STUDIES ON GENETIC VARIABILITY IN F_2 POPULATION OF PIGEONPEA (*Cajanus cajan* (L) Millsp.) FOR YIELD AND YIELD CONTRIBUTING CHARACTERS

By

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B.Sc. (Agri.)

DISSERTATION

Submitted To

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MASTER OF SCIENCE
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IN
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(GENETICS AND PLANT BREEDING)

DEPARTMENT OF AGRICULTURAL BOTANY
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MARATHWADA AGRICULTURAL UNIVERSITY,
PARBHANI

2004

Dedicated to

My Beloved

Father Sureshrao

and Mother

Sou. Madhuribai

CANDIDATE'S DECLARATION

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

Place : Latur

Date : 15/07/2004

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CERTIFICATE – I

This is to certify that the dissertation entitled "**STUDIES ON GENETIC VARIABILITY IN F_2 POPULATION OF PIGEONPEA (*Cajanus cajan* (L) Millsp.) FOR YIELD AND YIELD CONTRIBUTING CHARACTERS**" submitted by **Shri. SARSAMKAR SHAILESH SURESHRAO** 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 there of has not been previously submitted by him for a degree of any university.

Place : Latur
Date : 15/07/2004

(Dr. M.K. Ghodke)
Research Guide
&
Chairman

CERTIFICATE – II

This is to certify that the dissertation entitled **"STUDIES ON GENETIC VARIABILITY IN F_2 POPULATION OF PIGEONPEA (*Cajanus cajan* (L) Millsp.) FOR YIELD AND YIELD CONTRIBUTING CHARACTERS"** submitted by **Shri. SARSAMKAR SHAILESH SURESHRAO** 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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Place : LATUR

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(S. S. Sarsamkar)

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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 others
Fig.	-	Figure
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

INTRODUCTION

Pigeonpea (*Cajanus cajan L. Millsp*) is the second most widely grown legume in India. Being the area of origin and the principal center of diversity, India has had a virtual monopoly on pigeonpea production in the world so far. Over 90 per cent of the total world production of pigeonpea comes from India. Pigeonpea is mainly grown in the states of Uttar Pradesh, Madhya Pradesh, Maharashtra, Karnataka, Bhiar, Gujart, Tamilnadu and Andhra Pradesh. In India its cultivation extends over 3.67 million hectares with a production of 2.36 million tones. In Maharashtra pigeonpea is grown on around 10.96 lakh hectare area with production of 6.60 lakh tones with average productivity 600 kg/ha. (Anonymous 2003). Pigeonpea has been a 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. Its 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. Cropping system is a combination of crops in space and time and the objective of any system should be to provide the farmer with a high and stable level of returns. This depends on the inherent efficiency of the genotype. One of the important considerations in any crop improvement programme is the detailed study of genetic variability. The estimates of heritable and non-heritable variances give a clue on improvement possible for the character under study.

Yield is a complex character, which depends upon many determining characters. Hence the information on the correlation between yield and its component characters is a pre-requisite for crop improvement.

The phenotypic correlation indicate the extent of observed relationship between the two characters while the genotypic correlation provides information about linkage for the genes controlling the pair of characters. Therefore, the correlation coefficients both at genotypic and phenotypic levels are considered. However they do not provide the exact picture of direct and indirect causes of such association, which can be had through path analysis (Wright, 1921). Thus path analysis is very useful to pinpoint the important yield components, which can be utilized for recommending selection indices. Hence, it was also performed using phenotypic and genotypic correlation separately for grain yield.

Thus, breeding for high seed yield requires information on the nature and magnitude of variation as well as association of yield and its contributing characters in the available material. Such information in the segregating population will be more meaningful and of immediate practical utility. The present investigation comprises selected 12 F_2 populations and their 10 parents.

The objective can broadly be enumerated as

1. To assess the genetic variability parameters for yield and yield contributing characters.
2. To study the correlation and path analysis for yield and yield traits.

Findings emerged from these investigation are presented and discussed in this thesis.

REVIEW OF LITERATURE

Chapter 2.

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.

Kumar and Haque (1973) in studies of F_2 population reported that the extent of variability was more for number of pods, number of days to maturity, number of seeds and number of leaves per plant. The trait number of seeds per pod gave the highest estimate for genotypic coefficient of variation followed by number of leaves, seed yield and number of pods per plant.

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.

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 pods bearing nodes. It was also sufficiently high for height, number of pods per plant and seed weight. While low for grain yield. All the yield traits recorded high estimate of heritability. The highest being for 100-seed weight, where as it was lowest for grain yield per plant.

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

Yadavendra *et al.,* (1981) reported maximum heritability for test weight and seeds per pod, where as lowest for yield per plant. Expected genetic advance ranged from 14 (length of pod) to 33 (pods per plant). Co-heritability, genotypic correlation and path coefficient indicates that pods per plant are the most important components to consider when selecting for yield.

Malik *et al.,* (1981) reported that high variability was observed for pods per plant, clusters per plant, branches per plant and length of main fruiting branch, low variability for days to maturity, seeds per pods 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. Seed yield showed significant positive association with plant height, plant spread, number of branches per plant, length of main fruiting branch, clusters per plant and pods per plant. Path coefficient analysis further revealed that days to maturity, plant spread, clusters per plant and pods per plant were the major factors contributing towards seed yield.

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. The genotypic correlations were higher than the phenotypic correlations. The association analysis revealed number of primary branches, number of secondary branches and plant height to be the most important yield components.

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.

Khapre and Nerkar (1992) reported that genetic variability was found to be the highest for grain yield per plant under inter crop sorghum and the lowest for days to maturity under sole crop. Genetic advance was maximum for grain yield per plant under inter crop sorghum. The studies revealed that the traits like LAI, days to maturity, plant height, number of pods per plant and total biomass per plant have shown greater variation and significant positive association with grain yield in all the cropping systems need greater concentration for improvement of pigeonpea.

Singh *et al.,* (1996) observed that the magnitude of variability measured in term 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.

Dahat *et al.,* (1997) observed wide genetic variability in both monoculture and intercropping for number of primary and number of secondary branches per plant, plant height, number of pods per plant and seed yield per plant. High heritability accompanied with high genetic advance was observed for number of secondary branches per plant, plant height, number of pods per plant and seed yield per plant under both cropping systems. Plant height, number of primary and number of secondary branches per plant and number of pods per plant showed significant positive association with seed yield, both in monoculture and when intercropped.

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 % 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 grain 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. Grain yield was significantly and positively correlated with pods per plant and dry matter per plant.

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-grain 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-garin weight. Path analysis revealed that 100-garin weight had the highest positive direct effect on grain yield followed by number of pods per plant, number of clusters per plant, number of branches per plant, number of seeds per pods whereas 100-grain weight showed high positive indirect effect on grain yield.

Aher *et al.*, (1998) reported wide genetic variability for plant height, plant spread, number of secondary branches per plant and days to 50 % flowering. High heritability accompanied by high genetic advance was observed for number of secondary and number of primary branches per plant followed by grain yield per plant, days to 50 % flowering, plant spread and plant height. All the characters studied showed significant positive correlation with grain yield and also with each other.

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 that dominance genetic variance was high for days to maturity, branches per plant, clusters per plant, pods per plant, pod length, 100-seed weight and seed yield but negative for days to 50 % flowering, plant height and seeds per pod. Additive genetic variance was significant for days to 50 % flowering, plant height and seeds per pod. High heritability estimates and genetic advance were recorded for branches per plant indicating it is suitable selection criterion for increasing pods per plant and yield.

Jagdish Singh and Singh J. (1999). 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 exhibited 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. Path analysis also revealed pods per plant, plant height and number of secondary branches to be the major contributor for seed yield.

Deshmukh *et al.,* (2000) reported high heritability estimates for days to 50 % flowering, days to maturity, 100-grain weight, number of primary and number of secondary branches per plant under sole and inter-cropping system. All characters exhibited significant positive correlation with grain yield. Pods per plant was also highly correlated with days to flowering, days to maturity and number of primary and number of secondary branches under both cropping system and with plant height under CCS.

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, grain 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, grain 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. Where as 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 grain yield was positively and significantly correlated with bhussa (chaff) weight and weight of pods per plant. Grain 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 grains per pod and 100 seed weight but negatively correlated with plant height.

Awatade *et al.,* (1980) reported that in F_2 and F_3 generation derived from F_2 diverse parents, positive and highly significant correlation were noticed between yield and number of pods per plant, number of clusters per plant, plant height and days to maturity.

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

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

Singh (1981) revealed that the maximum genetic variability was present for number of pods per plant and minimum for days to maturity. Highest heritability estimates were obtained for 100-seed weight, the expected genetic advance was high for number of pods per plant. Seed yield per plant was found positively correlated with number of pods per plant, plant height, days to 50 % flowering, seeds per pod and days to maturity. The different yield component also showed favourable association with each other except 100-seed weight.

Aahuja *et al.,* (1981) reported that pods per plant were highly correlated with yield and the significant effect on yield of 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.

Marekar (1982) observed that in F_1generation grain 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.

Jadhav (1983) Showed that grain yield per plant had positive genotypic association with all the characters except NAR during 80-120 days. AGR during 40-80 days showed positive significant genotypic association with yield. LAI also showed strong positive association with grain yield.

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

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

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. Path analysis showed that pods per plant, clusters per plant and number of secondary branches per plant had significant direct effect on seed yield. Clusters per plant, number of secondary branches per plant also had a significant indirect effect on seed yield via number of pods per plant.

Dhamelia 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.

Mahajan *et al.,* (1995) reported that pod per plant was significantly and positively correlated with yield in all three environments (Rainfed at Parbhani, Irrigation at Parbhani and rainfed at Badnapur) in Maharashtra during kharif 1992.

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 % 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. Path coefficient analysis revealed that pods per plant and 100-seed weight had direct positive effect on seed yield. Pods per plant and 100-seed weight also exhibited high, positive indirect effect on grain yield through most of the other character. It is suggested that pods per plant, seeds per pod and 100-seed weight could have useful as selection criteria for early pigeonpea.

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.

Singh and Gumber (1995) reported that days to maturity was positively correlated with plant height in parental, F_2 and BC generations, and with seed yield in parental and F_1 generations. Number of fruiting branches had a highly significant positive correlation with seed yield and a significant positive correlation with harvest index in F_2 and BC generations.

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

Pansuriya *et al.,* (1998) observed that grain 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 J. (1999) 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.

Aswa (1977) studied segregating population and reported that number of primary and number of secondary branches did not affect yield independently but mainly via pods per plant.

Godawat (1980) observed that 100 seed weight had maximum direct effect on grain 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 per 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.

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

Balyan and Sudhakar (1985) reported that the plant height, number of primary branches, number of secondary branches, seeds per pod and 100 seed weight were all important for yield.

Sindhu *et al.*, (1985) found that pods per plant, plant height and seed size were the major contributing to seed yield.

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 correlation coefficients indicated that 100-seed weight and pods per plant bear a highly positive genotypic correlation with seed yield. On other hand, time to maturity and time to 50 % flowering showed negative correlation with seed yield at both phenotypic and genotypic levels. Path analysis revealed that 100-seed weight had the highest direct positive effect on seed yield. Time to 50 % 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 grain yield. Path coefficient analysis revealed that number of effective pods per plant was the major character effecting grain yield, both directly and indirectly. Plant height, 100-grain weight and number of primary and number of secondary branches per plant affected grain yield indirectly.

Dahiya and Singh (1994) reported that number of pods per plant had the highest direct effect on plant 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.

Paul *et al.,* (1996) in correlation studies observed that phenotypically yield was positively and significantly correlated with number of pods per plant (0.809), dry matter at maturity (0.755) and the number of secondary branches (0.623). At the genotypic level, the association was highest for dry matter at maturity (0.961), path coefficient analysis revealed 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) reported that yield showed a significant and strong positive association with days to 50 % flowering, days to maturity ,plant height, branches per plant, clusters per plant, pods per plant, pod length and 100 seed weight. Strong inter relationship was observed for between days to 50 % flowering and days to maturity, plant height, branches per plant, clusters per plant and between them selves. Association of pod length with seed per pod and 100 seed weight was significant and positive. Path analysis revealed that pods per plant and 100 seed weight had high positive and direct effect on seed yield.

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

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

Basavarajaiah *et al.*, (1999) observed the significant positive correlation of grain yield with pod weight, pods per plant, straw weight, branches per plant and shelling percentage. Path analysis revealed that pod weight had the direct effect on grain yield followed by plant height, branches per plant and pods per plant.

MATERIALS AND METHODS

Chapter 3.

MATERIALS AND METHODS

3.1 Experimental material

The experimental material for the present investigation consisting of 10 parents and 12 F_2 crosses was sown during kharif, 2003.

Details have been given in Table-1.

Sr. No.	Parents		Crosses
1	BDN-2	11	BDN-2 x BDN-2010
2	BSMR-175	12	BDN-2 x BSMR-853
3	BSMR-736	13	BDN-2 x ICPL-87119
4	Daithna local	14	BSMR-175 x AKT-8811
5	BDN-2010	15	BSMR-175 x ICPL-87119
6	BSMR-853	16	BSMR-175 x BSMR-853
7	ICPL-87119	17	BSMR-175 x BSMR-846
8	AKT-8811	18	BSMR-736 x AKT-8811
9	BWR-23	19	BSMR-736 x BWR-23
10	Nirmal	20	BSMR-736 x Nirmal
		21	BSMR-736 x ICPL-87119
		22	Daithna local x ICPL-87119

Table 1a : Pedigree of parental lines.

Sr. No.	Parents	Pedigree
1	BDN-2	Selection from Bori local
2	BSMR-175	Selection from (Plant A-3 x ICP-7035) x BDN-2
3	BSMR-736	Selection from (ICP-7117 x No. 148) x BDN-1.
4	Daithna local	Selection from local (Daithana, dist. Parbhanhi.)
5	BDN-2010	Selection from BSMR-736 x ICPL-8804.
6	BSMR-853	Selection from (ICP-7336 x BDN-1) x BDN-2
7	ICPL-87119	Selection from ICP-1-6-WB-W1 x C11
8	AKT-8811	Mass selection from bulk of segregation population of four crosses 1. ICPL-6 x DA-6 2. ICPL-6 x AL-57 3. ICPL-95 x H-80-110 4. ICPL-84008 x AL-57
9	BWR-23	Selection from plant A-3 x ICP-7035
10	Nirmal	Variety of Nirmal Seeds Company

3.2 Experimental methods

The experiment was laid out during kharif, 2003 at the experimental farm of College of Agriculture, Latur. The experimental details are as follows.

Design	:	R.B.D. (Randomized block design)
Treatment	:	22
Replication	:	Three
Spacing	:	Row to row - 60 cm Plant to plant - 30 cm
Fertilizer	:	25 kg N + 50 kg P_2O_5/ha.

3.2.1 Recording of observation

Five plants were selected from each parents randomly and 20 plants were selected from each F_2 crosses randomly for recording observation. Average value of each character was determined from these observational plants. Observation were recorded on following on agronomic traits.

3.2.1.1 Days to 50 % flowering

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

3.2.1.2 Days to maturity

Days required from sowing to maturity of all the plants were recorded.

3.2.1.3 Plant height (cm)

Height of the plants from ground level to the tip of the plant was recorded at the time of maturity.

3.2.1.4 Number of primary branches

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

3.2.1.5 Number of secondary branches

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.

3.2.1.7 100 seed weight

Well-filled 100 seeds were weighted.

3.2.1.8 Grain 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 character under study were 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	$6^2e+ g6^2r$	
Genotypes	(g-1)	MS_2	$6^2e+ r6^2g$	
Error	(r-1) (g-1)	MS_3	6^2e	
Total	(rg-1)			

1. Standard error (SE) $= \sqrt{\frac{EMSS}{r}}$

Where,

EMSS = Error mean sum of squares

r = number of replication.

2. Critical difference (C.D.) = S.E. x $\sqrt{2}$ x t value at 5% 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 (6^2g) $= \frac{\text{Treatment MSS - Error Mss}}{\text{Number of replications}}$

2. Phenotypic variance (6^2p) = Genotypic variance + error variance

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

3. Genotypic coefficient of variation (GCV) $= \frac{\sqrt{6^2g}}{\overline{X}} \times 100$

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

Where,

$б^2 g$	=	genotypic variance.
$б^2 p$	=	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 *et al.*, (1960).

1. Heritability (h^2) B.S. $= \frac{б^2 g}{б^2 P} \times 100$

Where,

$б^2 g$	=	genotypic variance.
$б^2 p$	=	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. Genetic advance (G A) = K. бp. h^2

Where,

K	=	Selection differential at 5% level i.e., 2.06.
б p	=	phenotypic standard deviation
h	=	heritability

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

$$3. \quad EGA = \frac{GA}{\overline{X}} \times 100$$

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 correlation among the characters. The interrelationship of different yield contributing character was worked out according to Johnson *et al.*, (1995) (b).

$$r = \frac{Cov.\,(x.y)}{(6^2x\ 6^2y)\ ½}$$

Where

r = correlation coefficient between the characters x and y

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

6^2 x and 6^2 y are the respective variances of x and y.

3.3.5 Path coefficient analysis

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.

$P_{01} + P_{02}\, r_{12} +$ - - - - - - $P_{OP}\, r_{1p} = r_{ol}$

$P_{01}\ r_{12}\, P_{02}\ +$ - - - - - $P_{OP}\, r2_p = r_{o2}$

$P_{01}\ r_{10} + P_{02}\, r_{2p}\ +$ - - - $P_{OP} = r_{op}$

Where, P_{01}, P_{02}, ...P_{OP} 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 was 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 - ($P^2_{01} + 2P_{01}\, P_{02} r_{12} + 2P_{01}\, P_{03}\, r_{13} +$ ....

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

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

RESULTS

Chapter 4.

RESULTS

The experimental results recorded on various characters are presented below under five section.

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 the parents and F_2 population for eight characters (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 parents and F_2 population for yield and its contributing characters.

Table 2: Analysis of variance for characters studied in parents and F_2 population.

Sr. No.	Source of variation	D.F.	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of secondary branches	Number of pods /plant	100 seed wt. (g)	Seed yield /plant (g)
1	Replication	2	30.00	0.43	41.62	1.56	9.19	19.25	0.36	111.57
2	Treatment	21	76.87**	183.09**	420.14**	19.64**	38.42**	5387.42**	6.34**	435.32**
3	Error	42	4.20	0.70	12.30	6.40	4.24	75.00	0.22	68.96

* Significant at 5%
** Significant at 1%

4.2 Mean performance

The mean performance of parents and F_2 population under study for eight characters is given in Table 3.

4.2.1 Days to 50% flowering

The range of days to 50% flowering was from 103 to 123 days with an average value of 113 days. The parental line Daithana local (103) exhibited early 50% flowering followed by BDN-2010 (105), AKT-8811 (105), BDN-2 (106), BSMR-853 (108) and BWR-23 (109). Similarly the F_2 populations BDN-2 x BDN-2010 was earliest in flowering. Higher days to 50 % flowering was observed in parents ICPL-87119 (115), BSMR-175 (115) and in F_2 cross BSMR-736 x Nirmal (121).

4.2.2 Days to maturity

Number of days to maturity ranged from 148.67 to 169.67 day with an average value of 161.39 days. Among the parental lines and F_2 population Daithana local (148.67), AKT-8811 (149.67), BSMR-853 (150.33), BDN-2 (152.67) and BDN-2 x BDN-2010 (157.67) showed early maturity respectively. However late maturity was observed in Nirmal (169.67), BSMR-175 (165.67) and BSMR-736 x Nirmal (169.67) BSMR-175 x ICPL-87119 (169.00) respectively in parents and F_2 in population.

Table 3 : Mean performance of 22 genotypes for yield and yield contributing characters.

Sr. No.	Genotype	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pods/ Plant	100 Seed weight (g)	Seed yield /plant (g)
1	BDN 2 x BDN 2010	112.00	157.67	174.33	14.00	19.00	216.00	14.37	91.50
2	BDN 2 x BSMR 853	114.33	165.33	147.67	10.00	15.67	212.00	12.50	86.83
3	BDN 2 x ICPL-87119	114.00	166.00	161.67	12.33	13.67	187.67	13.27	76.00
4	BSMR 175 x AKT 8811	114.33	167.00	195.00	9.67	10.67	156.67	12.63	75.13
5	BSMR 175 x ICPL -87119	115.00	169.00	191.00	6.67	11.67	175.33	13.83	78.37
6	BSMR 175 x BSMR -853	113.67	166.00	178.33	10.67	13.33	165.67	12.73	67.53
7	BSMR 175 x BSMR -846	113.00	166.00	181.33	6.67	9.67	139.33	13.10	74.10
8	BSMR 736 x AKT-8811	113.33	168.00	173.00	10.00	13.67	168.00	11.93	66.03
9	BSMR 736 x BWR-23	117.33	165.67	178.00	9.67	7.33	153.33	14.60	52.23
10	BSMR 736 x Nirmal	121.00	169.67	189.67	12.33	14.00	170.00	12.13	84.10
11	BSMR 736 x ICPL -87119	116.00	166.67	171.67	11.67	7.67	162.33	11.37	82.63
12	D. Local x ICPL-87119	115.67	168.00	174.33	14.33	14.67	194.00	13.53	71.17
13	BDN-2	106.00	152.67	153.33	10.00	9.33	94.00	9.76	57.80
14	BSMR-175	115.33	165.67	183.67	12.33	18.67	140.00	12.13	59.90
15	BSMR-736	114.67	156.33	164.33	16.67	17.67	194.67	10.87	74.33
16	D. Local	103.00	148.67	167.33	11.33	15.67	91.00	12.40	46.60
17	BDN-2010	105.00	155.67	176.00	9.67	9.33	55.00	11.80	67.10
18	BSMR-853	108.00	150.33	160.33	9.67	14.67	192.67	12.20	86.00
19	ICPL-87119	115.00	160.67	170.33	12.33	16.33	100.00	10.13	69.97
20	AKT-8811	105.00	149.67	163.00	14.67	19.00	167.00	10.03	90.00
21	BWR-23	109.00	145.67	181.33	12.67	10.33	155.00	13.70	74.33
22	Nirmal	123.00	169.67	175.00	12.33	12.33	102.67	15.13	61.00
	Grand mean	**112.87**	**161.85**	**173.21**	**11.48**	**13.37**	**154.19**	**12.46**	**72.39**

4.2.3 Plant height (cm)

The range was noted from 147.67 to 195.00 with the mean of 171.33 cm. The F_2 population BDN-2 x BSMR-853 (147.67) exhibited lowest plant height. However the maximum plant height was observed in BSMR-175 x AKT-8811 (195.00), BSMR-175 x ICPL-87119 (191.00), BSMR-736 x Nirmal (189.67) and BSMR-175 (183.67), BWR-23 (181.33) respectively in F_2 population and parental line.

4.2.4 Number of Primary branches per plant

Number of Primary branches per plant ranged from 6.67 to 16.67 with an average value of 11.67. Highest number of primary branches have been observed in BSMR-736 (16.67) followed by AKT-8811 (14.67), Daithana local x ICPL-87119 (14.33) and BDN-2 x BDN-2010 (14.00). The minimum number of number of primary branches observed in F_2 population in BSMR-175 x ICPL-87119 (6.67).

4.2.5 Number of secondary branches per plant

The range recorded for number of secondary branches per plant was 7.33 to 19.00 with an average of 13.16 in the parental line AKT-8811 (19.00) recorded maximum number of secondary branches per plant and F_2 population BDN-2 x BDN-2010 (19.00) followed by parental line BSMR-175 (18.67), BSMR-736 (17.67) and Daithana local (15.67).

4.2.6 Number of pods per plant

The range for number of pods per plant was from 55.00 to 216.00 with the mean of 135.50. The maximum number of pods were observed in F_2 population BDN-2 x BDN-2010 (216.00), followed by

BDN-2 x BSMR-853 (212.00) and Daithana local x ICPL-87119 (194.00), BSMR-736 (194.67) and BSMR-853 (192.67).

4.2.7 100-seed weight (g. :)

100-seed weight ranged from 9.76 to 15.13 with an average value of 12.18. Maximum test weight was recorded by parental line Nirmal (15.13) followed by F_2 population BSMR-736 x BWR-23 (14.60), BDN-2 x BDN-2010 (14.37) and BSMR-175 x ICPL-87119 (13.83). Minimum test weight was observed in parental line BDN-2 (9.76).

4.2.8 Seed yield per plant (g. .)

The character seed yield per plant ranged from 46.60 to 91.50 gm with mean of 69.00. The highest seed yield per plant was recorded by F_2 population BDN-2 x BDN-2010 (91.50), followed by parental line AKT-8811(90.00) and BSMR-853 (86.90). Similarly the F_2 population BDN-2 x BSMR-853 (86.83), BSMR-736 x ICPL-87119 (85.63) and BSMR-736 x Nirmal (84.10) recorded higher seed yield per plant.

4.3 Genetic parameter

The significant genotypes indicate their effectiveness in improvement of the plant type while the non-significant genotypes do not show any positive relation with the improvement.

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

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

Sr. No.	Character	Range	Mean	Genotype variance 6^2 g	Phenotypic variance 6^2 p	G.C.V. (%)	P.C.V. (%)	Herita-bility (%)	Genetic advance	Expected genetic advance
1.	Days to 50 % flowering	103.00 - 123.00	113.00	24.22	28.42	4.36	4.72	85.2	9.36	8.29
2.	Days to maturity	145.67 - 169.67	157.67	60.79	61.50	4.83	4.86	98.8	15.97	10.12
3.	Plant height (cm)	147.67 - 195.00	171.33	135.94	148.25	6.73	7.03	91.7	23.00	13.42
4.	No. of primary branches	6.67 - 16.67	11.67	4.41	10.81	18.29	28.63	40.8	2.76	23.65
5.	No. of secondary branches	7.33 - 19.00	13.16	11.39	15.63	25.23	29.56	72.9	5.93	45.06
6.	No. of pods /plant	55.00 - 216.00	135.5	1770.80	1845.80	27.29	27.86	95.9	84.91	62.66
7.	100 seed wt. (g.)	9.76 - 14.60	12.18	2.04	2.26	11.47	12.08	90.2	2.79	22.90
8.	Seed yield /plant (g)	46.60 - 91.50	69.00	366.36	435.32	26.43	28.82	84.15	36.11	52.33

4.3.1 Estimates of variability parameters

4.3.1.1 Genotypic coefficient of variation (GCV)

The genotypic coefficient of variation was observed to be high for number of pods per plant (27.29) followed by seed yield per plant (26.43), number of secondary branches per plant (25.23) number of primary branches per plant (18.29) and 100-seed weight (11.47). For rest of the characters, genotypic coefficient was ranged from 4.36 to 6.73.

4.3.2.2 Phenotypic coefficient of variation (PCV)

The phenotypic coefficient of variation was recorded to be high for number of secondary branches per plant (29.56) followed by seed yield per plant (28.82) number of primary branches per plant (28.63), number of pods per plant (27.86) and 100-seed weight (12.08). For rest of the characters phenotypic coefficient of variation was ranged from 4.72 to 7.03.

4.3. 3 Heritability

It has been observed that the heritability estimates (broad sense) were high for all the characters except number of primary branches per plant. On the basis of average the highest heritability estimates were observed for days to maturity (98.8) followed by number of pods per plant (95.90), plant height (91.70), 100-seed weight (90.20), days to 50 % flowering (85.20) and number of secondary branches per plant (72.90). The low heritability estimates were observed for number of primary branches (40.80).

4.3.4 Genetic advance

On the basis of mean, higher estimates of genetic advance were observed in number of pods per plant (84.91) followed by seed yield per plant (36.11) and plant height (23.00). Low genetic advance was observed in number of primary branches per plant (2.76) followed by 100-seed weight (2.79) and days to 50% flowering (9.36).

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 (62.66) followed by seed yield per plant (52.33), number of secondary branches per plant (45.06), number of primary branches per plant (23.63) and 100-seed weight (22.90). Low genetic advance as percent of mean was observed in days to 50 % flowering (8.29) days to maturity (10.12) and plant height (13.42).

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 association or correlations between the characters considered in the present study phenotypic and genotypic correlations coefficients were worked out for eight quantitative characters (Table 5).

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

Sr. No.	Character		Day to 50 % flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pod's /plant	100 seed wt. (g)	Seed yield/ plant (g)
1	Days to 50 % flowering	G	1.000	-0.205	-0.269	0.703**	0.390	0.300	-0.211	-0.094
		P	1.000	-0.168	-0.213	0.423*	0.303	0.280	-0.195	-0.058
2	Days to maturity	G		1.000	0.417	-0.234	0.216	0.002	0.375	0.854**
		P		1.000	0.394	-0.146	0.208	0.006	0.352	0.779**
3	Plant height (cm)	G			1.000	-0.241	-0.083	-0.086	0.475*	0.390
		P			1.000	-0.191	-0.093	-0.061	0.324*	0.358
4	No. of primary branches	G				1.000	0.197	0.136	-0.079	0.231
		P				1.000	0.125	0.076	-0.081	0.111
5	No. of secondary branches	G					1.000	0.730**	0.243	0.299
		P					1.000	0.563**	0.232	0.281
6	No. of pods /plant	G						1.000	-0.113	0.0446*
		P						1.000	-0.042	0.0426*
7	100 seed wt. (g)	G							1.000	0.454*
		P							1.000	0.433*
8	Yield /plant (g)	G								1.000
		P								

* Indicates significant at 5% level.
** Indicates significant at 1% level.

1. Yield per plant with other characters

Positive and significant phenotypic and genotypic correlations were observed between yield and yield contributing components namely days to maturity, pods per plant and 100-seed weight while plant height, number of primary branches per plant and number of secondary branches per plant has positive but lower correlation values for yield. However, there was negative correlation with days to 50 % flowering.

2. Days to 50% flowering and other characters

Positive and significant phenotypic and genotypic correlation were noted between number of primary branches per plant and days to 50% flowering. While positive but non-significant correlations were noted for number of secondary branches per plant and number of pods per plant. However, negative and non-significant correlation noted between 100-seed weight, plant height and days to maturity.

3. Days to maturity and other characters

Positive but non-significant phenotypic and genotypic correlations were noted between plant height, 100-seed weight number of secondary branches per plant and number of pods per plant. While number of secondary branches per plant showed negative association with ~~number~~ of days to maturity.

4. Plant height and other characters

Positive and significant genotypic correlation was noted between plant height and 100-seed weight. While rest of the characters exhibited negative association with plant height.

5. Number of primary branches and other characters

Positive but non-significant phenotypic and genotypic correlation noted between number of secondary branches per plant and number of pods per plant. while 100-seed weight showed negative correlation with number of primary branches per plant.

6. Number of secondary branches per plant with other characters

Number of secondary branches per plant noted positive and highly significant genotypic and phenotypic correlation with pods per plant. While 100-seed weight noted positive correlation with number of secondary branches per plant.

7. Number of pods per plant with other characters

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

Among the different characters days to maturity, number of pods per plant and 100-seed weight are the characters related to yield.

4.5 Path coefficient analysis

The path analysis was done for all the characters and direct as well as indirect effects were found out, which are sequentially described below in Table 6 and 7.

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

Sr. No.	Character	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pod's/plant	100 seed wt. (g)	Seed yield /plant (g) (r)
1	Days to 50 % flowering	**-0.210**	0.024	0.081	0.046	0.24	0.287	-0.176	1.00
2	Days to maturity	-0.179	**0.028**	0.087	-0.047	0.052	0.207	-0.145	0.854
3	Plant height (cm)	-0.082	0.012	**0.209**	-0.048	0.069	-0.080	-0.165	0.390
4	No. of primary branches	-0.049	-0.007	-0.050	**0.201**	-0.179	0.189	0.031	0.231
5	No. of secondary branches	0.020	-0.006	-0.056	0.141	**-0.254**	0.374	0.082	-0.094
6	No. of pods /plant	-0.063	0.006	-0.017	0.040	-0.099	**0.958**	-0.094	0.299
7	100 seed wt. (gm)	-0.095	0.010	0.089	-0.016	0.054	0.233	**-0.387**	0.454

Residual 0.3397

Table 7 : Phenotypic path analysis for direct (Diagonal) and Indirect effects of yield components on yield.

Sr. No.	Character	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pod's/plant	100 seed wt. (g)	Seed yield/ plant (g) (r)
1	**Days to 50 % flowering**	**0.001**	-0.074	0.039	-0.005	-0.004	0.173	-0.073	1.00
2	**Days to maturity**	0.001	**-0.095**	0.043	0.006	-0.014	0.128	-0.63	0.854
3	**Plant height (cm)**	0.001	-0.037	**0.110**	0.008	-0.017	-0.057	-0.067	0.390
4	**No. of primary branches**	0.001	0.014	-0.021	**-0.041**	0.033	0.077	0.015	0.131
5	**No. of secondary branches**	0.001	0.016	-0.023	-0.016	**0.082**	0.187	0.035	-0.094
6	**No. of pods /plant**	0.001	-0.020	-0.010	-0.005	0.025	**0.615**	-0.042	0.299
7	**100 seed wt. (g)**	0.001	-0.033	0.041	0.003	-0.016	0.143	**-0.180**	0.454

Residual 0.6332

1. Seed yield versus days to 50% flowering

Days to 50% flowering in genotypic path analysis had high negative direct effect on yield per plant. However, the indirect effects via pods per plant, plant height, number of primary branches, number of secondary branches per plant and days to maturity were of higher magnitude. The negative indirect effect was observed through 100-seed weight.

Days to 50% flowering at phenotypic level had low positive direct effect on seed yield. The indirect effects through plant height and pods per plant were considerably of higher magnitude, while rest of the characters were negatively correlated with yield in their indirect effect.

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 pods per plant, plant height and number of secondary branches per plant were of higher magnitude while number of primary branches per plant and 100-seed weight had low negative indirect effect on seed yield per plant.

Days to maturity at phenotypic level had negative direct effect on yield. However, the pods per plant, plant height, number of primary branches per plant and days to 50 % flowering had medium positive indirect effects on seed yield. The remaining characters number of secondary branches per plant and 100- seed weight had negative indirect effects on seed yield per plant.

3. Seed yield versus plant height

Plant height at genotypic level, had positive direct effect on seed yield. However, the positive indirect effects via, number of secondary branches per plant and days to maturity were of higher magnitude while 100- seed weight, days to 50 % flowering, pods per plant and number of primary branches per plant had low indirect effects on yield per plant.

Plant height at phenotypic level had positive direct effect on seed yield. The indirect effects through number of primary branches per plant and plant height were considerably of higher magnitude while days to maturity, number of secondary branches per plant, pods per plant and 100-seed weight had low negative indirect effect with seed yield.

4. Seed yields versus number of primary branches per plant

Number of primary branches per plant at genetic level had high direct effect on yield. However, the indirect effect via number of pods per plant, pods per plant and 100-seed weight were considerably of higher magnitude. While number of secondary branches per plant, plant height, days to 50 % flowering and days to maturity had negative indirect effects for yield per plant.

At phenotypic level number of primary branches per plant had small negative direct effect on seed yield. However, the indirect positive effects via number of pods per plant, 100-seed weight, number of secondary branches per plant, days to maturity and days to 50 % flowering were considerably of higher magnitude. The plant height was indirectly but negatively associated with seed yield.

5. Seed yield versus number of secondary branches per plant

Number of secondary branches per plant at genetic level had strong negative direct effect on yield. However, the indirect effect via number of pods per plant, 100-seed weight, number of primary branches per plant and days to 50 % flowering had higher association for yield. The negative indirect effect via plant height and days to maturity were of higher magnitude.

The number of secondary branches per plant at phenotypic level had positive direct effect on seed yield. However, indirect effects via. 100-seed weight, days to maturity and days to 50 % flowering were of higher magnitude. The remaining characters viz, plant height and number of primary branches per plant had negative indirect effect for yield.

6. Seed yield versus number of pods per plant

Pods per plant at genotypic level had strong direct effect on seed yield. However, the indirect effect via number of primary branches per plant and days to maturity were considerably of higher magnitude, while number of secondary branches per plant, 100-seed weight and 50 % flowering have negative effect on yield.

At phenotypic level number of pods per plant had strong direct effect on seed yield. However the indirect effect via number of secondary branches per plant and days to 50 % flowering were considerably of higher magnitude while the remaining characters were indirectly but negatively associated with yield.

7) Seed yield versus 100-seed weight

The character 100-seed weight at genetic level had negative direct effect on seed yield. However, indirect effects via number of pods per plant, plant height, number of secondary per plant and days to maturity were of higher magnitude while rest of the characters number of primary branches per plant and days to 50 % flowering had negative indirect effect for yield.

100-seed weight at phenotypic level had negative direct effect on seed yield. However, indirect effects via. number of pods per plant, plant height, number of primary branches per plant and days to 50 % flowering were of higher magnitude, while rest of the characters, days to maturity and number of secondary branches per plant had negative indirect effects on yield per plant.

DISCUSSION

Chapter 5.

DISCUSSION

The present investigation was undertaken with object to evaluate the variation among the material, consisted of 10 parents and 12 F_2's of pigeonpea in respect to eight quantitative characters. The vital genetic variability along with non-genetic variation was studied for each character. The correlation studies were made to access the associations between two characters, while heritability and genetic advance were studied to know the extent of genetic make up of a character. The path analysis revealed the direct and indirect effects of various characters on the seed yield per plant.

5.1 Analysis of variance

Analysis of variance revealed significant differences among all the characters studied indicating thereby the wide range of variability among the material, which is an ultimate object in improving the plant type. Similar observations were found by Kumar and Haque (1973) in pigeon pea.

5.2 Genotypic and phenotypic variance

In general, the phenotypic variances were higher than genotypic ones for almost all characters under study. The maximum variation was observed for the characters number of pods per plant and seed yield per plant, while the variation for other characters was more or less consistent. However, high phenotypic coefficient of variation as compared to genotypic coefficient of variation was noted high for number of primary branches, number of secondary branches per plant and seed yield per plant. Rest of the characters were more or less similar in respect to genotypic and phenotypic coefficient of variation. Awatade *et al.,* (1980) observed significant differences for seven yield components and reported higher PCV than GCV for these characters. Where Shoran (1983) observed high GCV for number of pods and seed yield per plant. This study indicates that the phenotypic selection basis for the characters which are much consistent in variation is effective, as phenotypes are the absolute expressions of genotypes.

Similar studies were also made by Patel *et al.,* (1998), Vikas and Singh (1998) in pigeon pea.

5.3 Mean performance and range of variability

A wide range of variability was noted for number of pods per plant, plant height and seed yield per plant. However, rest of the characters showed range of variation (Table 3). On the basis of mean performance early flowering and maturity was observed in parental and F_2 population Daithana local, AKT-8811 and BDN-2 x BDN-2010 respectively. The parental line BSMR-736, AKT-8811 and F_2 population Daithana local x ICPL-87119, BDN-2 x BDN-2010 exhibited maximum number of primary and number of secondary branches per plant. Maximum number of pods per plant were observed in parental line and F_2 population, viz. BSMR-736, BSMR-853 and BDN-2 x BDN-2010, BDN-2 x BSMR-853. High seed yield potential per plant was observed in F_2 population BDN-2 x BDN-2010, BSMR-736 x ICPL-87119 and in parental line AKT-8811, BSMR-853. Hence selection from F_2 population is desirable for better plant type.

5.4 Heritability and genetic advance

Heritability is the measure of transmission of an attribute from one generation to the other generation 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 nongenetic factors.

Heritability is an important constant used to know the precision and transmissibility of a particular character. The observed variability in field crops is partly heritable arising from the segregation of genes controlling a character and partly by environment. Heritability, is known to be consisted of two important components, are resulting from a purely additive action of genes and other from the presence of dominance and other non-additive interactions existed in them.

Heritability is the measurement of transmission of an attribute from one generation to the others. It can be in broad or narrow sense. The characters with high heritability are of great importance than those having low heritability estimates and which are readily influenced by environmental factors.

High heritability coupled with high genetic advance for a particular character indicates its applicability of being selected for further improvements. The characters with low heritability and low genetic advance are not necessarily being included in further studies, as they are not fixable and greatly impaired by environmental factors.

Among the characters studied, days to maturity, number of pods per plant, plant height, 100-seed weight, days to 50 % flowering and seed yield per plant exhibited high heritability estimates, while the moderate heritability was found for number of secondary branches per plant. However, number of primary branches showed low heritability estimates.

High genetic advance with high heritability were noted for number of pods per plant, seed yield per plant, plant height and days to maturity. While moderate and low heritability with low genetic gain was observed by number of secondary branches and number of primary branches per plant respectively.

Takalkar *et al.,* (1998) observed the high heritability estimates for all the characters under study. The expected genetic advance was high for pods per plant, plant height and days to maturity.

High heritability with high genetic advance was also reported by Patel *et al.,* (1998) for seed yield per plant number of primary and number of secondary branches and number of pods per plant. Venkateswarlu (2001) for number of pods per plant and plant height.

Deshmukh *et al.,* (2000) reported high heritability estimates for days to 50 % flowering, days to maturity, 100-grain weight, number of primary and number of secondary branches per plant.

Similar results were observed by Gupta *et al.,* (1975), Dahat *et al.,* (1997) and Pansuriya *et al.,* (1998)

5.5 Correlation

When a particular character is influenced by number of factors, it becomes necessary to evaluate as to how and to what extent are they associated. The correlation studies of eight quantitative characters were worked out at genotypic and phenotypic associations among the characters. These studies would enable the breeders to exercise the selection programme for those characters which are highly correlated with each other and specifically with yield. The results are presented in Table 5.

Among the characters the seed yield per plant was positive and significantly correlated with days to maturity, number of pods per plant and 100-seed weight both at genotypic and phenotypic levels. However, plant height, number of secondary branches per plant, number of primary branches per plant had positive correlation both at genotypic and phenotypic levels, while days to 50 % flowering showed non significant negative correlation at both genotypic and phenotypic levels.

Number of days to 50 % flowering was highly positive and significantly correlated with number of primary branches per plant at both genotypic and phenotypic levels. Character number of secondary branches and pods per plant were positive but non significantly correlated with days to 50 % flowering at both genotypic and phenotypic levels. However it had negative correlation with plant height, days to maturity and 100- seed weight. Days to maturity showed positive but non significant correlation with 100-seed weight, plant height, number of secondary branches and pods per plant at both genotypic and phenotypic levels. However, number of primary branches had negative correlation with days to maturity.

Plant height was found to be significantly correlated with 100-seed weight at genotypic and phenotypic level, however it had negative correlation with number of primary branches, number of secondary branches and pods per plant.

The number of primary branches were positively but non significantly correlated with number of secondary branches and pods per plant at both genotypic and phenotypic level. 100- seed weight was negative and non significantly correlated with number of primary branches. The number of secondary branches had positive and significant correlation with number of pods per plant. However, positive but non significant correlation with 100-seed weight at genotypic and phenotypic level. Number of pods per plant was negatively correlated with 100- seed weight both at genotypic and phenotypic levels.

Sindhu *et al.,* (1985) reported that seed yield was positively and significantly associated with plant height and branches per plant.

Salunke *et al.,* (1995) reported that seed yield per plant was significantly and positively associate with pods per plant, number of primary and number of secondary branches, plant height and 100-seed weight. Significant and positive correlation between number of branches per plant, number of pods per plant and 100-seed weight was also reported by Chandirakala and Raveendran (1998).

Similar results were also reported by Kingshlin and Subbaraman (1999).

Jagdish Singh and Singh J. (1999) observed the significant and positive association between seed yield and plant height, branches per plant, pods per plant, seed per pod. Where as significant positive correlation of grain yield with plant height, pods per plant and branches per plant was reported by Basavarajaiah et al., (1999).

5.6 Path analysis

Path analysis of yield and yield contributing characters showed that the number of pods per plant and plant height had greater direct effects on seeds yield at both genotypic and phenotypic levels, while the number of primary branches per plant days to maturity had direct effect on seed yield only at genotypic level. The number of days to 50 % flowering and number of secondary branches per plant at phenotypic level had positive direct effects on seed yield. This indicates that the selection for number of pods per plant, plant height, number of primary branches per plant and days to maturity would prove better in increasing the yield. The results are presented in Table 6 and 7.

Number of days to 50 % flowering and number of days to maturity were mainly but indirectly showed a positive association with the seed yield through plant height and number of pods per plant both at genotypic and phenotypic levels while negative indirect effects through 100-seed weight.

The plant height via days to maturity and number of secondary branches per plant had positive indirect effect on seed yield at genotypic level while the same character had positive indirect effect via number of primary branches per plant at phenotypic level.

The number of primary and number of secondary branches per plant via number of pods per plant and 100-seed weight had positive indirect effects on seed yield both at genotypic and phenotypic levels.

The number of pods per plant via days to maturity and number of primary branches per plant had positive indirect effects on seed yield at genotypic level, while number of days to 50 % flowering and plant height, number of secondary branches per plant and 100-seed weight had greater negative indirect effects on seed yield. At phenotypic level number of pods per plant via number of secondary branches, days to 50 % flowering and 100- seed weight had positive indirect effects on seed yield.

Path analysis studies indicated that the number of pods per plant, plant height and number of primary branches should be given maximum weightage while making selections.

These results are similar to those reported by Viramgama and Goyal (1994) who observed that number of pods per plant had the direct and indirect positive effect on seed yield and lant height. Number of pods per plant had the highest direct effect on plant yield followed by 100-seed weight was also reported by Dahiya and Singh (1994).

Vanniarajan (1996) observed strong positive association between seed yield and days to 50 % flowering, plant height, branches per plant and pods per plant. Similar studies were also done by Jag Shoran (1982), Balyan and Sudhakar (1985) Angadi *et al.*, (1988) Holkar *et al.*, (1991) and Viramgama and Goyal (1994).

SUMMARY AND CONCLUSION

Chapter 6.

SUMMARY

The present investigation was undertaken with the object to evaluate the variation among the population consisting of 8 parents and 12 F_2's of pigeon pea. The quantitative characters selected for the study were eight charcters viz, number of days to 50 % flowering, number of days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, 100-seed weight and seed yield per plant. The variability was studied in terms of genotypic and phenotypic variance, coefficient of genotypic and phenotypic variation, heritability, genetic advance, correlations and path analysis.

6.1 The wide range of variability was exhibited by number of pods per plant, plant height and seed yield per plant while the rest of the characters showed consistent variation. On the basis of mean performance of variability the parental line AKT-8811, BSMR-736, BSMR-853 and F2 population BDN-2 x BDN-2010 found promising for yield and yield contributing characters.

6.2 High heritability was exhibited by days to maturity, number of pods per plant, 100-seed weight, days to 50 % flowering and seed yield per plant. However, the moderate and low heritability estimates were exhibited by number of secondary branches per plant and number of primary branches per plant respectively.

6.3 High genetic advance coupled with high heritability estimates were noted for number of pods per plant, seed yield per plant, plant height,

days to maturity while moderate and low heritability along with low genetic gain was observed by number of secondary branches per plant and number of primary branches per plant respectively.

6.4 Positive and significant associations between yield and yield contributing characters viz., days to maturity, 100-seed weight and pods per plant were observed both at genotypic and phenotypic levels, while rest of the characters except days 50 % flowering showed positive correlations with yield. The days to 50 % flowering had positive and significant correlation with number of primary branches per plant while the plant height had positive and significant correlation with 100-seed weight.

The genotypic and phenotypic correlations between number of secondary branches per plant and pods per plant were positive and highly significant. This study indicates that the days to maturity, 100-seed weight and numbers of pods per plant should be given maximum weightage while making selections in improving the yield in pigeon pea.

6.5 Path analysis at genotypic and phenotypic levels revealed that number of pods per plant and plant height had greater direct effects on seed yield while the number of primary branches and days to maturity had direct effects on seed yield at genotypic level.

The indirect effects of days to 50 % flowering and days to maturity, plant height and number of pods per plant were positive at both genotypic and phenotypic level while negative indirect effects through 100-seed weight.

The number of primary branches per plant via pods per plant had positive indirect effect on seed yield both at genotypic and phenotypic level. The number of secondary branches per plant via pods per plant and 100-seed weight had positive indirect effect on seed yield both at genotypic and phenotypic level. Indirect effects of pods per plant via number of primary branches and number of secondary branches per plant were positive on yield both at genotypic and phenotypic level respectively. 100-seed weight via plant height and pods per plant had maximum indirect effect on seed yield both at genotypic and phenotypic level.

Path analysis studies indicate that the number of pods per plant, plant height and number of primary branches per plant had highly positive direct effects on seed yield, so these should be given maximum weightage while making selections for the improvement of plant type in pigeon pea.

Thus for improving grain yield in pigeonpea due emphasis should be place on pods per plant, seed yield per plant, plant height, 100-seed weight and number of branches per plant. All these characters had high heritability and highly significant positive association with grain yield.

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