. Being the area of origin and the principal center of diversity, India share nearly 90 per cent area and 70 per cent germplasm variability of the world. Pigeonpea is mainly grown in the states of Uttar Pradesh, Madhya Pradesh, Maharashtra, Karnataka, Bihar, Gujrat, Tamil Nadu and Andhra Pradesh. In India its cultivation extends over 3.67 million hectares with a production of 2.36 million tonnes. In Maharashtra pigeonpea is grown on around 10.59 lakh hectare area with production of 7.76 lakh tonnes with average productivity of 733 kg/ha (Anonymous 2005). Pigeonpea has been very important component of farming system in India because of its ability to fix atmospheric nitrogen being a deep-rooted crop; it can thrive well under rainfed conditions and hence serve as an important companion crop under intercropping. It's roots open the soil and improve the soil structure. In addition, it adds organic matter to the soil in the form of dried leaves and roots.

Interest in this crop is growing in many countries because of its multiple uses as a source of food, feed, fuel and fertilizer. The development of improved cultivars has made a major contribution to the increased production and quality of plants used for their food. Selection of the appropriate cultivar is one of the key decisions that an agricultural producer must make.

Selection is the basis of crop improvement, hence it is necessary to make improvement in production of this crop by evaluation of different germplasm lines of pigeonpea. The efficiency of selection depends on identification of genetic variability by the phenotypic expression of the characters. The observed variability could be partitioned into heritable (genetic) and non heritable (non-genetic) components. The genetic variability could be determined with the help of certain genetic parameters such as genetic coefficient of variation heritability estimates and genetic advance.

The association existing among yield and its components and their intensity can be measured by correlation coefficient which is vital in planning an efficient breeding programme.

Further, it is also necessary to know which of the yield components are responsible for influencing seed yield directly and indirectly, so that their potentiality can be exploited to achieve higher production.

The present investigation was therefore, planned to evaluate different germplasm lines of pigeonpea with following objectives.

1. To assess the genetic variability for yield and yield contributing characters.
2. To study the association between yield and yield contributing characters.

REVIEW OF LITERATURE

Chapter II

REVIEW OF LITERATURE

The literature on pigeonpea pertaining to variability, correlation and path analysis reviewed below.

2.1. Genetic variability for yield and yield contributing character.

Gupta *et al.,* (1975) reported that highest variability for pod clusters per plant, pods per plant and seed yield with high variation for plant height, days to maturity, 100-seed weight, seeds per pod and pod length.

Malhotra and Sodhi (1977) observed high heritability for seed yield (60.57 per cent) and number of branches (16.53 per cent). Genetic advance was also high for seed yield and number of branches. Pod number and number of clusters had average habitability and genetic advance.

Beohar *et al.,* (1980) observed that the variability was highest for number of pods per plant and plant height while it was lowest for 100-seed weight. GCV was high for number of primary branches and effective pod bearing nodes. It was also sufficiently high for height, number of pods per plant and seed weight. While low for seed yield. All the yield traits recorded high estimate of heritability. The highest being for 100-seed weight, whereas it was lowest for seed yield per plant.

Godawat (1980) studied genotypic and phenotypic coefficient of variability in 26 varieties of pigeonpea and observed that seed yield per plant and number of primary branches per plant have high genotypic coefficient of variation.

Singh *et al.,* (1981a) reported that the estimates of broad sense heritability and genetic advance based on the phenotypic coefficient of variation was high for all the characters.

Yadavendra *et al.,* (1981) reported maximum heritability for test weight and seeds per pod, whereas lowest for yield per plant. Expected genetic advance ranged from 14 (length of pod) to 33 (pods per plant).

Malik *et al.,* (1981) observed high variability for pods per plant, clusters per plant, branches per plant and length of main fruiting branch, low variability for days to maturity, seeds per pod and days to flowering. High heritability and genetic advance was observed for all the characters under study except for plant spread, pods per cluster and seeds per pod.

Sidhu *et al.,* (1981) reported that heritability estimates were relatively low for plant height, pod number, seed size and seed yield, but medium for remaining characters.

Bainwal *et al.,* (1981) found maximum variability for number of secondary branches followed by number of primary branches and seed yield. The expected genetic advance was calculated to be high for seed yield, number of secondary branches, plant height and number of primary branches.

Shoran (1983) observed that the magnitude of range for phenotypic variability was high for all the characters except seeds per pod. High estimates of genotypic coefficient of variation and heritability were observed to be accompanied by moderate to high genetic advance for pods per plant, days to maturity, plant height and days to flower across the varying environment.

Natarajan *et al.,* (1990) observed high GCV for number of pods and seed yield per plant. High heritability coupled with high genetic was observed for seed yield, number of primary branches per plant, number of pods per plant, pod thickness, plant height and number of clusters per plant.

Singh *et al.,* (1996) observed that the magnitude of variability measured in terms of phenotypic coefficient of variation averaged over different populations was greatest for seed yield per plant followed by pods per plant, number of primary branches and plant height.

Vikas and Singh (1998) observed that both GCV and PCV were high for plant height, number of pods per plant, 100-seed weight and seed yield per plot in both early and indeterminate groups and extra early and semi determinate groups. On the basis of variability and character association days to 75 per cent flowering, days to maturity, number of pods per plant and 100-seed weight should be taken into consideration during selection for improving seed yield in pigeonpea.

Pansuriya, *et al.,* (1998) reported that the genotypic and phenotypic coefficients of variation were highest for dry matter per plant, harvest index, pods per plant and seed yield per plant. Heritability estimates were high for all the characters studied. However, high genetic advance was obtained only for dry matter per plant followed by pods per plant and plant height. High heritability coupled with high genetic advance for these traits indicated that additive gene effects were probably more important in the inheritance of these traits.

Takalkar *et al.,* (1998) observed the high heritability estimates for all the characters under study except straw yield per plant. The expected genetic advance was high for pods per plant, plant height, straw yield per plant and days to maturity. However, low genetic advance was observed for branches per plant, seeds per pod, 100-seed weight and harvest index.

Chandirakala and Raveendran (1998) reported high phenotypic and genotypic coefficient of variation for number of branches per plant, number of pods per plant, number of clusters per plant and 100-seed weight. Seed yield was significantly and positively correlated with number of branches per plant, number of pods per plant, number of clusters per plant, number of seeds per pod and 100-seed weight.

Aher *et al.,* (1998) reported wide genetic variability for plant height, plant spread, number of secondary branches per plant and days to 50 per cent flowering. High heritability accompanied by high genetic advance was observed for number of secondary and number of primary branches per plant followed by seed yield per plant, days to 50 per cent flowering, plant spread and plant height.

Patel and Patel (1998) reported high GCV and PCV for number of clusters per plant, number of pods per plant and seed yield. High heritability coupled with genetic advance was observed for seed yield, number of primary branches per plant, number of pods per plant and pod thickness.

Kingshlin *et al.,* (1998) observed high heritability estimates and genetic advance for branches per plant indicating as suitable selection criterion for increasing pods per plant and yield.

Jagdish Singh and Singh (1999a) reported that genotypic and phenotypic coefficient of variation were high for seed yield per plant, biological yield per plant, pods per plant and branches per plant. These characters also exhibit high heritability coupled with high genetic advance, indicating additive gene action and suitability for direct selection.

Srinivas *et al.,* (1999) reported that genetic variability was highest for number of pods and lowest for seed per pod. Heritability estimates were high for all traits except seeds per pod. Genetic advance was maximum for pods per plant. Seed yield showed significant positive relationship with plant height, number of primary branches, number of secondary branches and pods per plant.

Bhasavarajaiah *et al.,* (2000) showed that high values of phenotypic and genotypic coefficients of variation were observed for days to 50 per cent flowering, straw weight, pods per plant, yield per plant and length of pod bearing branches. High heritability coupled with high genetic advance was observed for days to 50 per cent flowering, straw weight, yield per plant, length of pod bearing branches and 100-seed weight indicating that additive gene effects were operating for these characters.

Venkateswarlu (2001) reported maximum variability for number of pods per plant followed by straw yield per plant and plant height. The high heritability estimates were observed for the characters like number of secondaries per plant, seed yield per plant, days to maturity, straw yield per plant and number of primaries per plant. The expected genetic advance was high for straw yield per plant, plant height, number of pods per plant, seed yield per plant and days to maturity.

2.2 Correlation

Singh *et al.,* (1972) reported significant and positive phenotypic and genotypic association between yield and plant height, number of secondary branches and pod length. Whereas the correlation with days to flowering was negative.

Kumar and Haque (1973) reported that seed yield was significantly and positively correlated with number of leaves, branches, pods, seed per pod and plant height. There was negative correlation with days to flowering and maturity.

Mukewar and Muley (1974) reported that seed yield was positively and significantly correlated with bhussa (chaff) weight and weight of pods per plant. Seed yield was negatively correlated with plant height, 100-seed weight, days to maturity and days to flowering.

Dahiya *et al.,* (1978) observed that yield was significantly correlated with number of pods per plant, number of seed per pod and 100-seed weight but negatively correlated with plant height.

Godawat (1980) observed that seed yield per plant had significant positive correlation with number of primary branches per plant, 100-seed weight and number of pods per plant.

Ahalwat *et al.,* (1981) reported positive and highly significant correlation between seed yield, number of branches, number of pods and dry matter. Multiple regression and correlation studies revealed that the seed yield of pigeonpea was highly depended on number of branches, number of pods and dry matter of the plant.

Singh *et al.,* (1981b) observed that seed yield per plant was positively correlated with number of pods per plant, plant height, days to 50 per cent flowering, seeds per pod and days to maturity. The different yield component also showed favourable association with each other except 100-seed weight.

Ahuja *et al.,* (1981) reported that pods per plant were highly correlated with yield and the significant effect on yield much of the indirect effect could be explained through their effect on pod number.

Aswa *et al.,* (1981) observed that yield was positively correlated with pods per plant, seeds per pod and days to maturity.

Malik *et al.,* (1981) showed that seed yield was positively and significantly correlated with days to maturity, plant height, plant spread, fruiting branch length, number of branches and pods per plant, seeds per pod and 100-seed weight.

Marekar (1982) observed that in F_1 generation seed yield showed significant positive correlation both at genotypic as well as phenotypic levels with plant height, biomass per plant, harvest index, number of clusters per plant, number of primary branches per plant.

Kumar and Reddy (1983) observed significant positive correlation of seed yield with number of primary and secondary branches, pod bearing branch length and pod number. In addition to the above traits, days to maturity and seed weight also showed positive association with seed yield in the short group. Among medium talls seed yield was positively correlated with days to maturity and pod number, but a significant negative correlation with secondary branches. In the tall group, plant height, pod number and maturity time showed positive correlation while, seed weight had a strong negative association with yield.

Saraf and Hedge (1984) observed that seed yield was positively and significantly associated with plant height, branches per plant, dry weight per plant and leaf area index.

Sidhu *et al.,* (1985) reported that seed yield showed significant positive correlation with plant height, pods per plant, seed size and seeds per pod.

Marekar and Nerkar (1987) observed that high significant positive correlation of yield with plant height, number of pods and biomass per plant.

Sagar *et al.,* (1987) observed that seed yield was positively associated with number of pods, days to maturity, plant height, branches and plant spread.

Ahuja and Sharma (1988) showed that seed yield was positively correlated with number of branches and pods per plant, dry matter per plant and 1000-seed weight. The partial regression coefficients of yield with branches per plant, pods per plant and dry matter per plant were also significant.

Patel *et al.,* (1988) reported that seed yield was positively and significantly correlated with plant height, number of pods per plant and moderately correlated with days to flowering and days to maturity.

Brar (1993) observed that seed yield was positively correlated with pods per plant, clusters per plant, number of secondary branches per plant and plant height. Phenotypic and genotypic correlation coefficient were similar for seed yield per plant, number of pods per plant and clusters per plant.

Dhameliya and Pathak (1994) observed that genotypic correlation coefficients were in general higher than phenotypic correlations. Yield contributing traits such as branches per plant, pods per plant and plant height showed positive association with each other.

Salunke *et al.,* (1995) reported that seed yield per plant was significantly and positively associated with pods per plant, number of primary and number of secondary branches, plant spread, plant height and 100-seed weight. It had strong negative association with seeds per pod.

The yield components days to 50 per cent flowering, days to maturity, plant height, plant spread, number of primary branches, number of secondary branches and 100-seed weight were positively and significantly associated with each other. Pods per plant was positively and significantly associated with number of primary branches, number of secondary branches, plant height and plant spread.

Singh *et al.,* (1995) observed that plant height and days to maturity had strong positive genotypic and phenotypic correlations with seed yield. Days to flowering was positively correlated with days to maturity and plant height.

Vanniarajan *et al.,* (1997) reported that yield showed a significant and strong positive association with days to 50 per cent flowering, days to maturity, plant height, branches per plant, clusters per plant, pods per plant, pod length and 100-seed weight. Similarly, strong positive inter-relationships were observed between days to 50 per cent flowering and days to maturity, plant height, branches per plant, clusters per plant, pods per plant and between themselves. Association of pod length with seeds per pod and 100-seed weight was significant and positive.

Chandirakala and Raveendran (1998) showed that seed yield was significantly and positively correlated with number of branches per plant, number of pods per plant, number of clusters per plant, number of seeds per pod and 100-seed weight.

Pandey and Singh (1998) reported that the number of primary branches per plant were the prime contributes to seed yield.

Pansuriya *et al.,* (1998) observed that seed yield was significantly and positively correlated with pods per plant and dry matter per plant, indicating that selection on the basis of these traits would be effective for yield improvement.

Kingshlin and Subbaraman (1999) reported that branches per plant, clusters per plant, pods per plant, pod length, seeds per pod and 100-seed weight were strongly associated with seed yield.

Jagdish Singh and Singh (1999b) reported that seed yield per plant showed significant positive association with plant height, branches per plant, pods per plant, seeds per pod, biological yield per plant and harvest index. Maximum correlated response was recorded for biological yield per plant followed by pods per plant, branches per plant, harvest index and seed per pods. The results suggested that direct selection for biological yield per plant and pods per plant would be more effective than selection for seed yield itself.

2.3 Path analysis

Pokle and Mohatkar (1976) showed that pods per plant had high direct effect on yield and was the main yield contributing characters. Pod number indirectly affected the correlation, involving plant height, 100-seed weight and number of primary branches per plant.

Godawat (1980) observed that 100-seed weight had maximum direct effect on seed yield.

Awatade *et al.,* (1980) reported that number of clusters per plant and 100 seed weight had direct effect on seed yield at both genotypic and phenotypic levels where as seeds per pod had low direct effect on yield.

Reddy and Rao (1980) reported that direct influence of plant height, pod bearing length, pod width and number of secondary branches on seed yield.

Jag Shoran (1982) reported that pods per plant had the highest direct effect on seed yield followed by 100-seed weight, seeds per pod and days to maturity.

Kumar and Reddy *et al.,* (1982) observed that pod number, plant height and number of primary branches have large positive direct effect on yield per plant.

Singh *et al.,* (1982) showed that maximum direct and positive effect among the yield components was exerted by 100-seed weight.

Angadi *et al.,* (1988) reported that pod yield was significantly correlated with seed yield, pods per plant, days to flowering and plant height. Pod yield was the only character with a direct effect on seed yield.

Holkar *et al.,* (1991) studies on path analysis revealed that 100-seed weight had the highest direct positive effect on seed yield. Time to 50 per cent flowering and pods per plant had positive direct effect on seed yield, but their magnitude was lowered by negative indirect effect of 100-seed weight.

Jahagirdar and Nerkar (1994) reported that number of effective clusters per plant, number of effective pods per plant and 100-seed weight were strongly associated with seed yield. Path coefficient analysis revealed that number of effective pods per plant was the major character affecting seed yield, both directly and indirectly. Plant height, 100-seed weight and number of primary and number of secondary branches per plant affected seed yield indirectly.

Dahiya and Singh (1994) reported that number of pods per plant had the highest direct effect on seed yield followed by 100-seed weight.

Viramgama and Goyal (1994) observed that number of pods per plant had the highest direct and indirect positive effect on seed yield and height. Number of primary branches and test weight had indirect effects through pod number which were greater than individual direct effect.

Dhameliya and Pathak (1995) observed that pods per plant had the highest direct positive effect on yield followed by seeds per pod, days to flowering, branches per plant and 100-seed weight.

Salunke *et al.,* (1995) observed that pods per plant, seeds per pod and 100-seed weight had direct positive effects on seed yield, pods per plant and 100-seed weight, pods per plant and 100-seed weight also exhibited high, positive indirect effects on seed yield through most of the other characters.

Paul *et al.,* (1996) in path coefficient analysis observed that pods per plant had the greater direct effect on seed yield followed by dry matter at maturity and 100-seed weight.

Vanniarajan *et al.,* (1997) observed that pods per plant and 100-seed weight had high positive and direct effect on seed yield.

Kingshlin *et al.,* (1997) studies on path coefficient analysis observed that pod length, seed per pod and 100-seed weight made the greatest contribution towards seed yield both directly and indirectly.

Chandirakala and Reveedran (1998) reported that 100-seed weight had the highest positive direct effect on seed yield followed by number of pods per plant and number of clusters per plant. Number of branches per plant, number of pods per plant, number of clusters per plant, number of seeds per pod and 100-seed weight showed high positive indirect effect on seed yield.

Kingshlin and subbaraman (1999) in the studies of path analysis observed that 100-seed weight, pod length, days to 50 per cent flowering, days to maturity and seeds per pod were the major characters affecting seed yield directly.

Basavarajaiah *et al.,* (1999) observed in path analysis that pod weight had the direct effect on seed yield followed by plant height, branches per plant and pods per plant.

MATERIALS AND METHODS

Chapter III

MATERIALS AND METHODS

3.1 Experimental materials

The experimental material for the present investigation consisting of fifty two germplasm lines of pigeonpea collected from ARS, Badnapur and local selections including four checks were sown during kharif, 2004. Details have been given in Table 1.

Table 1 : Name and sources of the germplasm lines.

Sr. No.	Name	Source
1.	FS-5	Local selection
2.	GP-23	ARS, Badnapur
3.	FS-29	Local selection
4.	GP-45	ARS, Badnapur
5.	GP-46-1	ARS, Badnapur
6.	GP-46-2	ARS, Badnapur
7.	GP-47-2	ARS, Badnapur
8.	GP-49-2	ARS, Badnapur
9.	GP-49-1	ARS, Badnapur
10.	GP-50	ARS, Badnapur
11.	GP-51	ARS, Badnapur
12.	GP-56	ARS, Badnapur
13.	GP-33	ARS, Badnapur
14.	GP-10	ARS, Badnapur
15.	GP-64-1	ARS, Badnapur

Contd….

16.	GP-64-2	ARS, Badnapur
17.	GP-65-1	ARS, Badnapur
18.	GP-72-2	ARS, Badnapur
19.	GP-72-2	ARS, Badnapur
20.	GP-74-1	ARS, Badnapur
21.	GP-74-2	ARS, Badnapur
22.	FS-12-1	Local selection
23.	FS-12-2	Local selection
24.	RM-1	Local selection
25.	RM-2	Local selection
26.	853-1	Selection from BSMR-853
27.	853-2-2	Selection from BSMR-853
28.	853-2-1	Selection from BSMR-853
29.	853-3	Selection from BSMR-853
30.	853-4	Selection from BSMR-853
31.	853-5	Selection from BSMR-853
32.	853-6	Selection from BSMR-853
33.	853-7	Selection from BSMR-853
34.	853-9	Selection from BSMR-853
35.	853-10	Selection from BSMR-853
36.	853-13	Selection from BSMR-853
37.	BSMR-853	Check
38.	853-23	Selection from BSMR-853
39.	853-26	Selection from BSMR-853
40.	853-32	Selection from BSMR-853
41.	853-35	Selection from BSMR-853

Contd….

42.	736-1	Selection from BSMR-736
43.	736-8	Selection from BSMR-736
44.	736-9	Selection from BSMR-736
45.	BSMR-736	Check
46.	736-4	Selection from BSMR-736
47.	853-25	Selection from BSMR-853
48.	ICPL-87119	ARS, Badnapur
49.	ICP-8863	Check
50.	BDN-2	ARS, Badnapur
51.	BSMR-175	ARS, Badnapur
52.	AKT-8811	Check

3.2 Experimental methods

The experiment was laid out during *kharif*, 2004 at the Experimental Farm, College of Agriculture, Latur. The experimental details are as follows.

Design	:	R.B.D. (Randomized Block Design)
Treatments	:	52
Replications	:	Three
Plot size	:	1.80 x 3.0 m.
Fertilizer	:	25 kg N + 50 Kg P_2O_5/ha
Spacing	:	Row to row : 60 cm.
		Plant to plant : 30 cm.
Number of rows per entry	:	Three rows per entry.

3.2.1 Recording of observations

Five plants were selected from each treatment randomly for recording observations. Average value of each character was determined from these observational plants.

Observations were recorded on following agronomic traits.

3.2.1.1 Days to 50 per cent flowering

Number of days required from sowing to the flowering of approximately 50 per cent plants in each row and in each replication was recorded and average number of days to 50 per cent flowering was worked out.

3.2.1.2 Days to maturity

Number of days from sowing to maturity of all the plants were recorded.

3.2.1.3 Plant height (cm)

Height of plants was recorded at the time of maturity.

3.2.1.4 Number of primary branches per plant

Branches borne on the main shoot were counted as number of primary branches.

3.2.1.5 Number of secondary branches per plant

Branches borne on all the number of primary branches were counted as number of secondary branches.

3.2.1.6 Number of pods per plant

The effective pods per plant were counted at the time of harvest.

3.2.1.7 Number of seeds per pod

Average number of seed from selected pods were counted.

3.2.1.8 100-seed weight (g)

Well-filled 100-seeds were weighted.

3.2.1.9 Seed yield per plant (g)

The total seed harvested from a plant was weighted.

3.3 Statistical methods

3.3.1 Analysis of variance

The mean value of all the treatments for the characters under study was worked out. Standard error and critical difference at 1 and 5 percent level of significance were calculated by using the formula (Panse and Sukhatme, 1985).

Source of variation	d f	M S	Expected square	F
Replications	(r-1)	MS_1	$\delta^2e + g\,\delta^2r$	
Genotypes	(g-1)	MS_2	$\delta^2e + r\,\delta^2g$	
Error	(r-1) (g-1)	MS_3	δ^2e	
Total	(rg -1)			

r = Number of replications

g = Number of genotypes

δ^2e = Error variance.

δ^2g = Genotypic variance

δ^2r = Replication variance

1. Standard error (SE) $= \sqrt{\dfrac{MS_3}{r}}$

Where,

MS_3 = Error mean sum of squares

r = number of replication.

2. Critical difference (C D) = S E x $\sqrt{2}$ x t value at 5 per cent level of error degrees of freedom

3.3.2 Genetic variability

Various parameters of genetic variability were calculated by using the following formula

1. Genotypic variance ($\delta^2 g$) $= \dfrac{\text{Treatment MSS - Error MSS}}{\text{Number of replications}}$

2. Phenotypic variance ($\delta^2 p$) = Genotypic variance + Error variance

The genotypic and phenotypic, coefficients of variation (GCV and PCV) were calculated by following formula (Burton, 1952)

3. Genotypic coefficient of variation (GCV) $= \dfrac{\sqrt{\delta^2 g}}{\overline{X}} \times 100$

4. Phenotypic coefficient of variation (PCV) $= \dfrac{\sqrt{\delta^2 p}}{\overline{X}} \times 100$

Where,

$\delta^2 g$ = genotypic variance.

$\delta^2 p$ = phenotypic variance.

$\overline{X}$ = general mean of character.

3.3.3 Heritability and genetic advance

Heritability (broad sense) was calculated according to the method suggested by Allard (1960).

$$1. \quad \text{Heritability } (h^2 b\ s) = \frac{\delta^2 g}{\delta^2 P} \times 100$$

Where,

$\delta^2 g$ = genotypic variance.

$\delta^2 p$ = phenotypic variance.

The genetic advance at 5 percent selection intensity was calculated for each character using the formula suggested by Johnson *et al.,* (1955a).

$$2. \quad \text{Genetic advance } (G\ A) = K.\ \delta p.\ h^2$$

Where,

K = Selection differential at 5per cent level i.e., 2.06.

δp = phenotypic standard deviation

h^2 = heritability

The expected genetic advance in percentage of mean was calculated as,

$$3. \quad E\ G\ A = \frac{GA}{\overline{X}} \times 100$$

Where,

E G A	=	Expected genetic advance
G A	=	Genetic advance
$\overline{X}$	=	General mean of character

3.3.4 Correlation

Covariances were calculated for all the characters to find out correlations among the characters. The interrelationships of different yield contributing characters were worked out according to Johnson *et al.*, (1955b).

$$r = \frac{\text{Cov. (x.y)}}{(\delta^2 x\ \delta^2 y)\ ½}$$

Where

r = correlation coefficient between the characters x and y

Cov. (x.y) = covariance between x and y.

δ^2 x and δ^2 y are the respective variances of x and y.

The significance of correlation coefficient was tested against 'r' values given by Fisher and Yates (1963) at (n-2) degrees of freedam at 5 and 1 percent level of significance.

3.3.5 Path coefficient anlaysis

Path coefficient analysis was carried out according to Dewey and Lu (1959). The direct and indirect path coefficients were calculated by solving the following set of 'p' simultaneous equations by the abbreviated Doolittle technique.

$P_{01} + P_{02}\, r_{12} + \text{------} \quad P_{0P}\, r_{1p} = r_{ol}$

$P_{01}\ r_{12}\, P_{02}\ + \text{-----} \quad P_{0P}\, r2_p = r_{o2}$

$P_{01}\ r_{10} + P_{02}\, r_{2p}\ + \text{---} \quad P_{0P} = r_{op}$

Where, P_{01}, P_{02}, ...P_{0P} are the path effects of 1.2.......P variable on 'o' variable.

r_{12}, r_{13}.... r_{1p}........... $r_{p(p-1)}$ are the possible correlation coefficients between various independent variables and r_{01}, r_{02}......... r_{op} are the correlations of independent variables with dependent variables. The different effects of 'i' th variable via 'j'th variable were worked out as (P_{oj} x P_{ij}).

From the simultaneous equations it is clear that the correlation coefficient is the sum of direct and indirect path coefficients.

Residual effect was calculated as under

$P^2\, OX = 1 - (P^2{}_{01} + 2P_{01}\, P_{02} r_{12} + 2P_{01}\, P_{03}\, r_{13} + \ldots\ldots\ldots\ldots$

$P^2\, O2 = 2P_0{}^2\, P_{03}\, r_{23} + \ldots\ldots\ldots\ldots + P^2{}_{op})$

Residual factor $= P^2{}_{op}$

RESULTS

CHAPTER – IV

RESULTS

The experimental results obtained on various characters are presented below under five sections.

1. Analysis of variance
2. Mean performance
3. Genetic parameters
    - i) Variance component
    - ii) Estimates of variability parameters (GCV, PCV).
    - iii) Heritability.
    - iv) Genetic advance
    - v) Genetic advance as percent of mean (expected GA)
4. Correlation
5. Path analysis

4.1 Analysis of variance

Analysis of variance was worked out to assess the variation in 52 germplasm lines for nine characters. The significance was noted by applying 'F' test. Analysis of variance for nine characters consisting of replication mean squares, treatment mean squares, error mean squares standard error and critical differences at 5 per cent and 1 per cent is given in Table 2.

The analysis of variance showed that differences among the treatments in respect of all the characters were significant both at 5 per cent and 1 per cent level. This indicates that wide range of variability among the germplasm lines for yield and yield contributing characters.

Table 2: Analysis of variance for yield and yield contributing characters.

Sr. No.	Source of variation	D.F.	Days to 50 % flowering	Days to maturity	No. of pods/ plant	Plant height (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	Number of seeds /pod	100 seed wt. (g)	Seed yield /plant (g)
	Mean sum of squares										
1	Replication	2	38.13	4.92	44.33	186.01	3.04	0.24	0.18	0.64	38.39
2	Treatment	51	18.26**	70.22**	5906.5**	334.53*	5.45*	22.57**	0.16*	5.35**	382.98**
3	Error	102	1.10	1.01	139.19	61.63	1.12	0.97	0.030	0.30	20.21

* Significant at 5 per cent

** Significant at 1 per cent

4.2 Mean performance

The mean performance of germpalsm lines under study for nine characters is given in Table 3.

4.2.1 Days to 50 per cent flowering

The range of days to 50 per cent flowering was from 113 to 128 days with an average value of 120.50 days. The check variety AKT-8811 (113.00) exhibited early 50 per cent flowering followed by GP-46-1 (116.00), GP-45 (117.00), FS-29 (117.00), ICP-8863 (C) (117.00), GP-46-2 (118.00), GP-47-2 (118.00), BSMR-736-1 (118.00), GP-72-2 (118.00) and FS-5 (119.00). Higher days to 50 per cent flowering was observed in germplasm GP-51 (123.00), GP-74-2 (124.00) and BSMR-175 (128.00).

4.2.2 Days to maturity

Number of days to maturity ranged from 170.00 to 187.00 days with an average value of 178.50 days. Among the lines FS-29 (170.00), GP-45 (170.00), GP-56 (171.00), GP-64-1 (171.00), GP-46-2 (172.00), BSMR-736-1 (172.00), GP-46-1 (173.00), ICP-8863 (173.00) and FS-5 (174.00) showed early maturity. However the late maturity was observed in BSMR-175 (187.00) followed by BSMR-853-2-1 (185.00), 853-2-2 (185.00), GP-49-1 (184.00) and check variety ICPL-87119 (184.00).

4.2.3 Number of pods per plant

The range for number of pods per plant was from 96.00 to 281.00 with the mean of 188.50. The maximum number of pods were observed in germplasm line RM-2 (281.00) followed by 853-3 (241.00), RM-1 (238.00), 853-1 (226.00), GP-33 (222.00), 853-5 (215.00), and 736-1 (206.00).

Table 3 : Mean performance of germplasm lines for yield and yield contributing characters.

Sr. No.	Genotype	Days to 50% flowering	Days to maturity	No. of pods / plant	Plant height (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	No. of seeds / pod	100 Seed weight (g)	Seed yield /plant (g)
1	2	3	4	5	6	7	8	9	10	11
1	FS-5	119.00	174.00	177.00	194.00	9.40	13.63	4.10	8.32	43.00
2	GP-23	120.00	171.00	151.00	200.00	6.70	13.80	4.00	12.35	47.00
3	FS-29	117.00	170.00	141.00	182.00	8.00	8.70	4.00	8.70	36.00
4	GP-45	117.00	170.00	201.00	193.00	7.50	15.90	4.10	10.31	60.00
5	GP-46-1	116.00	173.00	176.00	180.00	8.50	12.00	4.00	9.10	34.00
6	GP-46-2	118.00	172.00	205.00	186.00	10.60	15.00	4.10	9.90	61.00
7	GP-47-2	118.00	170.00	187.00	190.00	9.00	9.50	4.30	9.50	50.00
8	GP-49-2	120.00	172.00	192.00	187.00	8.10	10.60	4.00	10.15	53.00
9	GP-49-1	121.00	184.00	151.00	179.00	7.20	11.00	3.73	11.80	46.00
10	GP-50	119.00	170.00	202.00	190.00	9.20	11.50	4.00	9.40	52.00
11	GP-51	123.00	181.00	96.00	194.00	7.00	8.50	4.00	12.65	36.00
12	GP-56	120.00	171.00	146.00	175.00	11.50	10.00	3.73	10.50	39.00
13	GP-33	120.00	170.00	222.00	181.00	10.00	12.70	4.00	9.55	54.00
14	GP-10	124.00	183.00	96.00	183.00	7.90	6.03	4.00	12.80	36.00
15	GP-64-1	122.00	171.00	114.00	188.00	9.00	9.70	4.00	11.70	38.00
16	GP-64-2	124.00	180.00	139.00	200.00	8.10	8.80	4.00	11.70	57.00
17	GP-65-1	121.00	178.00	122.00	183.00	9.10	10.10	4.10	8.90	32.00
18	GP-72-2	118.00	175.00	113.00	180.00	8.50	11.80	4.00	8.90	33.00
19	GP-72-2	117.00	176.00	109.00	174.00	9.70	7.90	4.00	10.71	32.00
20	GP-74-1	122.00	178.00	119.00	154.00	10.10	9.20	4.50	12.40	43.00
21	GP-74-2	124.00	182.00	179.00	177.00	9.80	15.83	4.00	9.45	45.00
22	FS-12-1	118.00	173.00	130.00	178.00	6.70	13.70	4.10	12.10	44.00
23	FS-12-2	119.00	172.00	175.00	176.00	8.70	11.10	4.10	10.45	55.00
24	RM-1	121.00	173.00	238.00	177.00	5.70	12.00	4.00	7.30	44.00

1	2	3	4	5	6	7	8	9	10	11
25	RM-2	121.00	171.00	281.00	177.00	8.70	12.10	4.00	7.35	56.00
26	BSMR-853-1	121.00	184.00	226.00	168.00	9.50	11.73	4.50	10.55	70.00
27	853-2-2	122.00	185.00	138.00	182.00	11.50	18.50	4.00	10.40	49.00
28	853-2-1	123.00	185.00	179.00	187.00	10.70	13.00	4.00	10.40	47.00
29	853-3	122.00	179.00	241.00	176.00	10.10	15.10	4.50	10.50	79.00
30	853-4	123.00	178.00	137.00	161.00	9.20	13.83	4.30	10.10	47.00
31	853-5	120.00	176.00	215.00	150.00	11.40	17.10	4.00	9.40	66.00
32	853-6	121.00	175.00	119.00	164.00	7.50	11.50	4.10	10.70	37.00
33	853-7	122.00	177.00	111.00	174.00	7.60	10.33	4.10	10.55	34.00
34	853-9	123.00	178.00	112.00	176.00	9.70	10.00	4.00	10.27	30.00
35	853-10	123.00	176.00	101.00	170.00	7.50	13.90	4.23	10.40	33.00
36	853-13	121.00	171.00	136.00	164.00	8.30	11.20	5.00	10.25	48.00
37	BSMR-853 (C)	120.00	177.00	187.00	172.00	9.40	13.50	4.10	9.70	57.00
38	853-23	119.00	175.00	149.00	170.00	9.10	11.70	4.50	11.35	53.00
39	853-26	122.00	184.00	150.00	162.00	7.00	12.53	4.00	9.70	34.00
40	853-32	119.00	182.00	110.00	167.00	8.40	8.60	4.10	12.94	44.00
41	853-35	120.00	171.00	96.00	166.00	7.50	5.60	4.50	11.45	35.00
42	BSMR-736-1	118.00	172.00	206.00	182.00	10.10	12.70	4.10	11.65	65.00
43	736-8	121.00	174.00	181.00	179.00	10.20	12.10	4.00	9.50	46.00
44	736-9	119.00	175.00	146.00	178.00	8.50	11.10	4.10	10.85	47.00
45	BSMR-736 (C)	119.00	174.00	169.00	186.00	9.50	12.70	4.20	10.35	57.00
46	736-4	120.00	177.00	199.00	182.00	8.60	16.20	4.00	11.80	63.00
47	853-25	121.00	181.00	102.00	169.00	7.60	11.20	3.30	12.70	34.00
48	ICPL-87119	121.00	184.00	105.00	182.00	9.10	12.60	4.10	11.40	37.00
49	ICP-8863 (C)	117.00	173.00	166.00	175.00	9.10	7.60	4.00	9.00	43.00
50	BDN-2	119.00	174.00	120.00	167.00	5.60	6.00	4.00	9.30	33.00
51	BSMR-175	128.00	187.00	158.00	185.00	8.10	9.83	4.00	12.15	48.00
52	AKT-8811 (C)	113.00	175.00	176.00	183.00	9.20	11.50	4.00	9.85	54.00
	Mean	**120.32**	**176.16**	**157.58**	**177.81**	**8.74**	**11.58**	**4.08**	**10.44**	**46.50**

4.2.4 Plant height (cm)

The range was noted from 150.00 to 200.00 cm with the mean of 175 cm. The line 853-5 (150.00) exhibited lowest plant height followed by 853-26 (162.00) and 853-6 (164.00). The maximum plant height was observed in GP-23 (200.00) followed by GP-64-2 (200.00), FS-5 (194.00), GP-51 (194.00), GP-45 (193.00) and 853-2-1 (187.00).

4.2.5 Number of Primary branches per plant.

Number of Primary branches per plant ranged from 5.60 to 11.50 with the mean of 8.55. Highest number of primary branches were observed in GP-56 (11.50) followed by 853-2-2 (11.50), 853-5 (11.40), 853-2-1 (10.70), 736-8 (10.20), 736-1 (10.10) and 853-3 (10.10). The minimum number of primary branches was observed in check variety BDN-2 (5.60).

4.2.6 Number of secondary branches per plant.

The range recorded for number of secondary branches per plant was 5.60 to 18.50 with an average of 12.05. The maximum number of secondary branches have been observed in 853-2-2 (18.50) followed by 853-5 (17.10), GP-45 (15.90), GP-74-2 (15.83), 853-10 (13.90). The minimum number of secondary branches observed in 853-35 (5.60).

4.2.7 Number of seeds per pod.

The range for number of seeds per pod was from 3.30 to 5.00 with the mean of 4.15. The maximum number of seeds per pod observed in 853-13 (5.00) followed by GP-74-1 (4.50), 853-1 (4.50), 853-3 (4.50), 853-4 (4.30), GP-47-2 (4.30) and 853-10 (4.23). The minimum number of seeds per pod was observed in 853-25 (3.30).

4.2.8 100-Seed Weight (g)

100-seed weight ranged from 7.30 to 12.94 g with an average value of 10.12. Maximum test weight was recorded by germplasm line 853-32 (12.94) followed by GP-10 (12.80), 853-25 (12.70), GP-51 (12.65), GP-74-1 (12.40). Minimum test weight was observed in germplasm line RM-1 (7.30).

4.2.9 Seed yield per plant (g)

The character seed yield per plant was ranged from 30.00 to 79.00 g with the mean of 54.50 g. The highest seed yield per plant was recorded by 853-3 (79.00) followed by 853-1 (70.00), 853-5 (66.20), 736-1 (65.50), 736-4 (63.50) and GP-46-2 (61.03). Among the checks maximum seed yield was recorded by BSMR-853 (57.50) followed by BSMR-736 (57.03) and AKT-8811 (54.50). The minimum seed yield per plant was observed in line 853-9 (30.00).

4.3 Genetic Parameters

Genetic parameters viz., the genotypic variance ($\delta^2 g$), phenotypic variance ($\delta^2 p$), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (broad sense), genetic advance (GA) and expected genetic advance as per cent mean (EGA) were worked out and are presented in Table 4.

4.3.1 The variance component

The amount of variation in quantitative characters is measured and expressed as variances. The whole amount of observed variation or phenotypic variation present in the character does not give a true account of the variation which is fixable in the succeeding years of generations, while genotypic variation is the amount of fixable index

Table 4 : Parameters of genetic variability for yield and yield contributing characters.

Sr. No.	Character	Range	Mean	Genotypic variance 6^2 g	Phenotypic variance 6^2 p	G.C.V. (%)	P.C.V. (%)	Heritability (%)	Genetic advance (GA)	Expected genetic advance (EGA)
1.	**Days to 50 % flowering**	113.00 – 128.00	120.50	5.72	6.82	1.98	2.16	83.8	4.51	3.74
2.	**Days to maturity**	170.00 – 187.00	178.50	23.07	24.08	2.69	2.74	95.8	9.68	5.42
3.	**No. of pods / plant**	96.00 – 281.00	188.50	1922.43	2061.62	23.26	24.08	93.2	87.21	46.26
4.	**Plant height (cm)**	150.00 – 200.00	175.00	90.96	152.59	5.44	7.05	59.6	15.16	8.66
5.	**No. of primary branches/ plant**	5.60 – 11.50	8.55	1.44	2.56	14.03	18.71	56.2	1.85	21.63
6.	**No. of secondary branches / plant**	5.60 – 18.50	12.05	7.2	8.17	22.26	23.72	88.1	5.18	42.98
7.	**No. of seeds / pod**	3.30 – 5.00	4.15	0.043	0.073	4.99	6.51	58.9	0.32	7.71
8.	**100 seed wt. (g)**	7.30 – 12.94	10.12	1.68	1.98	12.80	13.90	84.8	2.45	24.20
9.	**Seed yield /plant (g)**	30.00 – 79.00	54.50	120.92	141.13	20.17	21.79	85.6	20.96	38.45

from one generation to the next generation. The environmental variation varies from one place to other and as such can not be fixed up.

In general the genotypic and phenotypic variances were more or less equal for characters viz., Days to 50 per cent flowering, days to maturity, number of secondary branches per plant, number of seeds per pod and 100-seed weight. However the differences in genotypic and phenotypic variances were exhibited for number of pods per plant, plant height and seed yield per plant.

4.3.2 Estimates of variability parameters

4.3.2.1 Genotypic coefficient of variation (GCV)

On the basis of mean, the genotypic coefficient of variation was observed to be high for number of pods per plant (23.26) followed by number of secondary branches per plant (22.26), seed yield per plant (20.17), number of primary branches per plant (14.03) and 100-seed weight (12.80). For rest of the characters, genotypic coefficient was ranged from 1.98 to 5.44.

4.3.2.2 Phenotypic coefficient of variation (PCV)

On the basis of mean the phenotypic coefficient of variation was recorded to be high for number pods per plant (24.08), followed by number of secondary branches per plant (23.72), seed yield per plant (21.79), number of primary branches per plant (18.71) and 100-seed weight (13.90). For rest of the characters phenotypic coefficient of variation was ranged from 2.16 to 7.05.

4.3.3 Heritability

It has been observed that the heritability estimates (broad sense) was high for all the characters except number of primary branches per plant, plant height and number of seeds per pod. On the basis of average the highest heritability estimates were observed for days to maturity (95.8) followed by number of pods per plant (93.2), number of secondary branches per plant (88.1), seed yield per plant (85.6), 100-seed weight (84.8) and days to 50 per cent flowering (83.8). The medium heritability estimates were observed for number of primary branches (56.2), number of seeds per pod (58.9) and plant height (59.6).

4.3.4 Genetic advance

On the basis of mean, higher estimates of genetic advance were observed in number of pods per plant (87.21) followed by seed yield per plant (20.96). Low genetic advance was observed in plant height (15.16), days to maturity (9.68), number of secondary branches per plant (5.18), days to 50 per cent flowering (4.51), number of primary branches per plant (1.85) and number of seeds per pod (0.32).

4.3.5 Genetic advance as percent of mean (Excepted GA)

On the basis of mean, genetic advance as percent of mean showed higher values for number of pods per plant (46.26) followed by number of secondary branches per plant (42.98), seed yield per plant (38.45), 100-seed weight (24.20), number of primary branches per plant (21.63). Low genetic advance as percent of mean was observed in days to 50 per cent flowering (3.74), days to maturity (5.42), number of seeds per pod (7.71) and plant height (8.66).

4.4 Correlation

The correlation coefficient is a most important statistical constant used as a measure of the degree of association between two characters worked at the same time. The correlation studies help the breeder to compute the required genetic make up of the ideal variety. In order to find out the associations or correlations between the characters considered in the present study, phenotypic and genotypic correlations coefficients were worked out for nine quantitative characters (Table 5).

1. Yield per plant with other characters

Positive and significant phenotypic and genotypic correlations were observed between yield and yield contributing components namely number of pods per plant, number of primary and secondary branches per plant. While number of seeds per pod has positive and significant correlation for seed yield only at genotypic level. The plant height has positive but non significant values for seed yield both at genotypic and phenotypic levels. However, there was negative correlation of days to 50 per cent flowering, days to maturity and 100-seed weight with seed yield.

2. Days to 50 per cent flowering and other characters

Positive and significant phenotypic and genotypic correlations were noted between days to maturity, 100-seed weight and days to 50 per cent flowering. While positive but non-significant correlations were noted for number of seeds per pod. However, negative and non-significant correlations noted for rest of the characters.

Table 5 : Estimates of genotypic and phenotypic correlation coefficients between yield and yield contributing characters.

Sr. No.	Character		Days to 50 % flowering	Days to maturity	No. of pods/ plant	Plant height (cm)	No. of primary branches / plant	No. of secondary branches / plant	No. of seeds / pod	100 seed wt. (g)	Seed yield/ plant (g)
1	Days to 50 %	G	1.000	0.614**	- 0.229	-0.078	-0.037	-0.010	0.029	0.3151*	-0.112
	flowering	P	1.000	0.540**	- 0.198	-0.065	- 0.017	0.005	0.086	0.2355*	-0.097
2	Days to maturity	G		1.000	- 0.304*	-0.142	0.088	0.088	-0.144	0.408**	-0.062
		P		1.000	- 0.290*	-0.116	0.053	0.085	-0.122	0.367**	-0.053
3.	No. of pods/	G			1.000	0.145	0.333*	0.518**	0.022	-0.563**	0.766**
	plant	P			1.000	0.129	0.262*	0.485**	0.012	-0.503**	0.701**
4	Plant height	G				1.000	-0.091	0.040	-0.367**	0.026	0.106
	(cm)	P				1.000	-0.053	-0.045	-0.174	0.037	0.078
5	No. of primary	G					1.000	0.434**	0.086	-0.147	0.445**
	branches/ plant	P					1.000	0.271*	0.087	-0.089	0.311*
6	No. of secondary	G						1.000	-0.018	-0.214	0.544**
	branches/ plant	P						1.000	0.010	-0.162	0.455**
7	No. of seeds / pod	G							1.000	-0.015	0.331*
		P							1.000	-0.030	0.184
8	100 seed wt. (g)	G								1.000	-0.037
		P								1.000	-0.052
9	Seed yield /plant	G									1.000
	(g)	P									

* Indicates significant at 5% level.

** Indicates significant at 1% level.

3. Days to maturity and other characters.

Positive and significant correlations was with, 100-seed weight whereas negative significant correlation was with number of pods per plant. The characters number of primary branches and number of secondary branches per plant exhibited positive but non-significant correlation with days to maturity.

4. Number of pods per plant with other characters

Number of pods per plant noted positive and significant genotypic and phenotypic correlations with number of primary and secondary branches per plant. However there was positive but non-significant correlation with plant height and number of seeds per pod. Similarly 100-seed weight showed negative significant correlation with number of pods per plant.

5. Plant height and other characters

Positive but non-significant correlations were noted between 100-seed weight and plant height both at genotypic and phenotypic levels. While number of primary branches and number of seeds per pod showed negative correlation with plant height.

6. Number of primary branches per plant with other characters

Number of primary branches per plant noted positive and significant genotypic and phenotypic correlations with number of secondary branches per plant. While number of seeds per pod showed positive non-significant correlation with number primary branches per plant. However 100-seed weight showed negative correlation with number of primary branches per plant.

7. Number of secondary branches per plant with other characters

Negative and non-significant genotypic and phenotypic correlation was noted between 100-seed weight and number of secondary branches per plant.

8. Number of seeds per pod with other characters.

Negative and non-significant genotypic and phenotypic correlations were noted between 100-seed weight and number of seeds per pod.

Among the different factors number of pods per plant, number of primary branches per plant, number of secondary branches per plant and number of seeds per pod are the factors related to yield.

4.5 Path analysis

The path analysis was carried out to find out the direct and indirect contribution of each of the characters towards the seed yield per plant. Path coefficient analysis with genotypic and phenotypic correlation is presented in Table 6.

1. Seed yield versus days to 50 per cent flowering

Days to 50 per cent flowering in genotypic path analysis had low negative direct effect on yield per plant. While rest of the characters 100-seed weight, days to maturity, number of seeds per pod and number of pods per plant, plant height, number of primary branches per plant, number of secondary branches per plant exhibited positive and negative indirect effect on yield respectively.

Table 6 : Genotypic and phenotypic path analysis for direct (Diagonal) and Indirect (off diagonal) effects of yield components on yield.

Sr. No.	Character		Days to 50 % flowering	Days to maturity	No. of pods/ plant	Plant height (cm)	No. of primary branches / plant	No. of secondary branches / plant	No. of seeds / pod	100 seed wt. (g)	Correlated seed yield/ plant (r)
1	Days to 50 % flowering	G	**- 0.1539**	0.0990	-0.2215	-0.0085	-0.0044	-0.0009	0.0109	0.1671	-0.1122
		P	**0.1002**	0.0661	-0.1679	0.0002	-0.0013	0.0004	0.0172	0.0888	-0.0967
2	Days to maturity	G	- 0.0946	**0.1611**	-0.2941	-0.0153	0.0104	0.0080	-0.0544	0.2163	-0.0625
		P	- 0.0541	**0.1225**	-0.2461	0.0003	0.0041	0.0060	-0.0244	0.1388	-0.0529
3	No. of pods/ plant	G	0.0352	- 0.0490	**0.9671**	0.0157	0.0395	0.0473	0.0082	-0.2981	0.7659
		P	0.0198	- 0.0355	**0.8500**	0.0004	0.0203	0.0342	0.0024	-0.1901	0.7008
4	Plant height (cm)	G	0.0121	-0.0229	0.1407	**0.1079**	-0.0108	0.0037	-0.1384	0.0137	0.1060
		P	0.0065	-0.0142	0.1100	**-0.0030**	-0.0041	0.0032	-0.0350	0.0142	0.0776
5	No. of primary branches / plant	G	0.057	0.0141	0.3218	-0.0098	**0.1188**	0.0396	0.0323	-0.0780	0.4445
		P	0.0017	0.0065	0.2223	0.0002	**0.0777**	0.0191	0.0175	-0.0336	0.3114
6	No.of secondary branches / plant	G	0.0016	0.0142	0.5012	0.0044	0.0515	**0.0913**	-0.0068	-0.1136	0.5437
		P	- 0.005	0.0105	0.4125	-0.0001	0.0211	**0.0705**	0.0020	-0.0613	0.4547
7	No. of seeds /pod	G	-0.0045	-0.0233	0.0210	-0.0396	0.0102	-0.0016	**0.3768**	-0.0081	0.3308
		P	-0.0086	-0.0149	0.0103	0.0005	0.0068	0.0007	**0.2006**	-0.0112	0.1842
8	100 seed wt. (g)	G	-0.0485	0.0658	-0.5440	0.0028	-0.0175	-0.0196	-0.0058	**0.5300**	-0.0369
		P	-0.0235	0.0450	-0.4273	-0.0001	-0.0069	-0.0114	-0.0060	**0.3781**	-0.0522

Residual (G) : 0.0331, Residual (P) : 0.3187
Dark figures denotes direct effects

Path analysis at phenotypic levels reveals that the days to 50per cent flowering had low positive direct effect and indirect effect via 100-seed weight, days to maturity, plant height, number of secondary branches per plant and number of seeds per pod on seed yield. The negative indirect effects were observed through number of pods per plant and number of primary branches per plant.

2. Seed yield versus days to maturity

Days to maturity at genotypic level had positive direct effect on seed yield. However, the indirect effects via 100-seed weight was observed. The negative indirect effect was observed through number of pods per plant.

At phenotypic level days to maturity had low positive direct effect on seed yield. However the low positive indirect effects via 100-seed weight was observed. The number of pods per plant was indirectly but negatively associated with seed yield.

3. Seed yield versus number of pods per plant

Number of pods both at genotypic and phenotypic level had high direct effect on seed yield. Similarly 100-seed weight exhibited negative indirect effect on seed yield.

4. Seed yield versus plant height

Plant height at genotypic level, had direct effect on seed yield. However, the indirect effects via number of pods per plant had association for yield. The number seeds per pod was indirectly but negatively associated with seed yield.

At phenotypic level plant height had low negative direct effect on seed yield. However, number of pods per plant had positive indirect effect on seed yield.

5. Seed yield versus number of primary branches per plant

Both at genotypic and phenotypic level number of primary branches per plant had low direct effect on seed yield. However, positive indirect effects via number of pods per plant, were considerably of higher magnitude.

6. Seed yield versus number of secondary branches per plant

Number of secondary branches per plant both at genotypic and phenotypic level had positive direct effect on seed yield while positive indirect effect via pods per plant was considerably of higher magnitude, 100-seed weight was indirectly but negatively associated with seed yield. At genetic level had strong negative direct effect on yield.

7. Seed yield versus number of seeds per pod

Number of seed per pod both at genotypic and phenotypic level had positive direct effect on seed yield. However positive indirect effect via number of pods per plant and number of primary branches per plant considerably of higher magnitude. The characters days to 50 per cent flowering, days to maturity and 100-seed weight had negative indirect effect for seed yield.

8. Seed yield versus 100-seed weight

The character 100-seed weight both at genotypic and phenotypic level had high positive direct effect on seed yield. However number of pods per plant had high negative indirect effect on seed yield.

DISCUSSION

Chapter V

DISCUSSION

Pigeonpea (*Cajanus cajan* L. Millsp) is occupying an important place in the pulses scenario of the country. The protein content in pigeonpea varies from 18 to 26 per cent. Yield is a complex character and cannot be improved by direct selection as it is influenced by a set of other characters known as yield components. Thus association of various characters with yield and among themselves would provide criteria for indirect selection through components for improvement in pigeonpea. A broad spectrum of variability in a population is a pre-requisite for improvement in any crop.

The present investigation was undertaken with objective to evaluate the variation among the material, consisted of 52 germplasm lines of pigeonpea in respect to nine quantitative characters. The vital genetic variability along with non-genetic variation was studied for each character. The correlation studies were made to understand the associations between two characters, while heritability and genetic advance were studied to know the extent of genetic make up of a characters. The path analysis revealed the direct and indirect effects of various characters on the seed yield.

5.1 Analysis of variance and mean performance

Analysis of variance revealed significant differences among all the characters studied, indicating the wide range of variability among the lines which, is an ultimate objective in improving the plant type. The mean performance indicated that the germplasm line GP-46-1, GP-45, FS-29, ICP-8863, GP-46-2, BSMR-736-1 and FS-5 exhibited early 50 per cent flowering and maturity.

Similarly the germplasm lines BSMR-853-3, BSMR-853-5 and BSMR-736-1 exhibited maximum number of pods per plant, primary branches per plant and seed yield per plant. In pigeonpea significant amount of genetic variability has been reported by Singh *et al.* (1996) for seed yield per plant followed by pods per plant and number of primary branches per plant. Such high variability for important yield contributing characters in pigeonpea was also noticed by Gupta *et al.* (1975), Malik *et al.* (1981) and Venkateswarlu (2001).

5.2 Genetic parameters

The genetic diversity is the basis for plant breeding. For studying variability, various parameters were calculated viz., genotypic and phenotypic variance, coefficient of variation, heritabilty and genetic advance has been given in Table 4.

5.2.1 Variance components

The amount of variation in quantitative characters is measured and expressed as variances. The whole amount of observed variation or phenotypic variation present in the character does not give a true account of the variation which is fixable in the succeeding years generations, while genotypic variation is the amount of fixable index from one generation to the next generation. The environmental variation varies from one place to other and as such can not be fixed up.

Equal genotypic and phenotypic variances observed for days to 50 per cent flowering, days to maturity, number of secondary branches per plant, number of seeds per pod and 100-seed weight. Whereas maximum differences between genotypic and phenotypic variances were observed for number of pods per plant, plant height and seed yield per plant.

Highest genotypic and phenotypic coefficient of variance was observed for number of pods per plant followed by number of secondary branches per plant and seed yield per plant. In pigeonpea high genotypic and phenotypic coefficient of variances for seed yield and yield contributing characters has been reported by Natarajan *et al.* (1990), Singh *et al.* (1996); Vikas and Singh (1998), Patel and Patel (1998), Jadish Singh and Singh (1999a) and Bhasavarajaiah *et al.* (2000).

In general, more or less differences in genotypic and phenotypic variances as well as genotypic and phenotypic coefficient of variances indicates there is less effect of environment.

5.2.2 Heritability and genetic advance

Heritability is the measure of transmission of an attribute from one generation to the other while the genetic advance is a genetic gain of a particular character. The high heritability coupled with high genetic advance for any particular character indicates its suitability of being selected for further improvements. However, the characters with moderate heritability coupled with high genetic advance are of paramount importance in breeding programme, while low heritability with low genetic advance are not necessarily be included in further studies as they are much influenced by non-genetic factors.

Among the characters studied days to maturity (95.8), number of pods per plant (93.2), number of secondary branches per plant (88.1), seed yield per plant (85.6), 100-seed weight (84.8) and days to 50 per cent flowering (83.8) exhibited high heritability estimates whereas moderate hertability was found for plant height (59.6), number of seeds per pod (58.9) and number of primary branches per plant (56.2). These results were in conformity with the previous results of Pansuriya *et al.* (1998) and Venkateswarlu (2001).

High genetic advance with high heritability noted for number of pods per plant followed by seed yield per plant. High estimates of heritability and genetic advance were reported by Natarajan *et al.* (1990), Aher *et al.* (1998), Patel and Patel (1998) and Jagdish Singh and Singh (1999a).

Rest of the characters exhibited moderate to high heritability coupled with low genetic advance. The characters having high heritability and high genetic advance were controlled by additive gene effects, such characters can be selected directly. The number of pods per plant and seed yield per plant can be selected to improve yield.

5.3 Correlation studies

When a particular character is influenced by number of factors, it becomes necessary to evaluate as to how and to what extent they are associated. The correlation studies of nine quantitative characters were worked out at genotypic and phenotypic levels in order to know the absolute association among the characters.

In the present study the genotypic correlation coefficient were in general higher for most of the characters (Table 5). Seed yield per plant was highly significant and positively correlated with number of pods per plant, number of primary branches per plant, number of secondary branches per plant and number of seeds per pod.

Days to 50 per cent flowering had positive and significant correlation with days to maturity and 100-seed weight. Whereas, days to maturity showed significant positive correlation with 100-seed weight and negative correlation with number of pods per plant both at genotypic and phenotypic level.

The yield contributing characters viz., number of pods per plant, number of primary branches per plant and number of secondary branches per plant were positively and significantly correlated with each other both at genotypic and phenotypic level. It is evident from most of the reports that positive and significant correlation exist between yield and yield contributing characters. Kumar and Reddy (1983) observed significant positive correlation of seed yield with number of primary and secondary branches and pod number. Similar results also reported by Chandirakala and Raveendrana (1998), Pansuriya *et al.* (1998) and Kingshlin and Subbaraman (1999).

5.4 Path analysis

The path analysis reveals that whether the association of yield contributing characters with yield is due to their direct effect or is a consequences of their indirect effect via sources of other traits. If the correlation between yield and character is due to direct effect of character, it reflects a true relationship between them and selection can be practiced for such character. If the correlation is mainly due to indirect effect of the character through the another component trait, breeder has to select the latter trait through which the indirect effect is exerted.

Path analysis of yield and yield contributing characters showed that the number of pods per plant, number of seeds per pod and 100-seed weight had significant positive direct effects on seed yield at both genotypic and phenotypic level. Similarly days to maturity, number of primary branches per plant and number of secondary branches per plant had positive but low direct effect on seed yield. This indicates that selection for number of pods per plant, number of seeds per pod and 100-seed weight would prove better in increasing yield.

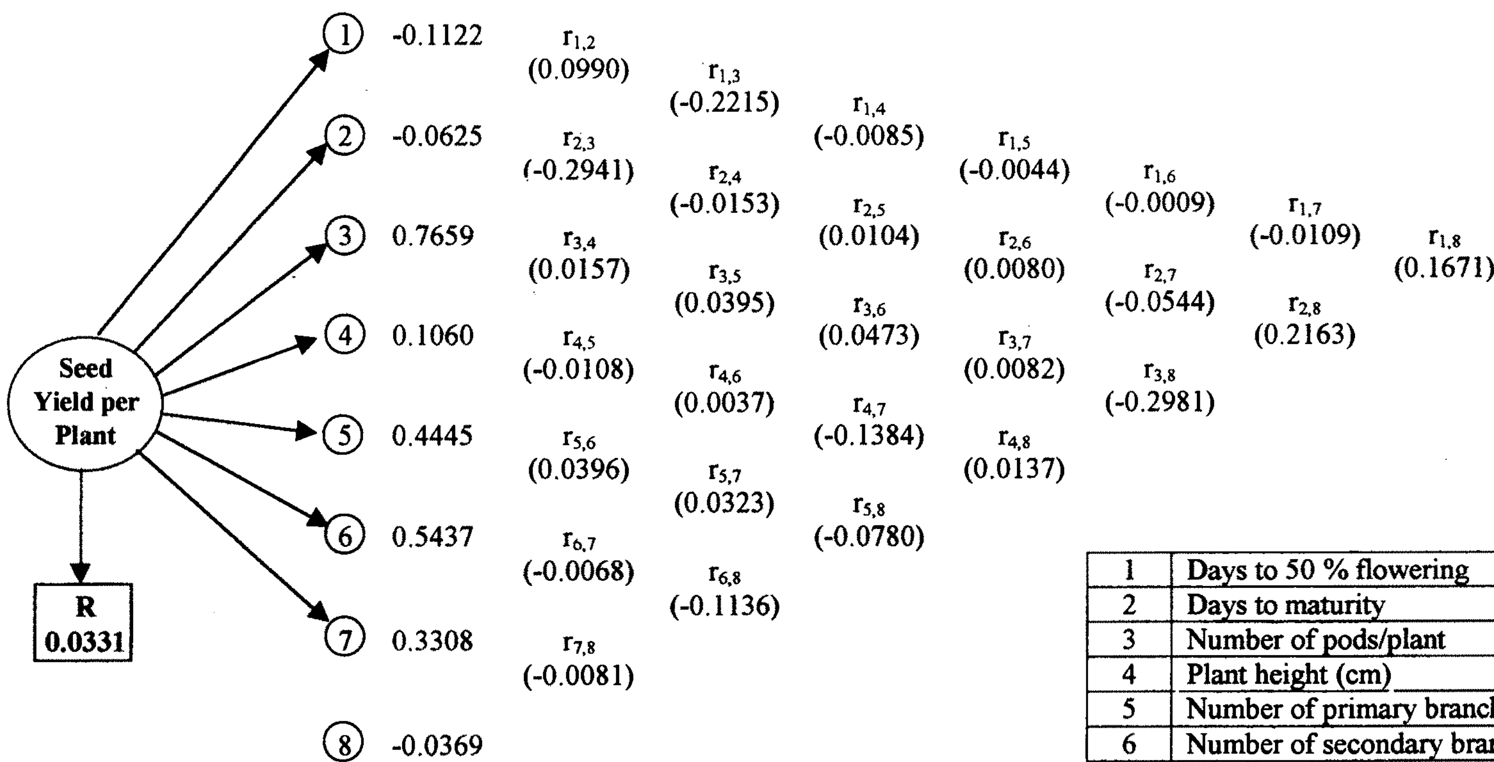
These results are in conformity with the previous results of Jag Shoran (1982), Jahagirdar and Nerkar (1994), Dahiya and Singh (1994), Dhameliya and Pathak (1995), Salunke *et al.* (1995) and Vannirajan *et al.* (1997).

The number of primary branches per plant and secondary branches per plant showed high positive indirect effect on seed yield via number of pods. The indirect selection through number of pods will be effective in yield improvement. Similar results also reported by Viramgama and Goyal (1994) and Chandirakala and Raveendran (1998).

The value of residual effect (0.0331) though it is moderate indicating that besides the character studied were important yield contributing characters both at genotypic and phenotypic level.

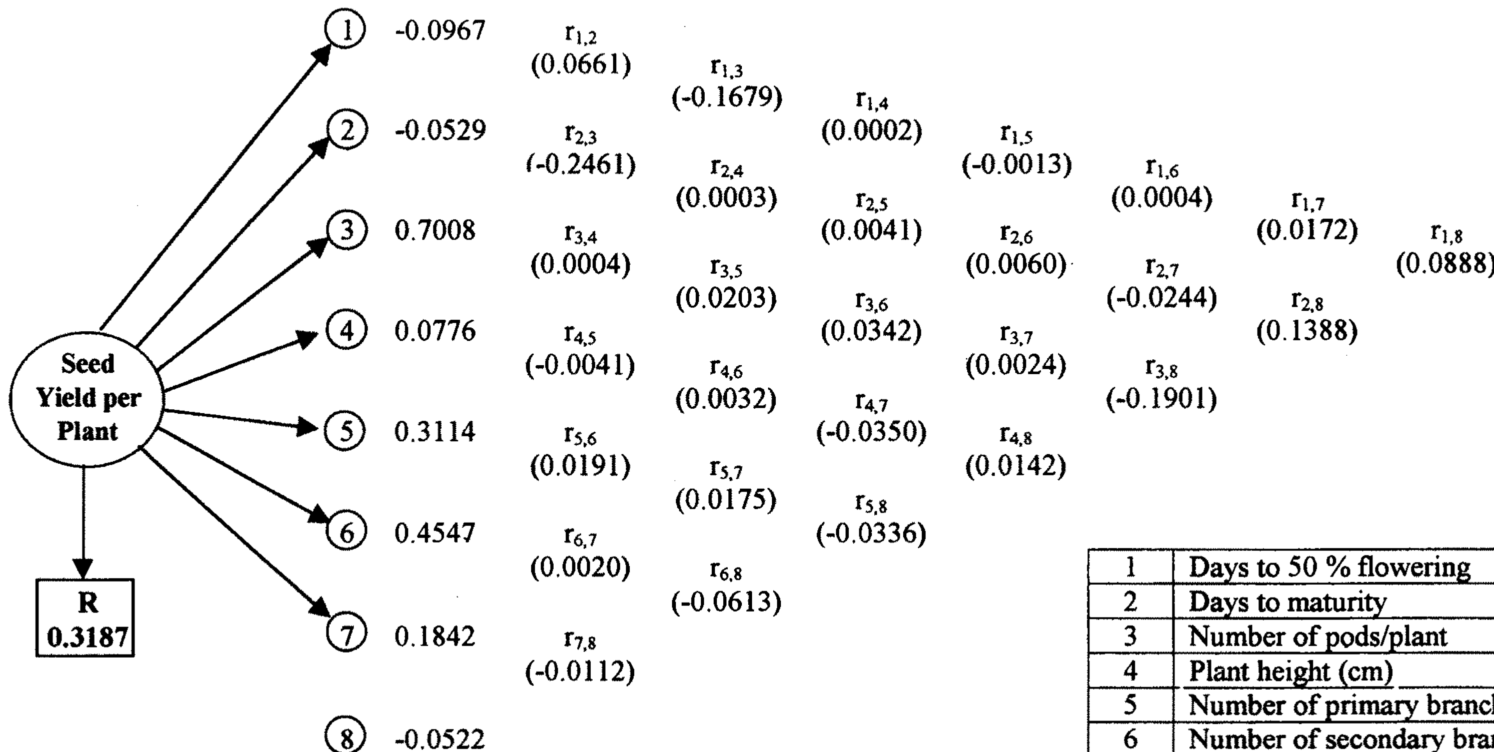
5.5 Utilization of information for improvement of pigeonpea crop.

To start any breeding programme assessment of variability must be studied. In this investigation desirable variability has been observed. There was less environment effects except number of primary branches per plant, which clear from various parameters of variability. Similarly heritability (h^2) was also more. If we want phenotypic selection there must be additive gene effects for most of the yield contributing characters, such characters may be selected. As there are many characters which contributes more towards yield, correlation and path analysis has been done. Selection for germplasm lines having number of pods per plant, number of primary branches per plant and 100-seed weight will improve the yield. The germplasm lines 853-3, 853-1 and 853-5 may be used as parents in future.



1	Days to 50 % flowering
2	Days to maturity
3	Number of pods/plant
4	Plant height (cm)
5	Number of primary branches/plant
6	Number of secondary branches/plant
7	Number of seeds/pod
8	100-Seed weight (g)

Fig. 1: Path diagram showing the factors influencing seed yield per plant (Genotypic)



1	Days to 50 % flowering
2	Days to maturity
3	Number of pods/plant
4	Plant height (cm)
5	Number of primary branches/plant
6	Number of secondary branches/plant
7	Number of seeds/pod
8	100-Seed weight (g)

Fig. 2: Path diagram showing the factors influencing seed yield per plant (Phenotypic)

SUMMARY

Chapter VI

SUMMARY

The present investigation was undertaken to estimate the extent of genetic variability, heritability, genetic advance, character association and path analysis studies for yield and yield contributing characters in pigeonpea (*Cajanus cajan* L. Millsp). The material used for present study comprised 52 germplasm lines including four checks viz., BSMR-853, BSMR-736, ICP-8863 and AKT-8811. The material was raised in randomized block design with three replications during kharif season of 2004.

Observations were recorded on the characters viz., days to 50% flowering, days to maturity, number of pods per plant, plant height, number of primary branches per plant, number secondary branches per plant, number of seeds per pod, 100-seed weight and seed yield per plant.

The data was analysed and results obtained are summarized below.

6.1 Analysis of variance showed significant differences for all the characters among germplasm lines indicating the presence of wide genetic variability in material.

6.2 On the basis of mean performance the highest seed yield per plant was observed in 853-3 (79.00) followed by 853-1 (70.00), 853-5 (66.20) and 736-1 (65.50). Maximum number of pods per plant, number of branches and 100-seed weight was also observed in the above germplasm lines.

6.3 High heritability was exhibited by days to maturity, number of pods per plant, number of secondary branches per plant, seed yield per plant, 100-seed weight and days to 50% flowering.

6.4 High genetic advance coupled with high heritability estimates were noted for number of pods per plant and seed yield per plant.

6.5 Positive and highly significant association between yield and yield contributing characters viz., number of pods per plant, number of primary branches per plant were positively and significantly correlated with each other both at genotypic and phenotypic level. This study indicates that these characters should be given maximum weightage while making selections in improving the yield in pigeonpea.

6.6 Path analysis at genotypic and phenotypic levels revealed that number of pods per plant, number of seeds per pod and 100-seed weight had significant positive direct effects on seed yield both at genotypic and phenotypic levels. The highest indirect positive effect both at genotypic and phenotypic level was recorded for number of primary and secondary branches per plant towards yields.

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