

**VARIABILITY AND CHARACTER ASSOCIATION
STUDIES IN CHICKPEA (*Cicer arietinum* L.)**

By

KATHANE SAMIP ANANDRAO

B.Sc. (Agri.)

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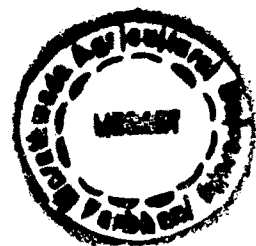
MASTER OF SCIENCE

(Agriculture)

IN

AGRICULTURAL BOTANY

(GENETICS AND PLANT BREEDING)



**DEPARTMENT OF AGRICULTURAL BOTANY
COLLEGE OF AGRICULTURE, LATUR
MARATHWADA AGRICULTURAL UNIVERSITY,
PARBHANI**

2006

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DISSERTATION

Submitted To

*The Marathwada Agricultural University, Parbhani. In Partial
Fulfillment Of The Requirements For The Degree Of*

**MASTER OF SCIENCE
(Agriculture)
IN
AGRICULTURAL BOTANY
(GENETICS AND PLANT BREEDING)**

**DEPARTMENT OF AGRICULTURAL BOTANY
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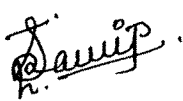
*Affectionately
Dedicated to my
Beloved Parents
Aai, Baba, Little
Loving Sister
And
Annaji*

CANDIDATE'S DECLARATION

I hereby declare that the dissertation
or part thereof, has not been
previously submitted by
me for a degree of
any University.

Place : Latur

Date : 31.05.2006


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CERTIFICATE – I

This is to certify that the dissertation entitled “**VARIABILITY AND CHARACTER ASSOCIATION STUDIES IN CHICKPEA (*Cicer arietinum* L.)**” submitted by **Shri. KATHANE SAMIP ANANDRAO** 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 : 18/9/2006


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

CERTIFICATE – II

This is to certify that the dissertation entitled
“VARIABILITY AND CHARACTER ASSOCIATION STUDIES IN
CHICKPEA (*Cicer arietinum* L.)” submitted by **Shri. KATHANE
SAMIP ANANDRAO** 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.


External Examiner

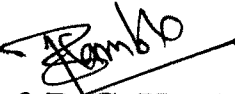

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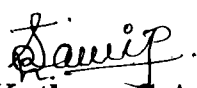
I hardly find my words to express my heartiest gratitude to my parents Shri. Anandrao Mahadevrao Kathane, Sau. Surekha Anandrao Kathane, little loving sister Simantini and also my grandfather Mahadevrao for gives me strength, spiritual inspiration, moral support, encouragement and sharing the difficulties in building my educational career from better to best still now.

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Date : / /2006


(Kathane S.A.)

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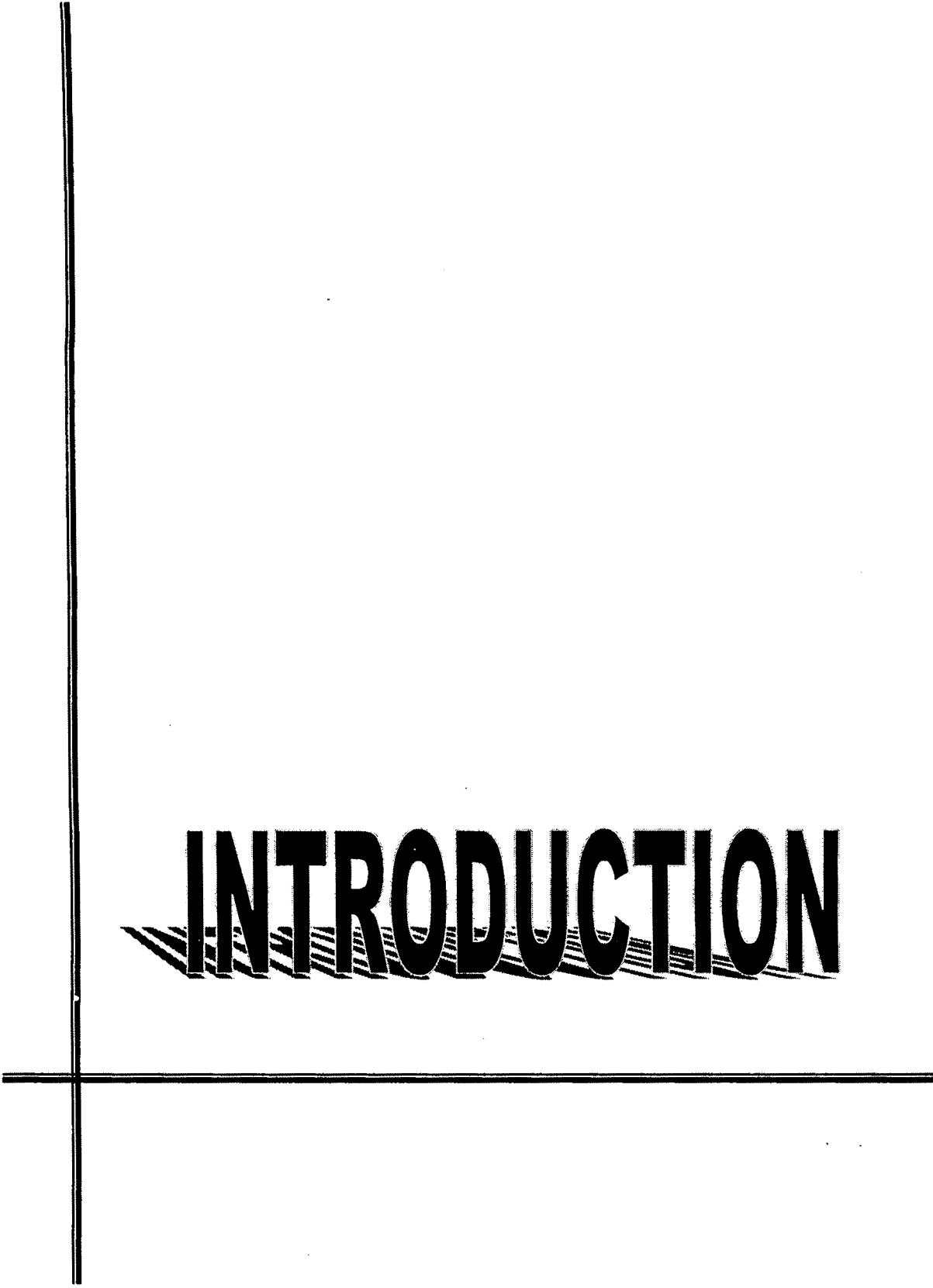
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ABBREVATIONS

*	-	Significant at 5 per cent
**	-	Significant at 1 per cent
d.f.	-	Degrees of freedom
<i>et al.</i> ,	-	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
per cent	-	per cent
r	-	Correlation coefficient
viz.,	-	Namely
vs	-	versus



INTRODUCTION

Chapter I

INTRODUCTION

Pulses have an importance like cereals and other agricultural crops as they are important source of proteins particularly in the people of tropical conditions. Secondly, because of their ability to use atmospheric nitrogen fixation which is economically more sound and environmentally acceptable. In India, pulses can be grown in two seasons, *kharif* as well as *rabi*. Major pulses suitable for *rabi* season are chickpea, lentil and rajmah etc.

Chickpea (*Cicer arietinum* L.) is a native of India is regarded as a self pollinated leguminous crop. The genus *Cicer* belong to the family leguminosae, sub family Papilionaceae. The somatic chromosome number is $2n = 16$. The genus *cicer* contain about 40 species out of which 31 are perennial and 9 are annuals (Ladizinsky and Adler, 1976b). Being the area of origin and the principle center of diversity, India has contributed about 40% to chickpea germplasm and maintained at ICRISAT with major share from Uttar Pradesh, Madhya Pradesh, Punjab and Maharashtra. It is extensively grown in West Asia, North Africa, Eastern Africa and Latin America. In India chickpea is mainly grown in Madhya Pradesh, Uttar Pradesh, Maharashtra, Andhra Pradesh, Rajasthan, Karnataka which together contribute 93 per cent of production from 92 per cent area. In India chickpea grown on about 6.67 million hectare area with production of 5.63 million tonns with 844 kg/ha average productivity. It represents 30 per cent and 38 per cent of national pulse area and production respectively. In Maharashtra chickpea is grown on around 0.85 million hectare area with the production of 0.49 million tonns with average productivity of 581 kg/ha (Anonymous, 2005).

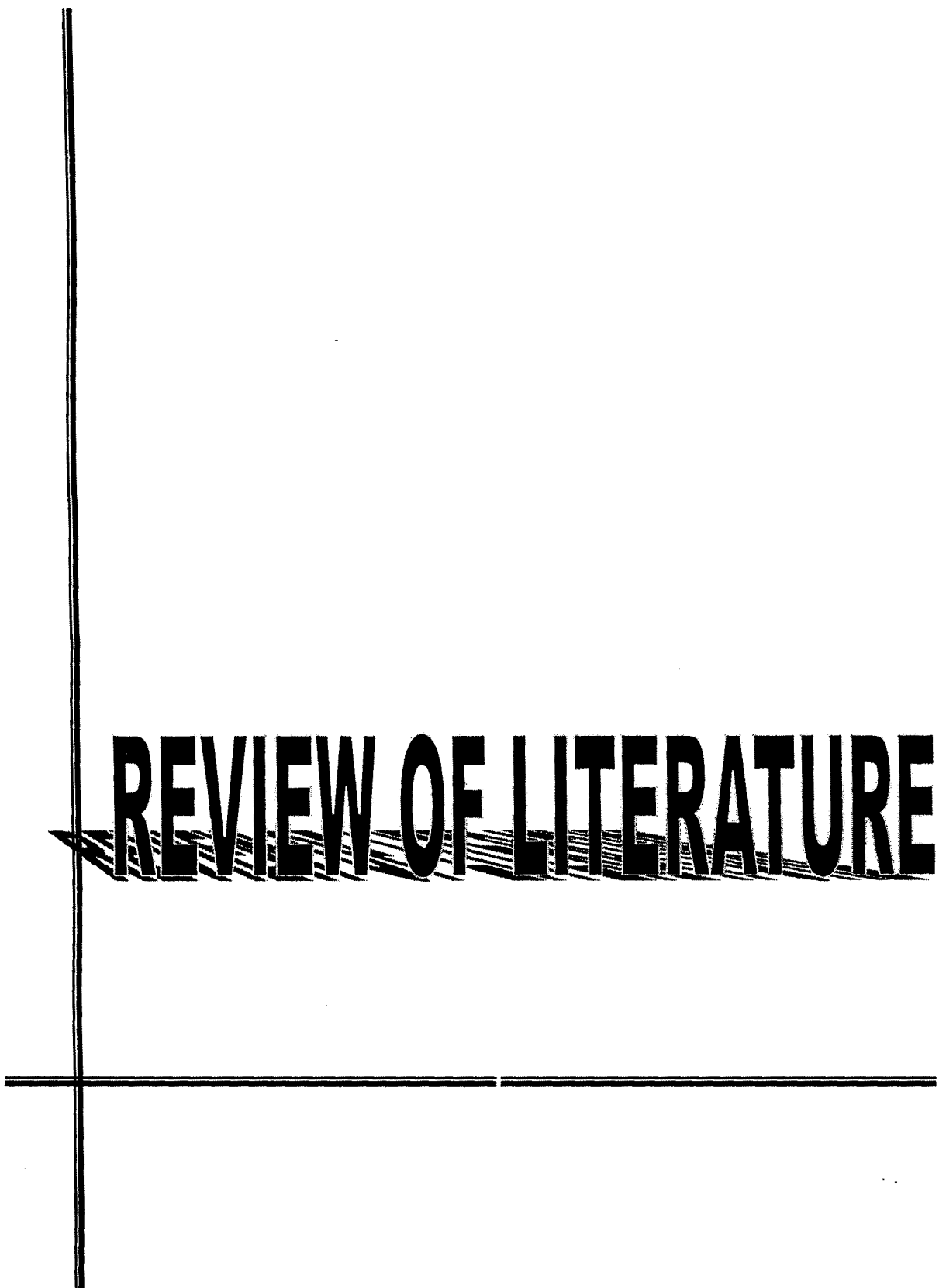
Selection is the basis of crop improvement and without genetic variability it couldn't be possible, hence it is necessary to make improvement in production of this crop by evaluation of different germplasm lines of chickpea. The efficiency of selection depends on identification of genetic variability by the phenotypic expression of the characters. The observed variability could be partitioned into heritable (genetic) and non heritable (non-genetic) component. The genetic variability could be determined with the help of certain genetic parameter 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 important in planning to 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 potential can be exploited to achieve higher production with particular component selection.

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

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



REVIEW OF LITERATURE

Chapter II

REVIEW OF LITERATURE

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

2.1. Genetic variability for yield and yield contributing character.

Adhikari and Pandey (1982) observed that the phenotypic coefficient of variation was higher than genotypic coefficient, being highest for seed yield, number of pods per plant, secondary branches per plant and seed weight. Although other characters such as days to flowering and seeds per pod had high heritability and genetic advance.

Khorgade *et al.*, (1985) reported moderate heritability for plant height, number of pods per plant and number of branches per plant. While it was high for time to 50 per cent flowering, number of seeds per pod and seed index. Yield per plant on the other hand exhibited the lowest estimates of heritability.

The character such as number of seeds per pod, time to 50 per cent flowering and to some extent number of branches per plant were high heritability and large genetic gain.

Mishra *et al.*, (1988) reported high heritability for all the characters. High heritability coupled with high genetic advance expressed as mean were observed for number of secondary branches per plant, number of pods per plant, seed yield per plant, biological yield per plant and harvest index.

Singh (1988) reported magnitude of PCV ranged 3% to 20 % and it was low (<10%) for days to 50 per cent flowering and days to

maturity, moderate (10-20%) for plant height, number of pods per plant, biological yield and high (>20%) for 100-seed mass, yield per plant and harvest index. Days to maturity showed a high heritability while days to 50 per cent flowering, 100-seed mass and yield per plant indicate moderate heritability. The remaining characters showed low heritability. The lowest estimate of heritability was for harvest index.

Sadhu and Mandal, (1989) observed considerable range of variability for plant height, pod number, seed number, seed weight and seed yield. Estimates for heritability and expected genetic gain was high for seed weight.

Sharma *et al.*, (1990) reported highest genotypic and phenotypic variation and genetic advance for secondary branches per plant, followed by 100-seed weight. Heritability was highest for 100-seed weight, days to maturity and plant height.

Singh *et al.*, (1990) observed wide variation for all the characters except days to flowering, days to maturity and protein content.

Misra (1991) observed high heritability estimates for time to 50 per cent flowering, time to maturity, plant height, pods per plant and 100-seed weight. Genetic advance was high for pods per plant, moderate for branches per plant, seeds per pods and 100-seed weight. High h^2 and GA estimates were closely correlated with yield. This indicated that selection would be effective for pods per plant and seed weight.

Jahagirdar *et al.*, (1994) reported high GCV and PCV for number of pods per plant. High heritability together with high genetic advance were estimated for 100-seed weight, days to 50 per cent flowering, number of secondary branches per plant and number of pods per plant.

Rao *et al.*, (1994) observed highest genotypic coefficient variation for 100-seed weight followed by secondary branches per plant, pods per plant and seed yield per plant. High heritability and high expected genetic advance were estimated for 100-seed weight and plant height. Seed yield per pods and secondary branches per plant had relatively low heritability estimates with high genetic advance.

Rao (1996) observed genetic variability was greatest for pod weight per plant, harvest index and 100-seed weight.

Tripathi (1998) reported high genotypic coefficient of variation and broad sense heritability coupled with high genetic advance for pods per plant, seeds per plant, biological yield and yield per plant.

Kumar *et al.*, (1999) observed high genotypic and phenotypic coefficient of variation for number of pods per plant, 100-seed weight, seed yield per plant and harvest index. Similarly these characters exhibited high heritability coupled with high genetic advance.

Wahid and Ahmad (1999) observed highest heritability for plant height (0.50%) followed by seed yield (0.45%) and pods per plant (0.35%). Genotypic coefficient of variation was greatest for plant height, pods per plant and seed yield. The phenotypic coefficient of variation was greater than genotypic coefficient or environmental coefficient of variation. Therefore suggested that plant height and pods per plant could be used as selection criteria for further improvement in chickpea yield.

Nimbalkar (2000) showed the major portion of variance was contributed by genotypic component with the environmental component being relatively small. The genetic (58.8%) and phenotypic (49.02%) coefficient of variability and genetic advance (100.28%) were highest for 100-seed weight and lowest (2.94, 3.26 and 5.50 per cent) respectively

for number of days to maturity. Heritability was highest for 100-seed weight (19.3%) and lowest for plant spread.

Sable *et al.*, (2002) observed seed yield per plant, 100-seed weight and biological yield per plant possessed high amount of genotypic coefficient of variation and exhibited high estimates of genetic advance coupled with high heritability.

Nawab (2002) observed the genetic variability existed among the genotype for plant height (cm), number of pods per plant, number of seeds per plant, 100-seed weight, total weight of the plant and seed yield per plant.

Qureshi *et al.*, (2004) observed highly significant differences for plant height (cm), number of primary and secondary branches per plant, number of pods per plant, 100-seed weight, biological yield per plant, harvest index and grain yield per plant.

Genetic variability for plant height, number of primary branches, number of secondary branches, number of pods per plant and total biological yield ranged from 40-90 cm, 1.5 – 6.5, 1.1 – 8.5, 1.0 – 7.5, 1.5 – 50.5 gm per plant. Whereas grain yield per plant varied from 5.5 – 25.5 gm and harvest index ranged from 10-70. The variation for days to flowering was in the range of 120-150.

Burli *et al.*, (2004) observed maximum range of variation for number of pods per plant followed by days to maturity and plant height. The phenotypic coefficient of variation was marginally higher than genotypic coefficient of variation for all the characters. Higher value of GCV and PCV were observed in the grain yield per plant, number of branches per plant and plant spread.

Heritability estimates were highest for days to maturity followed by 100-seed weight, days to 50 per cent flowering and plant height. High heritability and high genetic advance is observed in 100-seed weight, days to maturity and days to 50 per cent flowering.

Ozcelik *et al.*, (2004) showed that heritability for 100-seed weight, number of pods per plant, number of seeds per plant, plant height and seed yield were 79, 63, 62, 58 and 49 per cent respectively.

Arshad *et al.*, (2004) showed the high heritability with low advance for number of days to flowering, number of days to maturity and 100-seed weight.

2.2 Correlation

Adhikari and Pandey (1982) reported that seed yield was positively correlated with primary branches per plant, pods per plant and secondary branches per plant.

Islam *et al.*, (1984) reported that grain yield was positively and significantly correlated with number of pods per plant, plant height and number of primary branches. The number of pods had high positive correlation with number of primary branches, plant height and number of secondary branches, whereas the grain yield was negatively correlated with days to maturity.

Kundia *et al.*, (1986) reported that seed yield was positively and significantly associated with days to flowering. Association of days to maturity with pods per plant, 100-seed weight were significantly and negative indicating that late maturity would reduce the total number of pods per plant and 100-seed weight. However the correlation between pods per plant and 100-seed weight was positive and significant.

Paliwal *et al.*, (1987) showed seed yield per plant had positive association with plant height, days to maturity and 50 per cent flowering.

Jivani and Yadvendra (1988) reported that yield was positively and significantly correlated with branches per plant, pods per plant, 100-seed weight and harvest index.

Khorgade *et al.*, (1988) reported that seed yield was positively and significantly correlated with 100-seed weight, number of branches and pods per plant but negatively correlated with days to 50 per cent flowering and number of seeds per pods.

Mishra *et al.*, (1988) reported that branches per plant, pods per plant and seeds per pod was positive and significant association with seed yield, while plant height exhibited positive association with branches per plant, pods per plant and seeds per pod. Number of pods per plant had negative association with number of seeds per pod.

Shukla (1988) observed significant and positive phenotypic correlation of seed yield with plant height total branches, pods per plant and seeds per pod.

Zade and Wanjari (1988) reported that yield was significantly and positively correlated with pod weight per plant and 100 seed weight but negatively correlated with crop duration and duration of reproductive phase.

Sadhu and Mandal (1989) showed seed yield was positively correlated with primary and secondary branches per plant, pods number and number of seeds per pod, seed weight was negatively correlated with number of seed per pod.

Singh *et al.*, (1989) observed seed yield was significant and positive correlation with number of pods per plant, number of primary branches and secondary branches per plant.

Uddin *et al.*, (1990) reported that yield per plant was significant and positive correlation with pods per plant, 100-seed weight, harvest index and primary branches per plant.

Yaqoob *et al.*, (1990) showed negative correlation between grain yield and days to maturity.

Kharrat *et al.*, (1991) reported that plant yield was significantly and positively correlated with pods per plant, seeds per plant and seed size. There was no correlation between seed size and seeds per plant.

Kumar and Arora (1991) observed seed yield was significant for biological yield per plant, pods per plant, 100-seed mass and plant height.

Sandhu *et al.*, (1991) reported seed yield was positively, associated with seed per pod, primary, secondary branches, pods per plant and later three traits were correlated among themselves.

Dasgupta *et al.*, (1992) reported seed yield was significantly and positively correlated with pods per plant, seeds per plant and 100 seed weight but not days to maturity.

Roshan-lal *et al.*, (1993) observed seed yield was significantly and positively correlated with pods number and plant height and significantly negatively correlation with 100-seed weight.

Varghese *et al.*, (1993) reported that significant and positive correlation of seed yield with pod weight, biological yield, pods per plant, 100 seed weight and significant negatively correlated with harvest index.

Arora and Kumar (1994) observed seed yield per plant was positively associated with biological yield per plant, pods per plant, plant height, 100-seed weight and canopy.

Rao *et al.*, (1994) observed seed yield was positively correlated with primary branches, secondary branches, 100-seed weight, harvest index and pods per plant.

Sarvalia *et al.*, (1994) reported that yield was significantly and positively associated with 100-seed weight, plant height, number of primary branches per plant, number of pods per plant, days to maturity and days to flowering.

Muppidathi *et al.*, (1995) observed that yield was positively and significantly correlated with pod number primary and secondary branches per plant.

Mathur and Mathur (1996) reported that grain yield per plant showed significant positive association with pods per plant and 1000 grain weight. Negative correlation with plant height and days to flowering.

Ozdemir (1996) showed that seed yield was highly significant and positively correlated with, seeds per pod, pods per plant, secondary branches per plant, biological yield, harvest index and plant height. But 100-seed weight was either significantly positively or negatively associated with seed yield or yield enhancing characters.

Chand and Singh (1997) observed that the grain yield was positive and significant correlation with seed per pod, pods per plant and, biological yield, while harvest index had positive and significant correlation with pods per plant, seeds per pod, and grain yield.

Manjare *et al.*, (1997) observed grain yield per plant was positively and significantly associated with number of pods per plant, while yield component viz., number of branches per plant and 100 seed weight were associated among themselves.

Singh *et al.*, (1997) reported that grain yield was significant and positive association with number of pods per plant, harvest index, number of primary branches, number of secondary branches number of tertiary branches and biological yield.

Cinsoy and Yaman (1998) observed there was significant correlation between pods per plant, seed weight per plant and duration of flowering, while canopy height were negatively correlated with seed yield.

Tripathi (1998a) showed grain yield per plant had positive correlation with pods per plant, harvest index, while biological yield had positive correlation with days to flowering, days to maturity, plant height, and branches per plant.

Wahid and Ahmad (1998) reported that seed yield was positive and significant correlation with plant height and pods per plant. The traits had negative association with days to flower, maturity, 100 seed weight and harvest index.

Yadav and Sharma(1998) observed yield was positively correlated with days to maturity and number of seeds per pod, while negatively correlated with days to 50 per cent flowering, number of branches per plant and 100-seed weight.

Arora and Jeena (1999) observed seed yield was significantly and positively correlated with plant height, pods per plant, biological yield per plant. Biological yield expressed positive correlation

with pods per plant, while days to 50 per cent flowering positively associated with days to maturity.

Kumar *et al.*, (1999) observed that number of pods per plant, 100-seed weight and harvest index was highly significant and positive correlation with seed yield per plant while plant height showed negative correlation.

Khedar and Maloo (1999) showed seed yield was significantly and positively correlated with pods per plant, primary branches per plant and 100-seed weight.

Wahid and Ahmad (1999) showed plant height and pods per plant had strong positive association with seed yield.

Yadav and Sharma (1998) estimated the genotypic and phenotypic correlation was positive and highly significant association among grain yield, biological yield and harvest index.

Rao and Kumar (2000) observed that biological yield was positive association with harvest index. Pod-bearing length had positive association with 100-seed weight, seed yield and biological yield. It indicated that maximum contribution of biological yield followed by harvest index towards seed yield.

Amanullah *et al.*, (2001) observed that days to maturity, pods per plant, dry matter yield and harvest index were significantly positive correlated with grain yield.

Ali *et al.*, (2002) results revealed that secondary branches per plant, total weight of plant, pods per plant was positive and significantly correlated with seed yield.

Nawab (2002) observed genotypic correlation of seed yield per plant with number of primary branches per plant, number of pods per

plant, number of seed per plant, 100-seed weight and total weight of the plant was positive and significant whereas at phenotypic level the correlation coefficient were highly significant for days to maturity, number of secondary branches per plant, plant height and number of seeds per pod.

Singh *et al.*, (2002) observed correlation coefficient was positive and significant association with number of secondary branches, pods per plant, plant height, days to flowering, maturity and test weight with yield per plant. Besides, these characters had positive inter-relationship among them.

Arora *et al.*, (2003) observed that pods per plant exhibited the highest positive and significant association with seed yield per plant followed by seeds per plant, biological yield per plant and secondary branches per plant.

Bhaduoria *et al.*, (2003) observed significant positive correlation among various characters to first podding (0.62), days to 50 per cent podding (0.22), days to 100-seed weight (0.66), primary branches per plant (0.85), pods per plant (0.90) and seeds per pod (0.69). Yield per plant showed significantly negative correlation with days to 50 per cent flowering (-0.80), plant height (-0.25), physiological maturity (-0.86) and secondary branches per plant, (-0.49), however positive correlation between pods per plant, primary branches per plant (0.86), pods per plant (0.90) and seeds per pod (0.78).

Gupta *et al.*, (2003) observed that correlation coefficient of seed yield with the total number of flower, number of pods and dry matter of pods was significant at 5% probability level.

Kumar *et al.*, (2003) observed that genotypic correlation coefficient were higher than their respective phenotypic correlation. Harvest index exhibited the highest significant positive association with seed yield followed by pods per plant, biological yield per plant and secondary branches per plant.

Malik *et al.*, (1988) observed that pods per plant, seeds per pods and 100 seed weight were positively correlated with seed yield.

Raval and Dobaria (2003) showed that seed yield was positively and significantly correlated with biological yield per plant, 100-seed weight, number of pods per plant, harvest index, number of secondary branches per plant and plant spread at both genotypic and phenotypic level. While correlation of seed yield with days to 50 per cent flowering, days to maturity and number of seeds per pod was significantly negative.

Sial *et al.*, (2003) showed seed yield per plant was positively correlated with number of pods per plant, pod weight per plant and number of seeds per plant at genotypic, phenotypic level and with plant height, number of leaves and number of branches at genotypic levels. Seed yield was negatively correlated with number of days to maturity, days to 50 per cent flowering and 100-seed weight at phenotypic and genotypic level respectively.

Qureshi *et al.*, (2004) observed correlation coefficient of primary branches, secondary branches, pods per plant, biological yield and harvest index with grain yield were positive and highly significant, however days to maturity were negatively correlated with grain yield.

Ozcelik *et al.*, (2004) showed that positive and significant correlation were determined between seed yield and number of seeds per plant.

Arshad *et al.*, (2004) showed grain yield had positive and significant correlation with plant height, pods per plant, 100-seed weight and biological yield. Harvest index although later had a negative association with grain yield.

Brar *et al.*, (2004) showed that seed yield was highly significant and positive correlation with pods per plant, plant height and primary branches per plant.

Ciftci *et al.*, (2004) showed that positive and significant relationship among seed yield per plant, plant height, number of branches, number of pods per plant, biological yield, harvest index and number of seeds per plant. Negative and non-significant relationship was determined seed yield and 100-seed weight.

Toker (2004a) evaluated biological yield number of pods per plant were significantly correlated with seed yield.

Toker *et al.*, (2004b) observed the grain yield was positively and statistically significantly correlated with biological yield, harvest index, plant height, branches and pods per plant.

2.3 Path analysis

Adhikari and Pandey (1982) observed that days to flowering, pods per plant and 100 seed weight had high and direct effect on yield.

Singh *et al.*, (1985) noticed that seeds per pod exhibited highest positive effect on yield, while most of the characters affected yield indirectly through pods per plant.

Maloo and Sharma (1987) studied pods per plant had highest positive direct effect on seed yield followed by 100-seed weight and days to 50 per cent flowering.

Paliwal *et al.*, (1987) showed that 100-seed weight exhibited highest positive direct effect on yield followed by pods per plant, seeds per pod and days to maturity.

Sharma and Maloo (1988) observed that number of pods per plant exhibited highest positive and direct effects on grain yield followed by number of primary branches per plant and days to flowering.

Sadhu and Mandal (1989) revealed that 100-seed weight seed per pods, pods per plant and primary branches are important grain yield contributing character.

Singh *et al.*, (1989) reported that number of pods per plant had the highest positive direct effects on seed yield while number of primary and secondary branches per plant exerted high positive indirect effects via number of pods per plant.

Singh *et al.*, (1990) showed that biological yield and harvest index were major direct contribution for seed yield, while 100-seed weight and seed yield were major contribution to biological yield.

Uddin *et al.*, (1990) showed days to maturity, pods per plant 100-seed weight, harvest index, plant height and primary branches per plant had positive direct effect on seed yield per plant.

Chinna *et al.*, (1991) reported that pods per plant had highest direct positive effect on seed yield and also contributed via secondary branches to increased yield.

Sandhu *et al.*, (1991) showed that pods per plant had the highest direct genotypic and phenotypic effect on seed yield.

Dasgupta *et al.*, (1992) indicated that seeds per plant, 100 seed weight while seed per pod registered highly positive direct effect on yield.

Varghese *et al.*, (1993) reported that pod weight, shelling percentage, biological yield and harvest index had positive and direct effect on seed yield.

Arora and Kumar (1994) showed biological yield per plant, harvest index, pod per plant and 100 seed weight had the highest positive and direct effect on seed yield per plant.

Sarvalia and Goyal (1994) showed number of pods per plant and 100 seed weight had high direct effect on seed yield.

Muppidathi *et al.*, (1995) reported that number of pods showed highest positive and direct effect on seed yield.

Ozdemir (1996) reported that plant height, secondary branches, per plant, seeds per pod and harvest index pods per plant, primary branches per plant and biological yield while 100-seed mass had negative effect on seed yield.

Manjare *et al.*, (1997) showed that number of branches per plant, days to 50 per cent flowering and number of grain per pod exhibited high direct effects on grain yield per plant, whereas number of pods per plant influenced the grain yield through number of branches per plant and plant spread.

Shivkumar (1998) observed number of pods per plant, seeds per pod and 100-seed weight were identified as the most important yield contributing character.

Dasgupta *et al.*, (1998) studied pods per plant biomass plant and harvest index had high positive direct effect and indirect effect on seed yield per plant.

Tripathi (1998a) showed maximum direct contribution toward seed yield by biological yield followed by harvest index, days to maturity and branches per plant.

Wahid and Ahmad (1998) showed pods per plant had maximum direct contribution towards seed yield. The direct effect of 100-seed weight on seed yield was also positive, however plant height, pods per plant and plant yield proved to be most important contribution for seed yield in chickpea.

Khedar and Maloo (1999) reported that pods per plant was high positive direct effect on seed yield followed by seeds per pod, 100-seed weight and primary branches per plant.

Kumar *et al.*, (1999) showed that harvest index and biomass yield per plant was highly positive direct effect on seed yield, however number of pods per plant and 100 seeds weight showed negative direct effect on yield but showed positive indirect effect via biological yield per plant and harvest index.

Yadav *et al.*, (1999) showed that harvest index, biological yield and 100 seed weight had maximum direct contribution and also exerted appreciable indirect influence towards grain yield.

Jeena and Arora (2000) results suggested that selection is likely to be effective for 100-seed weight, pods per plant, seed yield per plant and length of pod bearing branch, harvest index, secondary branches per plant and seeds per pod.

Singh and Singh (2002) revealed that pods, test weight and secondary branches had negative direct effect but it had high positive indirect effect via pods per plant as seed yield.

Singh *et al.*, (2002) studied positive direct effect on grain yield was exerted by biological yield, number of pods per plant and harvest index.

Bhaduoria *et al.*, (2003) observed that the maximum positive direct effect was of pods per plant (0.450) whereas maximum negative direct effect was due to physiological maturity (0.450).

Gupta *et al.*, (2003) showed harvest index had high positive direct effect on seed yield followed by dry matter accumulation 100 seed weight and total number of flower. The total number of flower exhibited high positive indirect effect on seed yield through harvest index. 100-seed weight and dry matter accumulation had negative indirect effects on seed yield.

Ravel and Dobaria (2003) showed that highest positive direct effects of biological yield per plant and harvest index towards seed yield. Most of the characters contributed indirectly through biological yield per plant and harvest index.

Arshad *et al.*, (2004) reported that most of yield component had high indirect contribution on yield via biological yield, thus the biological yield and harvest index should be given more consideration while selection criteria for rainfed situation.

Ciftci *et al.*, (2004) recorded strong direct effects of the biological yield, harvest index and number of seeds per plant on the seed yield respectively.

MATERIALS AND METHODS

Chapter III

MATERIALS AND METHODS

3.1 Experimental materials

The experimental material for the present investigation consisting of ninety nine germplasm lines including three checks of chickpea collected from ARS, Badnapur and ICRISAT, Hyderabad were sown during *Rabi* 2005-2006. Details have been given in Table 1.

Table 1 : Name and sources of the germplasm lines.

Sr. No.	Name	Source
1	G-20	ARS, Badnapur
2	G-22	ARS, Badnapur
3	G-25	ARS, Badnapur
4	G-26	ARS, Badnapur
5	G-33	ARS, Badnapur
6	G-38	ARS, Badnapur
7	G-40	ARS, Badnapur
8	G-41	ARS, Badnapur
9	G-42	ARS, Badnapur
10	G-44	ARS, Badnapur
11	G-45	ARS, Badnapur
12	G-57	ARS, Badnapur
13	G-62	ARS, Badnapur
14	G-63	ARS, Badnapur
15	G-64	ARS, Badnapur
16	G-70	ARS, Badnapur
17	G-72	ARS, Badnapur
18	G-73	ARS, Badnapur
19	G-74	ARS, Badnapur
20	G-76	ARS, Badnapur
21	G-77	ARS, Badnapur

Contd...

22	G-78	ARS, Badnapur
23	G-79	ARS, Badnapur
24	G-80	ARS, Badnapur
25	G-81	ARS, Badnapur
26	G-82	ARS, Badnapur
27	G-83	ARS, Badnapur
28	G-84	ARS, Badnapur
29	G-85	ARS, Badnapur
30	G-87	ARS, Badnapur
31	G-88	ARS, Badnapur
32	G-90	ARS, Badnapur
33	G-91	ARS, Badnapur
34	G-92	ARS, Badnapur
35	G-94	ARS, Badnapur
36	G-95	ARS, Badnapur
37	B-23	ARS, Badnapur
38	B-24	ARS, Badnapur
39	B-25	ARS, Badnapur
40	B-27	ARS, Badnapur
41	B-29	ARS, Badnapur
42	B-30	ARS, Badnapur
43	B-31	ARS, Badnapur
44	B-32	ARS, Badnapur
45	B-34	ARS, Badnapur
46	B-46	ARS, Badnapur
47	B-47	ARS, Badnapur
48	B-48	ARS, Badnapur
49	B-49	ARS, Badnapur
50	B-50	ARS, Badnapur
51	B-51	ARS, Badnapur
52	B-55	ARS, Badnapur
53	B-56	ARS, Badnapur
54	B-57	ARS, Badnapur

Contd....

55	B-58	ARS, Badnapur
56	B-59	ARS, Badnapur
57	B-60	ARS, Badnapur
58	B-65	ARS, Badnapur
59	B-69	ARS, Badnapur
60	B-86	ARS, Badnapur
61	B-609	ARS, Badnapur
62	B-611	ARS, Badnapur
63	B-621	ARS, Badnapur
64	B-630	ARS, Badnapur
65	B-633	ARS, Badnapur
66	B-636	ARS, Badnapur
67	B-637	ARS, Badnapur
68	B-701	ARS, Badnapur
69	B-768	ARS, Badnapur
70	BCP-17	ARS, Badnapur
71	BCP-36	ARS, Badnapur
72	BCP-54-1	ARS, Badnapur
73	BCP-54-2	ARS, Badnapur
74	BCP-73	ARS, Badnapur
75	BCP-91	ARS, Badnapur
76	BCP-97	ARS, Badnapur
77	L-1	ARS, Badnapur
78	L-2	ARS, Badnapur
79	L-3	ARS, Badnapur
80	L-102	ICRISAT, Hyderabad
81	L-108	ICRISAT, Hyderabad
82	L-109	ICRISAT, Hyderabad
83	L-111	ICRISAT, Hyderabad
84	L-112	ICRISAT, Hyderabad
85	L-113	ICRISAT, Hyderabad
86	L-201	ICRISAT, Hyderabad

Contd..

87	L-202	ICRISAT, Hyderabad
88	L-302	ICRISAT, Hyderabad
89	L-303	ICRISAT, Hyderabad
90	L-305	ICRISAT, Hyderabad
91	L-311	ICRISAT, Hyderabad
92	L-312	ICRISAT, Hyderabad
93	L-313	ICRISAT, Hyderabad
94	GTP-11	ARS, Badnapur
95	LDG-1	ARS, Badnapur
96	LHP-1	ARS, Badnapur
97	Annegiri (C)	ICRISAT, Hyderabad
98	BDN-9-3 (C)	ARS, Badnapur
99	BDN-797 (C)	ARS, Badnapur

3.2 Experimental methods

The experiment was conducted during *rabi*, 2005-2006 at the Experimental Farm, Department of Agril. Botany, College of Agriculture, Latur. The experimental details are as follows.

Design	:	R.B.D. (Randomized Block Design)
Treatments	:	99 (96 germplasm lines + 3 checks)
Replications	:	Three
Plot size	:	0.45 x 3.0 m. (one row of 3 m length)
Fertilizer	:	25 kg N + 50 Kg P ₂ O ₅ /ha
Spacing	:	Row to row : 45 cm. Plant to plant : 15 cm.
Date of sowing	:	11 / 11 / 2005

The experiment comprising 96 germplasm lines and 3 standard checks viz., Annegiri, BDN-9-3 and BDN-797 was sown in a

randomized block design with three replications at experimental farm Department of Agril. Botany, College of Agriculture, Latur during *rabi* 2005-2006 under rainfed condition. The sowing was carried out in a single row plot of 3 meter length following the spacing of 45 cm and 15 cm between rows and plants in a row respectively. The method of sowing followed was dibbling. One plant per hill was maintained by thinning at 15 days after sowing. The recommended dose of fertilizer 25 kg N + 50 kg P_2O_5 /ha was applied at the time of sowing. All other cultural practices and plant protection measures were undertaken to maintain the crop health.

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 biometrical 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 Number of primary branches per plant

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

3.2.1.4 Plant height (cm)

Height of plants was recorded at the time of maturity.

3.2.1.5 Number of pods per plant

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

3.2.1.6 Number of seeds per pod

Average number of seed from selected pods were counted.

3.2.1.7 100-seed weight (g)

Well-filled 100-seeds were weighted.

3.2.1.8 Harvest index

Harvest index was calculated by

$$\text{Harvest index} = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

Whereas,

Biological yield = seed yield + dry matter

Economical yield = seed yield per plant.

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	$\delta^2_e + g \delta^2_r$	
Genotypes	(g-1)	MS ₂	$\delta^2_e + r \delta^2_g$	
Error	(r-1)(g-1)	MS ₃	δ^2_e	
Total	(rg -1)			

r = Number of replications

g = Number of genotypes

δ^2_e = Error variance.

δ^2_g = Genotypic variance

δ^2_r = Replication variance

$$1. \quad \text{Standard error (SE)} = \sqrt{\frac{mS_3}{r}}$$

Where,

mS₃ = Error mean sum of squares

r = number of replication.

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

3.3.2 Genetic variability

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

1. Genotypic variance (δ^2g) = $\frac{\text{Treatment MSS} - \text{Error MSS}}{\text{Number of replications}}$
2. Phenotypic variance (δ^2p) = 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) = $\frac{\sqrt{\delta^2g}}{\bar{X}} \times 100$
4. Phenotypic coefficient of variation (PCV) = $\frac{\sqrt{\delta^2p}}{\bar{X}} \times 100$

Where,

- δ^2g = genotypic variance.
 δ^2p = phenotypic variance.
 $\bar{X}$ = general mean of character.

3.3.3 Heritability and genetic advance

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

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

Where,

$\delta^2\text{g}$ = genotypic variance.

$\delta^2\text{p}$ = phenotypic variance.

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

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

Where,

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

$\delta\text{ p}$ = phenotypic standard deviation

h^2 = heritability

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

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

Where,

E G A = Expected genetic advance

G A = Genetic advance

$\bar{X}$ = 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).

$$r = \frac{\text{Cov. (x.y)}}{(\delta^2 x \delta^2 y)^{1/2}}$$

Where

r = correlation coefficient between the characters x and y

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

$\delta^2 x$ and $\delta^2 y$ 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 freedom at 5 and 1 percent level of significance.

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.

$$P_{01} + P_{02} r_{12} + \dots + P_{0p} r_{1p} = r_{01}$$

$$P_{01} r_{12} + P_{02} + \dots + P_{0p} r_{2p} = r_{02}$$

$$P_{01} r_{10} + P_{02} r_{2p} + \dots + P_{0p} = r_{0p}$$

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

$r_{12}, r_{13}, \dots, r_{1p}, \dots, r_{p(p-1)}$ are the possible correlation coefficients between various independent variables and $r_{01}, r_{02}, \dots, r_{0p}$ are the correlations of independent variables with dependent variables. The different effects of 'i' th variable via 'j' th variable were worked out as $(P_{0j} \times P_{ij})$.

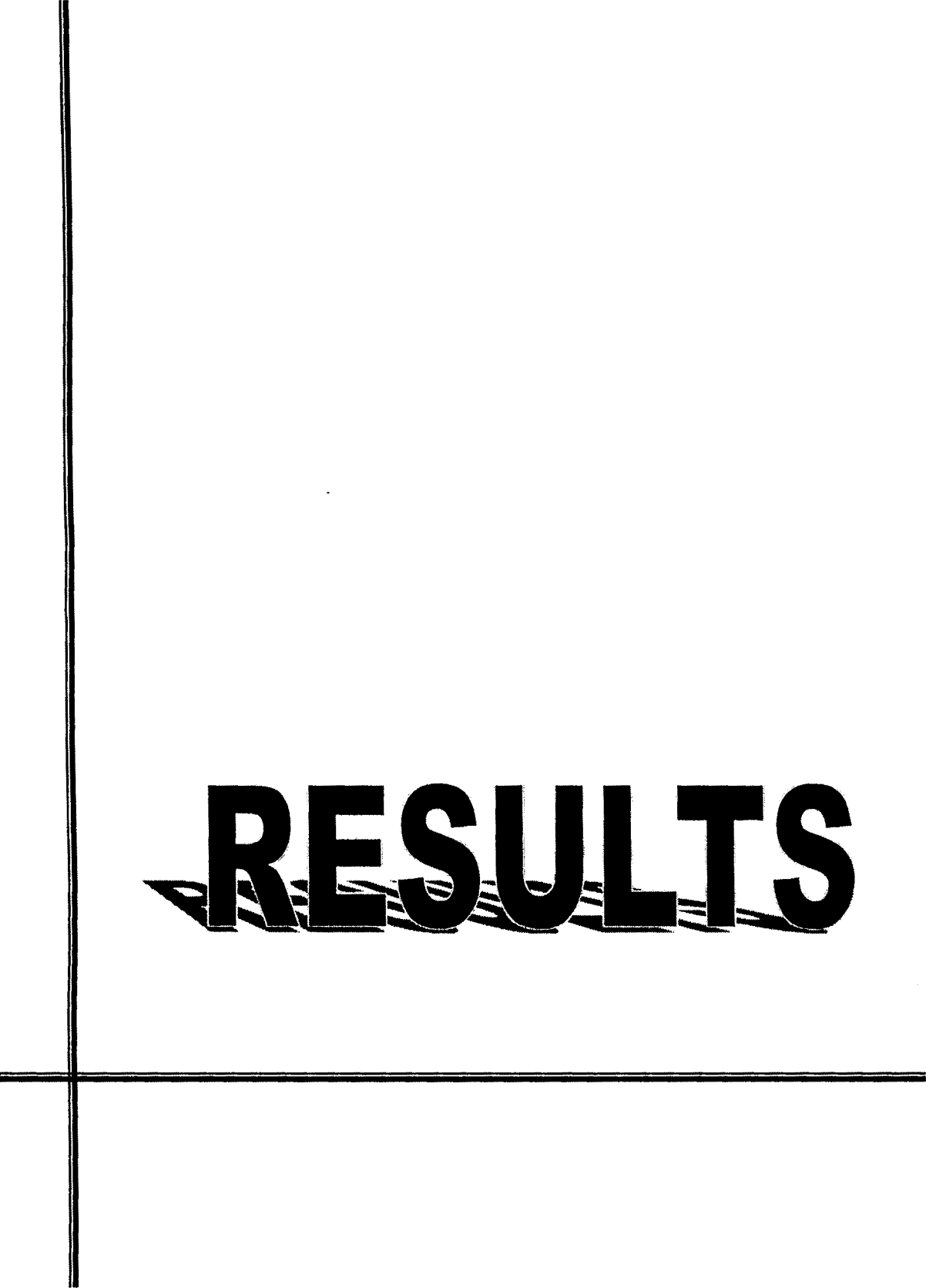
From the simultaneous equations it is clear that the correlation coefficient is the sum of direct and indirect path coefficients.

Residual effect was calculated as under

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

$$P^2 O2 = 2P_{02}^2 P_{03} r_{23} + \dots + P_{0p}^2)$$

$$\text{Residual factor} = P_{0p}^2$$



RESULTS

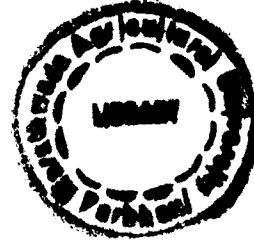
CHAPTER – IV

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RESULTS

The results obtained in the investigation are presented in this chapter under the following sub-headings.

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 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 differences exist 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 primary branches/ plant	Plant height (cm)	No. of pods / plant	Number of seeds /pod	100 seed wt. (g)	Harvest index (%)	Seed yield /plant (g)
	Mean sum of squares										
1	Replication	2	2.75	2.39	0.026	2.14	6.23	0.0004	0.56	9.14	0.007
2	Treatment	98	164.18**	114.17**	4.14*	108.06**	586.78**	0.122*	112.51**	208.00**	24.11**
3	Error	196	2.30	1.44	0.037	0.86	5.45	0.004	0.53	5.60	0.022

* Significant at 5 per cent

** Significant at 1 per cent

4.2 Mean performance

The mean performance of germplasm 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 27.66 to 61.66 days with an average value of 44.66 days. Among the lines G-20 (27.66), B-25 (33.33), LDG-1 (33.66), GTP-11 (34.00), B-48 (34.33), G-84 (34.33), G-80 (34.33), B-24 (34.66), LHP-1 (34.66), were showed early days to 50 per cent flowering. However, a higher days to 50 per cent flowering was observed in germplasm B-32 (61.00), B-633 (60.66) and B-636 (60.60).

4.2.2 Days to maturity

The range of days to maturity was from 72 to 100.66 days with an average value of 86.33 days. Among the lines GTP-11 (72.00), LHP-1 (74.00), B-24 (74.00), LDG-1 (75.00), G-20 (79.00), G-84 (79.00), G-80 (81.00), B-48 (81.00) and G-38 (81.00) showed early maturity. However the late maturity was observed in L-312 (100.66), L-313 (100.33), B-637 (100.00) and L-108 (99.00).

4.2.3 Number of primary branches per plant

Number of primary branches per plant ranged from 3.10 to 8.93 with mean of 6.06. Highest numbers of primary branches were observed in lines BCP-73 (8.93), G-88 (8.50), G-87 (8.40), L-2 (7.60), BCP-36 (7.60), B-56 (7.40), B-32 (7.20), G-33 (6.90), B-23 (6.80). The lowest number of primary branches was observed in L-108 (3.1) and G-44 (3.20).

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 primary branches/plant	Plant height (cm)	No. of pods/plant	Number of seeds /pod	100 seed wt. (g)	Harvest index (%)	Seed yield /plant (g)
1	2	3	4	5	6	7	8	9	10	11
1	G-20	27.66	79.00	4.00	45.70	39.16	1.52	20.26	63.74	6.16
2	G-22	42.00	90.00	4.50	45.70	40.83	1.53	18.90	50.20	6.31
3	G-25	45.00	88.00	4.60	41.46	28.33	1.40	21.16	65.88	10.55
4	G-26	40.66	81.00	4.40	44.83	31.00	1.13	18.07	68.21	8.37
5	G-33	53.00	94.00	4.90	40.20	60.33	1.41	16.36	58.47	8.24
6	G-38	38.33	81.00	4.10	46.00	42.13	1.00	34.90	34.99	13.21
7	G-40	51.33	92.00	5.10	57.80	36.00	1.21	18.95	60.74	11.53
8	G-41	37.00	84.00	4.80	30.43	42.53	1.32	31.83	76.02	16.01
9	G-42	42.00	91.00	6.20	49.80	50.73	1.32	22.44	67.13	14.26
10	G-44	40.33	82.00	3.20	52.20	35.66	1.46	18.54	67.21	9.26
11	G-45	36.00	81.33	5.00	38.50	40.53	1.46	19.00	49.97	8.32
12	G-57	52.66	91.00	7.20	43.73	50.20	1.33	20.70	61.20	10.61
13	G-62	42.33	99.00	4.40	48.46	28.00	1.06	25.78	49.69	8.60
14	G-63	51.66	97.00	6.50	41.46	50.93	1.13	26.43	59.30	10.68
15	G-64	44.00	90.00	6.80	37.56	51.60	1.26	18.31	66.35	11.52
16	G-70	44.33	92.00	5.40	50.70	49.33	1.26	18.33	66.15	12.39
17	G-72	45.00	90.00	6.80	42.00	54.20	1.41	20.20	51.40	10.42
18	G-73	44.00	89.33	5.90	48.16	57.53	1.53	11.20	65.86	8.44
19	G-74	49.66	91.00	5.90	45.50	45.20	1.06	15.54	63.35	8.05
20	G-76	56.33	91.00	4.10	39.60	38.80	1.06	15.94	63.71	6.53
21	G-77	42.00	89.00	4.20	35.56	48.43	1.26	16.08	55.77	6.97
	G-78	39.66	84.00	5.90	41.76	52.46	1.06	16.70	71.32	9.60
	G-79	34.33	81.00	4.80	41.76	46.26	1.26	15.40	65.57	11.43

1	2	3	4	5	6	7	8	9	10	11
24	G-80	37.33	81.00	5.50	35.53	35.58	1.10	36.11	74.49	9.01
25	G-81	40.00	89.00	5.30	44.66	41.73	1.15	24.11	71.22	10.48
26	G-82	38.00	84.00	5.50	58.00	47.20	1.06	23.66	66.11	12.67
27	G-83	34.33	79.00	4.93	41.66	52.73	1.30	16.30	70.88	10.08
28	G-84	42.00	88.00	5.60	35.93	42.73	1.06	18.84	66.23	7.61
29	G-85	42.00	88.00	5.80	41.20	31.53	1.80	26.44	76.43	11.27
30	G-87	56.66	94.00	8.50	47.50	44.70	1.10	23.91	55.31	9.84
31	G-88	50.66	91.30	8.40	42.20	36.96	1.10	25.74	51.26	8.78
32	G-90	35.00	88.00	5.00	46.60	36.60	1.72	28.35	73.65	11.09
33	G-91	51.00	93.00	4.80	39.20	40.56	1.13	18.40	66.55	7.12
34	G-92	49.33	91.00	5.00	58.40	38.46	1.10	20.87	71.68	9.66
35	G-94	40.00	83.00	4.50	41.06	43.20	1.10	35.26	70.74	11.77
36	G-95	40.00	82.00	3.50	37.60	30.06	1.00	40.56	75.01	10.97
37	B-23	51.00	97.00	6.80	43.00	20.13	1.26	30.27	61.70	5.92
38	B-24	34.66	74.00	4.00	48.00	29.56	1.24	19.63	73.77	6.25
39	B-25	33.33	98.00	4.10	42.80	20.36	1.00	28.56	58.87	6.29
40	B-27	40.66	88.00	5.40	36.80	35.73	1.53	16.70	63.29	6.13
41	B-29	42.00	91.00	5.70	40.73	71.53	1.73	16.36	70.71	13.27
42	B-30	38.00	92.00	6.00	40.36	75.96	1.06	16.54	66.71	16.26
43	B-31	46.66	95.00	6.20	47.40	94.00	1.33	13.60	61.31	7.91
44	B-32	61.00	97.00	7.20	42.00	47.00	1.33	14.10	61.73	8.18
45	B-34	42.00	92.00	5.00	32.40	89.13	1.13	14.10	63.18	11.22
46	B-46	51.00	91.00	5.80	42.00	76.83	1.47	16.60	70.86	12.04
47	B-47	45.00	92.00	5.30	54.80	48.86	1.33	30.51	69.43	11.45
48	B-48	34.33	81.00	3.30	41.93	35.86	1.33	14.91	69.38	7.92
49	B-49	42.66	90.00	4.20	37.80	44.56	1.00	25.26	71.78	10.56
50	B-50	49.00	96.00	3.40	50.50	23.93	1.00	30.61	62.05	7.40
51	B-51	40.66	88.00	4.20	37.20	36.26	1.00	28.68	62.94	5.96
52	B-55	44.33	85.00	3.60	35.00	29.33	1.21	26.86	68.07	7.48
53	B-56	53.00	97.00	7.40	50.06	76.86	1.35	18.00	71.49	12.04

1	2	3	4	5	6	7	8	9	10	11
54	B-57	40.66	89.00	5.40	50.23	59.33	1.00	29.60	54.72	7.60
55	B-58	37.33	89.66	5.80	39.40	30.30	1.06	31.23	67.39	10.56
56	B-59	45.66	87.00	5.60	47.60	82.43	1.13	25.13	76.05	18.81
57	B-60	43.33	85.00	5.20	34.40	33.03	1.20	20.40	66.94	6.68
58	B-65	43.00	93.00	6.40	43.80	34.06	1.00	17.43	60.15	7.13
59	B-69	42.00	89.00	5.10	30.20	33.00	1.05	16.77	70.03	5.94
60	B-86	52.00	94.00	5.80	43.00	55.19	1.00	20.46	59.90	9.43
61	B-609	40.66	87.00	4.60	53.83	29.03	1.10	30.34	62.77	11.10
62	B-611	60.66	98.00	4.90	44.20	31.26	1.13	27.40	50.95	7.84
63	B-621	47.00	88.00	5.20	41.46	34.66	1.00	24.77	78.04	10.13
64	B-630	46.33	94.00	5.50	42.20	54.83	1.26	19.08	63.60	11.25
65	B-633	60.66	97.00	5.60	49.00	40.53	1.00	25.73	54.73	8.87
66	B-636	60.66	98.00	6.10	47.80	39.00	1.54	26.36	52.56	10.93
67	B-637	58.00	100.00	4.20	52.20	31.00	1.00	35.70	66.65	10.33
68	B-701	43.33	88.00	5.20	44.20	54.26	1.46	25.56	63.97	10.55
69	B-768	47.33	91.00	5.70	45.20	60.63	1.00	17.10	68.10	10.77
70	BCP-17	47.00	98.00	6.10	50.80	47.16	134	33.13	70.77	16.37
71	BCP-36	55.00	91.00	7.60	41.46	40.33	1.54	23.23	68.54	10.95
72	BCP-54-1	41.66	89.00	6.10	43.10	44.36	1.26	23.73	65.12	10.14
73	BCP-54-2	42.00	86.00	3.60	46.20	32.46	1.21	27.13	65.49	9.88
74	BCP-73	46.00	96.00	8.96	36.46	28.06	146	15.54	78.23	4.84
75	BCP-91	35.66	85.00	4.10	47.70	40.13	1.06	24.60	69.59	9.41
76	BCP-97	40.66	95.00	5.10	53.80	52.46	1.06	23.84	70.16	11.54
77	L-1	36.33	90.00	4.60	50.53	50.33	1.00	24.63	66.44	12.38
78	L-2	46.00	96.00	7.60	47.00	42.40	1.07	28.14	70.63	12.91
79	L-3	58.00	98.00	5.00	39.50	35.26	1.53	17.14	60.27	5.56
80	L-102	58.00	95.00	4.10	35.00	38.33	1.21	15.44	58.98	6.00
81	L-108	55.00	99.00	3.10	33.43	32.86	1.13	19.34	56.33	6.52
82	L-109	56.33	95.00	6.70	49.20	38.86	1.45	17.63	55.92	9.13

1	2	3	4	5	6	7	8	9	10	11
83	L-111	57.33	99.00	4.10	38.06	36.10	1.46	17.56	47.42	3.71
84	L-112	40.00	84.00	5.10	41.36	45.40	1.13	22.10	69.15	11.73
85	L-113	42.66	91.00	4.93	41.46	25.50	1.41	14.75	67.45	8.81
86	L-201	42.66	86.00	4.90	36.20	40.33	1.13	18.16	60.11	6.34
87	L-202	43.00	90.00	5.10	36.26	30.93	1.33	17.63	53.94	7.22
88	L-302	43.33	89.00	5.10	37.26	46.90	1.06	19.27	69.56	11.32
89	L-303	49.33	94.00	6.10	41.40	48.86	1.06	17.48	63.04	11.19
90	L-305	50.00	89.00	6.20	34.16	52.50	1.46	13.88	66.31	6.30
91	L-311	49.00	90.00	5.40	42.60	41.73	1.43	16.03	51.74	6.59
92	L-312	46.00	110.66	4.70	36.40	31.10	1.47	22.63	39.60	5.43
93	L-313	57.00	110.00	4.60	44.00	42.26	1.73	17.66	48.19	5.35
94	GTP-11	34.00	72.00	3.60	41.40	30.73	1.52	11.97	55.14	5.22
95	LDG-1	33.66	75.00	4.20	37.70	31.73	1.43	15.26	75.41	6.02
96	LHP-1	34.66	74.00	4.90	41.60	36.53	1.13	16.80	58.18	6.08
97	Annegiri (C)	38.33	88.00	6.10	36.53	43.03	1.26	18.26	73.84	9.87
98	BDN-9-3 (C)	40.33	88.00	6.60	44.90	58.73	1.34	19.40	72.27	12.51
99	BDN-797 (C)	42.00	91.00	6.40	46.86	62.93	1.41	19.10	55.02	10.40
	Mean	44.79	89.73	5.32	43.05	43.76	1.24	21.67	63.82	9.43
	S.E. $\pm$	0.87	0.69	0.11	0.53	1.34	0.03	0.42	1.36	0.08
	C.D. at 5%	2.44	1.93	0.31	1.50	3.76	0.10	1.17	3.81	0.24

4.2.4 Plant height (cm)

The range was noted from 30.20 – 58.40 cm with an average 44.30 cm. The line B-69 (30.2) followed by G-41 (30.43), B-34 (32.40) and L-108 (33.43) exhibited dwarf plant height. The maximum plant height was observed in G-93 (58.40) followed by G-83 (58.00), B-47 (54.80), B-609 (53.83), BCP-97 (53.40) and B-637 (52.20).

4.2.5 Number of pods per plant.

The number of pods per plant ranged from 20.36 – 94.00 with an average of 57.18. The maximum numbers of pods were observed in line B-31 (94.00) followed by B-34 (89.13), B-59 (82.43), B-56 (76.86), B-46 (76.83), B-30 (75.96), B-29 (71.53), BDN-797 (62.93) and B-768 (60.63). However minimum number of pods per plant was observed in B-25 (20.36) and G-82 (28.00).

4.2.6 Number of seeds per pod.

The range for number of seeds per pod was observed from 1.00 to 1.80 with an average of 1.40. The highest number of seeds per pod observed in G-87 (1.80) followed by G-29 (1.70), G-91 (1.70), B-636 (1.54), BCP-36 (1.53), L-3 (1.53), G-22 (1.53) and B-27 (1.53) while the minimum number of seeds per pod was observed in B-49 (1.00), B-50 (1.00), B-51 (1.00).

4.2.7 100-seed weight (gm)

100-seed weight ranged from 11.20 to 40.56 gm with an average 25.88 gm. Maximum test weight was recorded by germplasm lines G-95 (40.56) followed by G-80 (36.11), B-637 (35.7), G-94 (35.26), G-38 (34.9), BCP-17 (33.13), G-41 (31.83). However, minimum test weight was observed G-74 (11.20).

4.2.8 Harvest index (%)

Harvest index was ranged from 34.99 to 78.23 per cent with the mean 56.61 per cent. The highest harvest index observed in BCP-73 (78.23) followed by B-621 (78.04), G-87 (76.43), B-59 (76.05), G-41 (76.02), , LDG-1 (75.41) and G-81 (74.49). However lowest harvest index observed in G-38 (34.99), LHP-1 (36.6), B-611 (50.95), G-73 (51.04).

4.2.9 Seed yield per plant (g)

The character seed yield per plant was ranged from 3.17 to 18.81 gm with mean of 11.26 gm. The highest seed yield per plant was recorded by B-59 (18.81) followed by BCP-17 (16.37), B-30 (16.26), G-41 (16.01), G-42 (14.26), B-29 (13.27), G-38 (13.21) over the highest yield check BDN-9-3 (12.51). The lowest seed yield per plant was observed in L-111 (3.71).

4.3 Genetic Parameters

Genetic parameters viz., the genotypic variance (δ^2g), phenotypic variance (δ^2p), 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 (δ^2 g)	Phenotypic variance (δ^2 p)	GCV (%)	PCV (%)	Heritability (%)	Genetic advance (GA)	Expected genetic advance (EGA)
1.	Days to 50 % flowering	27.66 – 61.66	44.66	53.95	56.26	16.39	16.74	95.9	14.81	33.08
2.	Days to maturity	72.00-100.66	86.33	37.57	39.02	6.83	6.96	96.2	12.39	13.80
3.	No. of primary branches/ plant	3.20 – 8.93	6.06	0.36	1.40	21.95	22.26	97.03	2.37	44.62
4.	Plant height (cm)	30.20 – 58.4	44.30	35.73	36.60	13.88	14.05	97.06	12.16	28.25
5.	No. of pods / plant	20.36 – 94.00	57.18	193.77	199.23	31.80	32.25	97.26	28.28	64.61
6.	No. of seeds / pod	1.00 – 1.8	1.4	0.039	0.043	15.92	16.76	90.2	0.38	31.92
7.	100 seed wt. (g)	11.20 – 40.56	25.88	37.32	37.85	28.18	28.38	98.60	12.49	57.66
8.	Harvest index (%)	34.99 – 78.23	56.61	67.46	73.06	12.86	13.39	92.3	16.25	25.47
9.	Seed yield /plant (g)	3.71 – 18.81	11.26	8.03	8.05	30.04	30.08	99.72	5.83	61.85

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

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

4.3.2 Estimates of Genotypic and Phenotypic coefficient of variation (GCV and PCV)

On the basis of mean, the genotypic and phenotypic coefficient of variation was observed to be high for number of pods per plant (31.80, 32.25) followed by seed yield per plant (30.04, 30.08), 100-seed weight (28.18, 28.38) and number of primary branches (21.95, 22.26). For rest of the characters, genotypic and phenotypic coefficient of variation was ranged from 6.83, 6.96 to 16.39, 16.74. Equal magnitude of PCV and GCV observed for all characters.

4.3.3 Heritability and Genetic Advance

The range of heritability in broad sense varied between 90.2 to 99.72. The heritability estimates (broad sense) were high for all the characters under study. The genetic advance ranged between 0.38 to 28.28. Higher estimates of genetic advance were observed for number of pods per plant (28.28) followed by harvest index (16.25), days to 50 percent flowering (14.81), 100 seed weight (12.49), days to maturity (12.39) and plant height (12.16).

4.3.4 Genetic advance

Low genetic advance was observed for seed yield per plant (5.83), number of primary branches per plant (2.37) and number of seeds per pod (0.38).

4.3.5 Expected genetic advance as percent of mean (EGA)

Expected genetic advance as percent of mean (EGA) ranged between 13.80 to 64.61. It was highest for number of pods per plant (64.61) followed by seed yield per plant (61.85), 100-seed weight (57.66), number of primary branches per plant (44.62). However, low genetic advance as percent of mean was observed in days to maturity (13.80), harvest index (25.47), plant height (28.25), number of seeds per pod (31.92) days to 50 per cent flowering (33.08).

4.4 Correlation

The correlation coefficient is a most important statistical constant used as a measure of the degree of association between two characters. 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 primary branches per plant (0.2371**, 0.2328**) plant height (0.3338**, 0.3299**), number of pods per plant

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 primary branches/plant	Plant height (cm)	No. of pods / plant	Number of seeds /pod	100 seed wt. (g)	Harvest index (%)	Seed yield /plant (g)
1	Days to 50 % flowering	G 1.000 P 1.000	0.7434** 0.7163**	0.3365** 0.3238**	0.0740 0.0729	0.0451 0.0443	0.0446 0.0454	-0.0639 -0.0671	0.3173** 0.2985**	-0.1311* -0.1290*
2	Days to maturity	G P	1.000 1.000	0.3451** 0.3375**	0.1265* 0.1255*	0.0991 0.0980	-0.0064 0.0010	0.0560 0.0549	0.3064** 0.2903**	-0.0137 -0.0133
3.	No. of primary branches/ plant	G P	 	1.000 1.000	0.0602 0.0562	0.3473** 0.3360**	0.1320* 0.1233*	-0.1285* -0.1264*	0.0587 0.0525	0.2371** 0.2328**
4	Plant height (cm)	G P	 	 	1.000 1.000	0.0891 0.0870	-0.0771 -0.0647	0.2150** 0.2107**	-0.0253 0.0207	0.3338** 0.3299**
5	No. of pods / plant	G P	 	 	 	1.000 1.000	0.0573 0.0481	-0.3048** -0.3006**	0.1083 0.0984	0.4912** 0.4837**
6	No. of seeds / pod	G P	 	 	 	 	1.000 1.000	-0.3588** 0.3387**	-0.0740 0.0605	-0.1188* -0.1127
7	100 seed wt. (g)	G P	 	 	 	 	 	1.000 1.000	0.0644 0.0663	0.3371** 0.3350**
8	Harvest index (%)	G P	 	 	 	 	 	 	1.000 1.000	0.3751** 0.3601**
9	Seed yield /plant (g)	G P	 	 	 	 	 	 	 	1.000

* Indicates significant at 5% level.

** Indicates significant at 1% level.

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

(0.4912**, 0.4837**) 100 seed weight (0.3371**, 0.3350**) and harvest index (0.3751**, 0.3601**). However, three component viz., days to 50 per cent flowering, days to maturity and number of seeds per pods had negative association with seed yield.

2. Days to 50 per cent flowering and other characters

Days to 50 percent flowering was significantly and positively correlated with days to maturity (0.7434**, 0.7163**), number of primary branches per plant (0.3365**, 0.3268**) and harvest index (0.3173**, 0.2985**) while positive but non-significant correlations were noted for plant height, pods per plant and number of seeds per pod. However, negative and significant correlation was noted for seed yield per plant both at genotypic and phenotypic level.

3. Days to maturity and other characters.

Positive and significant correlation with, primary branches per plant, plant height and harvest index. While the pods per plant and 100-seed weight exhibited positive but non-significant correlation with days to maturity both at genotypic and phenotypic level.

4. Number of primary branches per plant with other characters

Number of primary branches per plant noted positive and significant correlation with pods per plant, number of seeds per pod and seed yield per plant both at genotypic and phenotypic level. While plant height and harvest index showed positive but non-significant correlation with number of primary branches per plant. However, 100-seed weight showed negative correlation with number of primary branches per plant.

5. Plant height and other characters

Positive and significant correlation was noted for 100-seed weight and seed yield per plant both at genotypic and phenotypic level. However, positive and non-significant correlation with pods per plant.

6. Number of pods per plant with other characters

Pods per plant showed positive and significant correlation between number of seeds per pod, seed yield per plant at both genotypic and phenotypic level. However, positive and negative correlation existed between harvest index and 100 seed weight respectively.

7. Number of seeds per pod with other characters.

Number of seeds per pod was exhibited negative and significant genotypic correlations with 100-seed weight and seed yield per plant.

8. 100-seed weight with other characters

100-seed weight showed positive association with harvest index both at genotypic and phenotypic level.

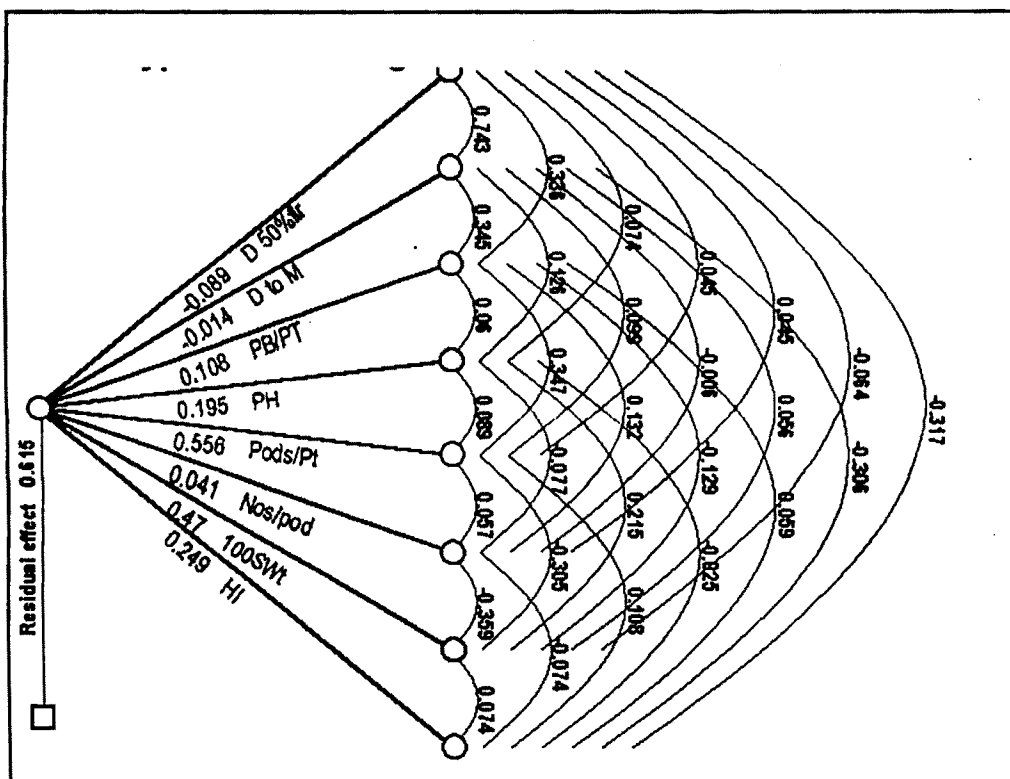
4.5 Path analysis

The correlation studies do not show the exact picture of direct and indirect effect of yield contributing characters. 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 coefficient presented in Table 6.

Sr. No.	Character	Days to 50 % flowering	Days to maturity	No. of primary branches/ plant	Plant height (cm)	No. of pods / plant	Number of seeds /pod	100 seed wt. (g)	Harvest index (%)	Correlated seed yield /plant (r)
1	Days to 50 % flowering	G -0.0893 P -0.0853	-0.0664 -0.0611	-0.0301 -0.0276	-0.0066 -0.0062	-0.0040 -0.0038	-0.0040 -0.0039	0.0057 0.0057	0.0283 0.0255	-0.1311 -0.1290
2	Days to maturity	G -0.0103 P -0.0174	-0.0138 -0.0242	-0.0048 -0.0082	-0.0017 -0.0030	-0.0014 0.0024	0.0001 0.0000	-0.0008 -0.0013	0.0042 0.0070	-0.0137 -0.0133
3	No. of primary branches/ plant	G 0.0362 P 0.0372	0.0371 0.0387	6.1075 0.1148	0.0065 0.0065	0.0373 0.0386	0.0142 0.0141	-0.0138 -0.0145	0.0063 0.0060	0.2371 0.2328
4	Plant height (cm)	G 0.0144 P 0.0142	0.246 0.0244	0.0117 0.0110	0.1946 0.1946	0.0173 0.0169	-0.0150 -0.0145	0.0418 0.0410	-0.0049 0.0040	0.3338 0.3299
5	No. of pods / plant	G 0.0251 P 0.0243	0.0550 0.0538	0.1930 0.1843	0.0495 0.0477	0.5558 0.5486	0.0318 0.268	-0.1694 -0.1649	0.0602 0.0540	0.4912 0.4837
6	No. of seeds / pod	G 0.0018 P 0.0017	-0.0003 0.0000	0.0054 0.0046	-0.0032 -0.0028	0.0024 0.0018	0.0411 0.0376	-0.0147 -0.0127	-0.0030 0.0023	-0.1188 -0.1127
7	100 seed wt. (g)	G -0.0300 P -0.0312	0.0263 0.0255	-0.0604 -0.0588	0.1010 0.0981	-0.1431 -0.1400	-0.1685 -0.1577	0.4697 0.4656	0.0349 0.0309	0.3371 0.3350
8	Harvest index (%)	G -0.0797 P -0.0725	-0.0763 -0.0705	0.0146 0.0128	-0.0063 -0.0050	0.0270 0.0239	-0.0184 -0.0147	0.0185 0.0161	0.2491 0.2430	0.3751 0.3601

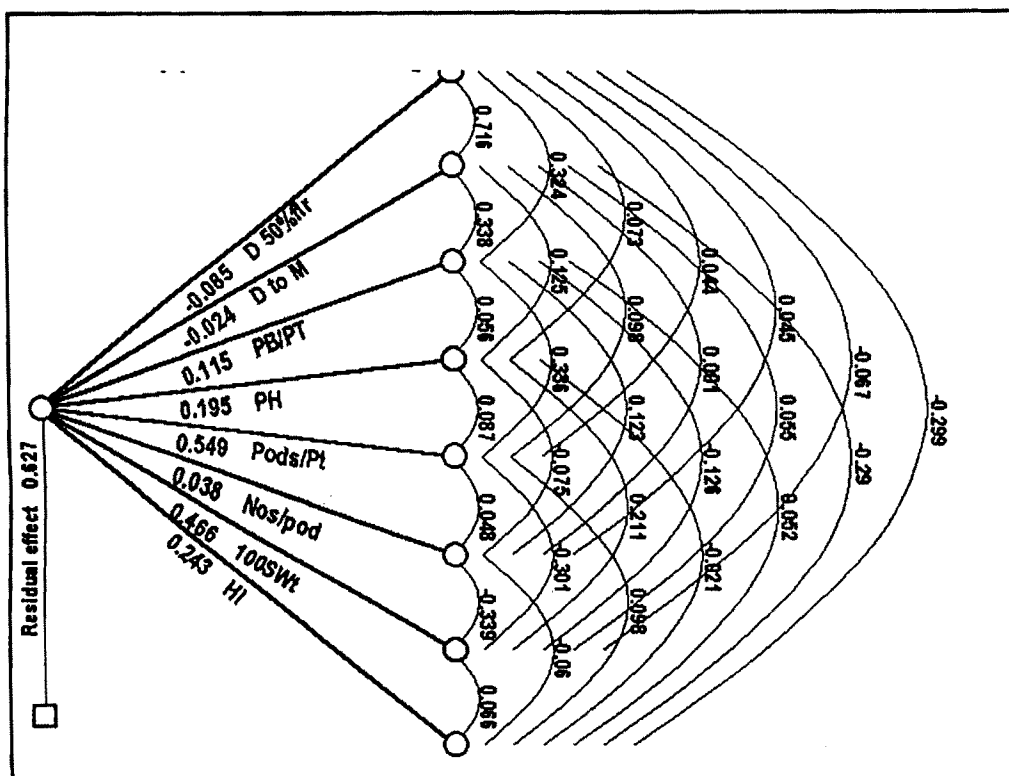
Residual (G) : 0.6146, Residual (P) : 0.6171

Dark figures denotes direct effects



1. Days to 50% flowering.
2. Days to maturity
3. Number of primary branches per plant
4. Plant height
5. Number of pods per plant
6. Number of seeds per plant.
7. 100 seed weight
8. Harvest index
9. Seed yield per plant

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 primary branches per plant
4. Plant height
5. Number of pods per plant
6. Number of seeds per plant.
7. 100 seed weight
8. Harvest index
9. Seed yield per plant

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

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 except 100-seed weight and harvest index, exhibited low positive indirect effect on yield.

Path analysis at phenotypic levels revealed that the low negative direct effect on yield per plant. Whereas, low positive indirect effect via 100-seed weight and harvest index. Rest of the characters were negative indirect effect on seed yield.

2. Seed yield versus days to maturity

Days to maturity at genotypic level had low negative direct effect on seed yield. However, positive indirect effect via harvest index in very low magnitude was observed. Remaining characters are negative indirect effect on seed yield per plant.

At phenotypic level days to maturity had low negative direct effect on seed yield. However, positive indirect effect via harvest index and number of pods per plant on seed yield.

3. Seed yield versus number of primary branches per plant

Both at genotypic and phenotypic level number of primary branches per plant had positive direct effect on seed yield. Rest of characters except 100 seed weight exhibited positive indirect effect on seed yield.

4. Seed yield versus plant height

Plant height at both genotypic and phenotypic level had moderate positive direct effect on seed yield per plant. However, the

positive indirect effect via days to 50 per cent flowering, days to maturity were of low magnitude.

5. Seed yield versus number of pods per plant

Number of pods both at genotypic and phenotypic level had high positive direct effect on seed yield. However, the positive indirect effect through days to 50 per cent flowering, days to maturity, number of primary branches per plant, plant height, number of seeds per pods and harvest index were of moderate magnitude. 100-seed weight had negative indirect effect on yield.

6. Seed yield versus number of seeds per pods

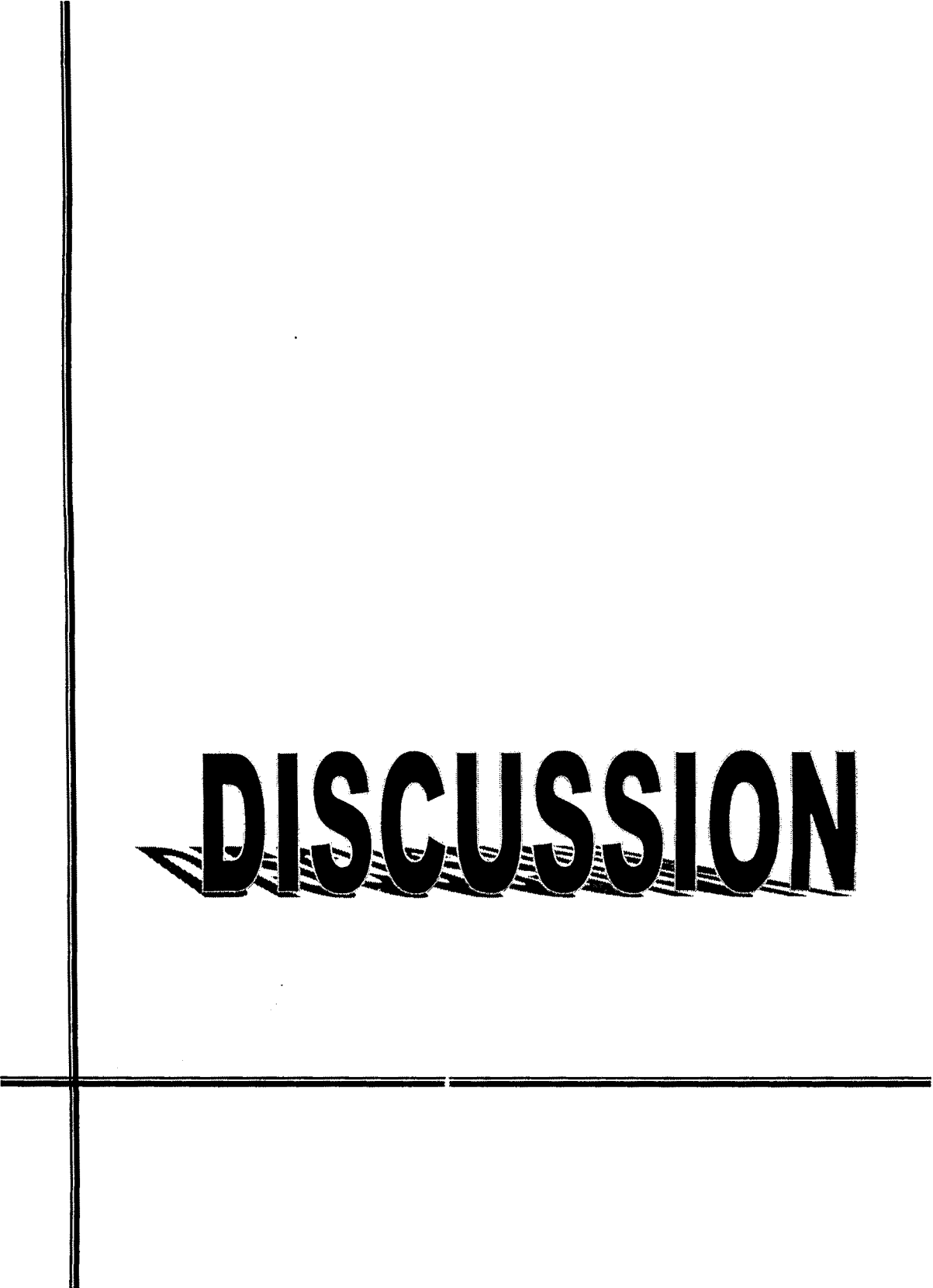
Number of seeds per pod both at genotypic and phenotypic level had low positive direct effect on seed yield. However, positive indirect effect via number of primary branches, number of pods per plant and days to 50 per cent flowering were of low magnitude.

7. 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 days to maturity, plant height and harvest index have low positive indirect effect at genotypic level on seed yield. Rest of the character exhibited negative indirect effect on seed yield.

8. Seed yield versus harvest index

Harvest index both at genotypic and phenotypic level had moderately high positive direct effect on seed yield. However number of primary branches per plant, number of pods per plant and 100-seed weight had positive indirect effect on seed yield.



DISCUSSION

Chapter V

DISCUSSION

Chickpea (*Cicer arietinum* L.) is the premier important pulse crop in our country. The protein content in chickpea varies from 21-25 per cent. Yield is a complex character and can not 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 improvement in chickpea. A broad spectrum of variability in a population is a prerequisite for improvement in any crop.

The present investigation was undertaken with objectives to evaluate the variation among the material, consisted of 96 germplasm lines with 3 checks of chickpea for 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 association 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 effect 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. The mean performance indicated that the germplasm line G-20, LDG-1, B-24, G-84, G-80, LHP-1, GTP-11 and G-38 exhibited early days to 50 per cent flowering and days to maturity. The line B-69, G-41, B-34, L-108 showed dwarf plant height (30.2 to 33.43 cm). Maximum pods per plant were observed in B-31 followed by B-34, B-59, B-56 and B-46. G-87, G-29, G-91, B-636 and BCP-36 showed maximum number of seeds per pod. Germplasm lines G-95 followed by G-80, B-637, G-94,

G-38, BCP-17 and G-41 recorded highest test weight. The lines BCP-73, B-621, G-87, B-59 and G-41 exhibited high harvest index. The character seed yield per plant was found highest in B-59 followed by BCP-17, B-30, G-41 and G-42. While the germplasm lines BCP-73, G-88, G-87, L-2 showed maximum primary branches per plant.

In chickpea significant amount of genetic variability for yield contributing character was also reported by Singh *et al.* (1990) except days to flowering and days to maturity. Nawab (2002) and Qureshi *et al.* (2004) reported significant amount of genotypic variability for plant height (cm), number of pods per plant, number seeds per plant, 100 seed weight and seed yield per plant (g).

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, heritability and genetic advance has been given in Table 4.

5.2.1 Variance components

Equal genotypic and phenotypic variances observed for days to maturity, number of primary branches per plant, plant height, 100-seed weight and seed yield per plant indicated variability remains unaltered by environmental condition and effective selection can be made for this trait. Whereas differences found between genotypic and phenotypic variances for days to 50 per cent flowering, number of pods per plant and harvest index revealed that variability changes under different environmental condition.

Highest genotypic and phenotypic coefficient of variance was observed for number of pods per plant followed by seed yield per plant, 100-seed weight and number of primary branches per plant. It indicates that there is little influence of environment on the expression of character and effective selection can be made. In chickpea high genotypic and phenotypic coefficient of variances for seed yield and yield contributing characters has been reported by Adhikari and Pandey (1982), Rao *et al.* (1994), Sable *et al.* (2002), Nawab (2002) and Ozcelik *et al.* (2004).

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 all the characters exhibited high heritability estimates and indicates that these characters least influenced by environmental effects and selection of such character would be rewarding. These results were in conformity with the previous results of Singh (1988), Sharma *et al.* (1990), Wahid and Ahmad (1999) and Burli *et al.* (2004).

High genetic advance coupled with high heritability noted for number of pods per plant followed by harvest index and days to 50

per cent flowering indicates that heritability is due to additive gene action and direct selection may be effective. High estimates of heritability and genetic advance were reported by Mishra *et al.*, (1988), Jahagirdar *et al.* (1990).

Remaining characters accompanied with high heritability coupled with low genetic advance is indicative of non-additive gene action. The high heritability is being exhibited due to favourable influence of environments and selection for this trait may not be rewarding.

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, 100-seed weight, number of primary branches per plant, plant height and harvest index it means that there is strong association between characters genetically.

Days to 50 per cent flowering had positive and significant correlation with days to maturity, primary branches per plant and harvest index. Whereas, days to maturity showed significant positive correlation with primary branches per plant, plant height, harvest index negative correlation with seed yield per plant at both genotypic and phenotypic level.

The yield contributing characters viz., number of pods per plant and number of primary branches per plant were positively correlated at both genotypic and phenotypic level with number of seeds per pod. However, plant height with 100 seed weight, indicates strong association between characters genetically. It is evident from most of the reports that positive and significant correlations exist between yield and yield contributing characters Dasgupta *et al.* (1992) reported that significant positive correlation of seed yield with number of pods per plant, 100 seed weight and seeds per pod. Similar results were also reported by Khorgade (1988), Zade and Wanjari (1988), Jivani and Yadvendra (1988), Ozdemir (1996), Arora *et al.* (2003) and Arshad *et al.* (2004).

However, negative and significant correlation both at genotypic and phenotypic levels exhibited between days to 50 per cent flowering and seed yield, number of primary branches with 100 seed weight and number of pods per plant with 100 seed weight, indicates correlation between these characters but both vary in opposite direction.

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 yield contributing characters 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 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, 100-seed weight and harvest

index had high significant positive direct effect on seed yield at both genotypic and phenotypic level shown in Fig. 1 and Fig. 2. It indicates true relationship between them and direct selection for this trait will be effective for improvement in yield.

Similarly medium positive direct effect on seed yield was exhibited by number of primary branches per plant, plant height and number of seeds per pod. These results are in conformity with the previous results of Singh *et al.* (1990), Khedar and Maloo (1999) and Khedar *et al.* (1999)

The number of primary branches per plant via days to maturity and number of pods per plant. Plant height via days to maturity and 100-seed weight, number of pods per plant via primary branches per plant and number of seeds per pods, 100-seed weight via days to maturity, plant height and harvest index showed positive indirect effect on seed yield indicates that indirect selection through the trait will be effective in yield improvement. Similar results also reported by Ozdemir (1996), Manjare *et al.* (1997) and Jeena *et al.* (2000).

The value of residual effect (0.6146) through it is moderate indicating that besides the character studies were important yield contributing characters both at phenotypic and genotypic level.

5.5 Utilization of information for improvement of chickpea crop.

The results obtained through assessment of variability, correlation and path analysis for 9 morphological characters in 99 germplasm line of chickpea. The following implications in breeding are suggested. In this investigation desirable variability has been observed. There was less environment effects on characters, which clear from

various parameters of variability. Similarly heritability (broad sense) was also more for all characters.

High genetic advance coupled with high heritability noted for number of pods per plant followed by harvest index indicates that the heritability is due to additive gene action therefore direct selection may be effective. In correlation studies seed yield per plant was highly significant and positively correlated with number of pods per plant, 100-seed weight, number of primary branches per plant, harvest index and plant height, indicated strong association between characters genetically. Path analysis of yield and yield contributing characters showed that the number of pods per plant, 100-seed weight and harvest index had high significant positive direct effect on seed yield at both genotypic and phenotypic level. Selection for germplasm lines having high mean performance for number of pods plant, 100-seed weight, number of primary branches per plant and harvest index will improve the chickpea yield.

The germplasm lines B-59, BCP-17, B-30, G-41 may be used as parents in future for improving seed yield.

SUMMARY AND CONCLUSION

Chapter VI

SUMMARY AND CONCLUSION

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 chickpea (*Cicer arietinum* L.) The material used for present study comprised ninety six germplasm lines and three checks viz., Annegiri, BDN-9-3 and BDN-797. The material was raised in randomized block design with three replications during rabi season of 2005-2006.

Observations were recorded on 9 biometrical characters viz., days to 50 per cent flowering, days to maturity, number of primary branches per plant, plant height, number of pods per plant, number of seeds per pod, 100-seed weight, harvest index and seed yield per plant.

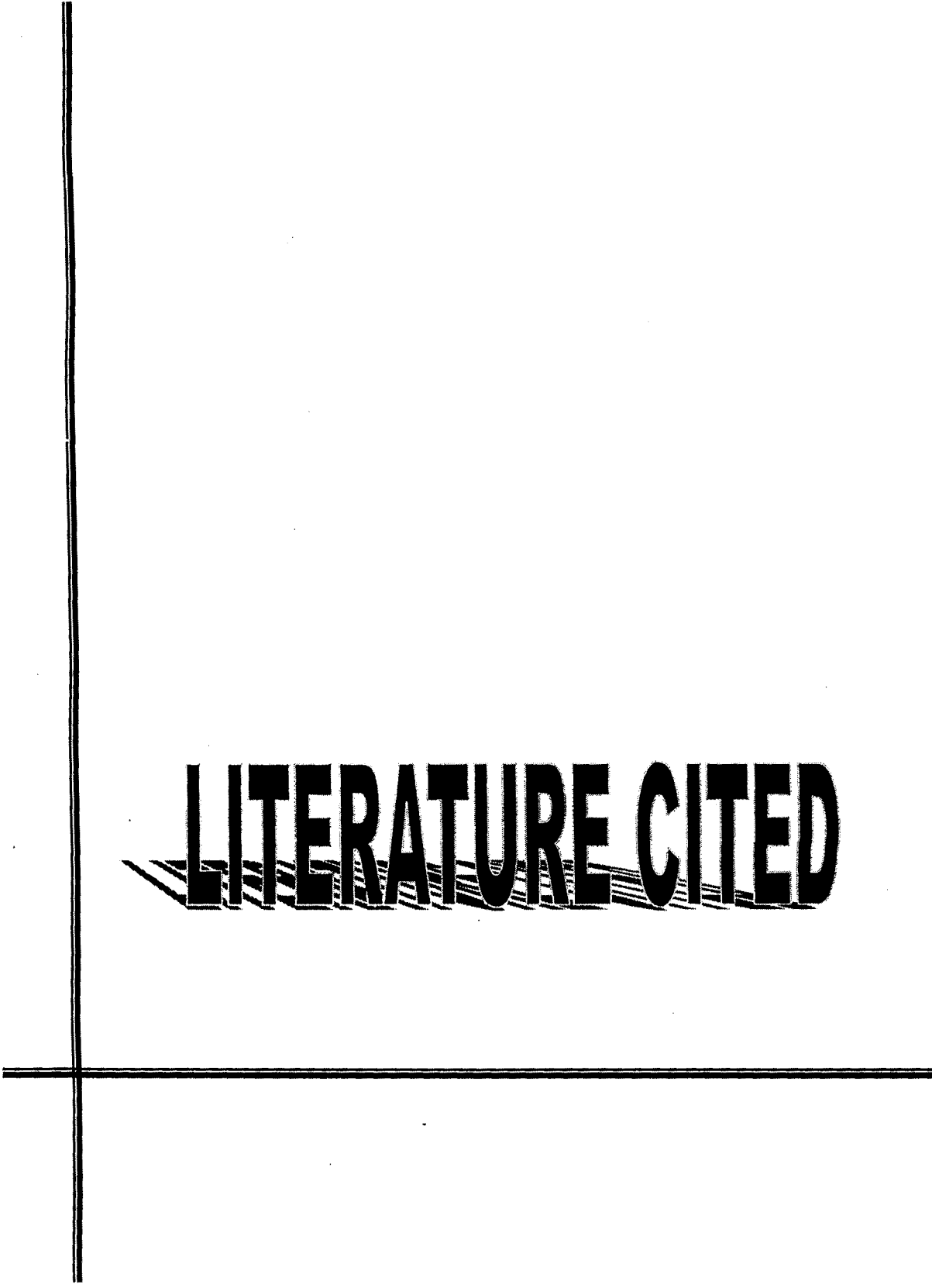
The data was analysed and results obtained are summarized below.

- 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 line B-59 (18.81), BCP-17 (16.37), B-30 (16.26) and G-41 (16.01) whereas maximum number of pods per plant observed in line B-31 (94.00) followed by B-34 (89.13), B-59 (82.43), B-56 (78.86). Maximum 100-seed weight was observed in G-95 (40.56) followed by G-80 (36.11), B-637 (35.70) and G-94 (35.26). Number of seeds

per pod was more in line G-87, G-29 and G-91. High genotypic and phenotypic coefficient of variation was observed for number of pods per plant (31.80, 32.25) seed yield per plant (30.04, 30.08), 100-seed weight (28.18, 28.38) and number of primary branches (21.45, 22.36). Equal magnitude of GCV and PCV was observed for all characters.

- 6.3 Broad sense heritability estimates were high for all yield and yield contributing characters.
- 6.4 High genetic advance coupled with high heritability estimates were noted for number of pods per plant, harvest index and days to 50 per cent flowering. The character seed yield per plant showed high heritability but low genetic advance that indicates predominant role of non-additive gene action in inheritance of seed yield
- 6.5 Positive and highly significant association between yield and yield contributing characters viz., number of pods per plant, 100-seed weight, number of primary branches per plant, plant height and harvest index both at phenotypic and genotypic level. This study indicates that these characters should be given maximum weightage while making selection in improving the yield in chickpea.
- 6.6 Path analysis at genotypic and phenotypic levels revealed that number of pods per plant, 100 seed weight and harvest index had significant positive direct effects on seed yield both at genotypic and phenotypic levels indicates true relationship between them. The indirect positive effect both

at genotypic and phenotypic level was recorded for number of primary branches per plant, number of pods per plant and 100-seed weight via days to maturity and number of pods per plant, plant height via days to maturity and 100-seed weight, number of pods per plant via primary branches and seeds per pod indicates indirect selection through these traits will be effective in yield improvement.



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* Original not seen