EVALUATION OF EARLY GENOTYPES OF PIGEON PEA
(*Cajanus cajan* (L.) Millsp.)

By

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MAY, 2016

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A thesis submitted to

DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH, DAPOLI

(Agricultural University)
Dist. Ratnagiri (Maharashtra), India

In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
(AGRICULTURE)

in

GENETICS AND PLANT BREEDING

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CERTIFICATE

This is to certify that the thesis entitled **"EVALUATION OF EARLY GENOTYPES OF PIGEON PEA (*Cajanus cajan* (L.) Millsp.)"** submitted to Faculty of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra State in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **GENETICS AND PLANT BREEDING** embodies the results of piece of *bona fide* research work carried out by **Ms. BAL CHINMAYEE PRASAD (Regd. No. 2351)** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma and published in other form. All the assistance and help received during the course of investigation and the sources of literature have been duly acknowledged by her.

Place : Dapoli
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Place: Dapoli

Date: ***(Bal C.P.)***

DEPARTMENT OF AGRIL. BOTANY,
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ABSTRACT

Present investigation was undertaken to study evaluation of population for yield components in pigeon pea (*Cajanus cajan* (L.) Millsp.). An experiment was conducted with thirty four genotypes in *Rabi* season in year 2014-15 at Botany Farm, Department of Agricultural Botany, College of Agriculture, Dapoli. Observations were recorded for thirteen quantitative characters *viz*., plant height, days to initiation of flowering, days to 50 per cent flowering, days to maturity, number of primary branches per plant, number of pods per plant, pod length, pod breadth, number of seeds per pod, hundred seed weight, straw yield per plant, harvest index and grain yield per plant.

All the characters studied exhibited significant variability among all population. However, grain yield per plant, number of pods per plant, harvest index, hundred seed weight and number of primary branches per plant showed comparatively higher estimates of genotypic and phenotypic coefficients of variation indicating high level of variability and ample scope for effective improvement. The

higher estimates of heritability coupled with high genetic advance as per cent of mean indicated additive gene action for above characters. Correlation studies revealed strong positive association of seed yield per plant with harvest index, pod length and plant height, number of seeds per pod, pod breadth and number of pods per plant both at phenotypic and genotypic levels, which suggested to pay attention to these characters alongwith yield. The path analysis studies indicated that the characters plant height, days to initiation of flowering, days to maturity, number of pods per plant, pod length, hundred seed weight, straw yield per plant and harvest index had direct bearing on seed yield per plant in pigeon pea population under study.

The genotypes ICPL 20329, ICPL 20326, ICPL 20328, ICPL 11318, ICPL 20325, ICPL 11242 and ICPL 20333 are observed as promising genotypes in the studied population as these genotypes performed well for most of the important quantitative traits, need to be tested in adaptive trials for incorporating in stability analysis and coming programme as well.

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CHAPTER I

INTRODUCTION

India is the largest producer of pulses in the world, both in quantity and variety. Pulses are the primary source of protein for the poor and the vegetarians who constitute in majority of Indian population. The traditional cropping pattern always included a pulse crop either as a mixed crop or in rotation, while the commercialization of agriculture has encouraged the practice of sole cropping. Cereal shortage in the mid-sixties and the green revolution accompanied with changes in the infrastructure and incentives including input supplies and price support systems in favour of major cereals altered the traditional cropping pattern against pulses.

Grain legumes occupy unique position in world agriculture by virtue of their high protein content and their capacity of fixing atmospheric nitrogen. For many of the developing countries, pulses constitute the only concentrated source of dietary protein. As regards to developed countries, grain legumes are an important source of protein being animal feeds of good biological value. Indians, as they prefer vegetarian food, pulses are the main source of protein.

Major portion of the country is under rainfed condition and the pulses have been adjusted well in different mixed or intercropping crop rotations. Having inbuilt capacity to utilize the atmospheric nitrogen, they help in increasing the soil fertility. India is the largest producer of pulses contributing to 25 per cent of total world pulse production and the largest producer of pigeon pea contributing 75-80 per cent of world pigeon pea production. Pigeon pea is grown on 36.3 Lakh ha. area in India, with total production of 27.6 lakh tons and productivity of 760.33 kg ha^{-1}. In Maharashtra, pigeon pea is grown on 11.75 Lakh ha area and production of 10.83 lakh tons (Anonymous, 2014). Madhya Pradesh, Maharashtra, Uttar Pradesh, Andhra Pradesh, Karnataka and Rajasthan are the major states growing pulses in India. These six states contribute 80 per cent of total pulse production and area (Anonymous, 2014).

The centre of origin of pigeon pea is the eastern part of peninsular India, including the state of Odisha, where the closest wild relatives (*Cajanus cajanifolia*) occur in the tropical deciduous woodlands and then travelled to East and West Africa. There it was first encountered by Europeans, named as congo pea. By means of slave trade, it came to the American continent probably in the 17^{th} century. In India, pigeon pea has spread to Uttar Pradesh, Madhya Pradesh, Bihar, Maharashtra, Gujarat, Andhra Pradesh, Tamil Nadu and Karnataka states.

Pigeon pea (*Cajanus cajan* (L.) Millisp.) is important legume crop of rainfed agriculture in the semiarid tropics. The Indian subcontinent, eastern Africa and Central America, in that order are the world's three main pigeon pea producing regions. Pigeon pea are cultivated in more than 25 tropical and subtropical countries either as sole crop or intermixed with cereals.

Pigeon pea is also known as 'arhar, tur or redgram' with chromosome number i.e. 2n=2x=22. It belongs to family 'leguminosae'. The genus *Cajanus* belongs to the sub tribe 'cajanae' under 'phaseolae' with subfamily 'Papilionaceae'.

Pigeon pea is both a food crop (dried peas, flour or green vegetable peas) and a forage or cover crop. Pigeon pea plays important role in fixing atmospheric nitrogen symbiotically with *Rhizobium* spp., which enriching the soil with nitrogen, thereby improving it's fertility and physio-chemical properties. It has ability to fix nitrogen (Peoples *et al*. 1995) and produces more nitrogen per unit area from plant biomass than any other legume. The crop provides yield stability particularly in drought prone areas where less drought tolerant cereals often fails. Its deep root system allows for optimum moisture and nutrient utilization.

Pigeon pea offers multiple benefits-protein rich seed (21% protein), fuel, fodder and erosion control. It is largely consumed in the form of split pulse as 'dal' while its tender green pods constitute a very favourite vegetable in some parts. The outer integuments of the seed together with part of kernel provides a valuable feed for the milch cattle. The stalks are utilized for various purposes, such as roofing, walling, sides of carts and basket making and burning as fuel.

Pigeon pea is cultivated mainly as kharif crop. It is cultivated both as a sole crop and mixed crop. In mixed cropping system, pigeon pea is sown with bajara (*Pennisetum glaucum*), sorghum (*Sorghum bicolor*) and cotton (*Gossypium* spp.). Generally one or two lines of pigeon pea along with three to six lines of main crop are sown. In Konkan, rainfall is restricted to four months only. Considering the average crop duration of pigeon pea, it is very difficult to grow this crop. Moreover the crop is grown on bunds of rice crop.

Traditional varieties of pigeon pea are long duration types taking more than ten months to mature. They have little role to play in intensive agriculture as they cannot be fitted in multiple cropping system because of their longer duration. In order to make pigeon pea more profitable, particularly in rainfed areas in Maharashtra, it is essential to develop high yielding, early maturing and relatively short statured types, which could respond to better management and can be suitably fitted in newly developed multiple and intercropping patterns (Ramanujan and Singh, 1981). Under the All India Co-ordinated Pulse Improvement Programme, efforts have been made for generating variability particularly in early maturing group which can be exploited for developing suitable varieties for the new cropping system.

Among grain legumes, pigeon pea is an exception with tendency towards a high percentage of outcrossing and it can be classified as often cross-pollinated crop. A narrow genetic base and limited efforts to generate a wide genetic variability and the lack of planned handling of the segregating populations have largely been responsible for less grain yield. Since the choice of parents plays a key role in any breeding program, knowledge of genetic variability of genotypes are needed. Depending upon the need and interest, the variability could be generated by identifying the more diverse parents existing in the material.

Use of advanced, novel techniques of plant improvement will no doubt be inevitable for the twenty first century, however traditional plant breeding tools such as character associations studies will also play an important role in plant breeding for identifying superior types by indirect selection programme.

In any crop improvement programme, study of amount of variability present in crop species is a pre-requisite as it provides basis for effective selection and also for selecting desirable genotypes towards crop improvement. However, sometimes the variability present in the population does not satisfy the objective of the breeder.

Hence, breeder needs to generate the variability through hybridization and recombination, which could be exploited in advance segregating generations. A clear understanding of variability in various quantitative characters existing in the breeding material helps plant breeder for selecting superior genotypes on the basis of different genetic parameters such as genotypic variation, heritability, genetic gain etc. to understand the nature and magnitude of variation for the available plant characters. Hence, it is necessary to estimate the relative amount of genetic and non-genetic variability exhibited by the traits under the study. This is achieved by partitioning total variance into genotypic, phenotypic and environmental variances. Estimation of genetic variability by suitable parameters of variation, heritability estimates and expected genetic advance for the individual characters and by working out correlation between these traits with the hope that some components, which are less susceptible to environmental variations may provide more efficient basis of selection.

Yield is not independent character, It depends on various characters and environmental conditions that exist during crop growth. Thus, selection pressure given only on yield misleads many times. It is, therefore, essential to study association of characters among themselves and with yield of crop. This can be done by character association studies under a set of environment conditions. Genotypic correlation provides a measure of genotypic association between two characters and helps to identify more useful relationship between characters. Indirect associations become complex and important when a number of variables are included in the study of correlation. In such cases more refined technique as path coefficient analysis helps to find out direct and indirect causes of character association. Every component character has a direct effect on yield. The effects of an independent one on dependent traits via other independent trait are known as indirect effects. If correlation is due to direct effect, it reflects true relationship and selection is practiced for such a character for improving the yield. In case, if the effect is indirect through another component trait, the breeder has to select the latter trait through which indirect effect is exerted.

Considering the importance of above mentioned points the present investigation entitled "Evaluation of Early Genotypes of Pigeon Pea (*Cajanus cajan* (L.) Millsp.)" was undertaken with following objectives

1. To study the range of genetic variability present in yield and yield components
2. To find out association between yield and yield contributing characters
3. To identify promising cultures, in pigeon pea

CHAPTER II

REVIEW OF LITERATURE

The purpose of the present study was to know the genetic variability and correlation studies in pigeon pea. Hence in the present review of literature an attempt has been made to review available information on the extent of genetic variability and correlation studies. The recent literature available on the aspects has been reviewed here.

GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE

Rathanaswamy *et al.* (1973) studied twenty one varieties of red gram for their genetic variability. All the characters had wide phenotypic variation. Among the characters studied, clusters per plant, seeds per plant, pods per plant, weight of pods, branches per plant, plant height and days to flower were found to have high genetic co-efficient of variation. Plant height, branches per plant, clusters per plant, pods per plant, days to flower had high heritability and similar genetic gain and as such these characters might be considered as reliable for exercising selection in red gram.

Chandra *et al.* (1975) reported wide range of gross variation in all the traits studied except for pod length and number of seeds per pod where it was low in 23 varieties of pigeon pea. Highest value of genotypic variance was expressed by number of days to maturity. The phenotypic variance was different from the genotypic variance indicating that the influence of environmental factors on this trait was striking. Number of days to flowering, plant height, and yield per plant were the other characters in order which gave high genotypic variance. The difference between genotypic and phenotypic variance for number of days to flowering was very little indicating that the influence of environmental factors on this trait was less. Number of seeds per pod exhibited lowest genotypic variance. In general, the phenotypic variance was higher than genotypic variance in almost all the character.

Shoram (1983) evaluated one hundred genotypes of pigeon pea for 8 characters under five environments in two years. 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 was 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 various environments. Therefore, it was suggested that, there was ample scope for selection with respect to these character in pigeon pea and mass selection could be quite effective.

Balyan and Sudhakar (1985) studied the nature of genetic variability different traits to gain yield, in genotypes of early maturity group in pigeon pea. Out of eight traits studied, five traits namely, primary branches, secondary branches, pods per plant, 100 seed weight and yield per plot exhibited high estimates of phenotypic and genotypic coefficients of variation.

Bhongale and Raut (1987) noticed the highest GCV for yield per plant followed by pod number in 12 different characters. Days to 50 per cent flowering, days to maturity and 100 seed weight had high variability coupled with high genetic advance.

Patil *et al.* (1989) estimated genetic parameters in pigeon pea. A study conducted with twenty-two genotypes of pigeon pea indicated that GCV was maximum in case of number of branches per plant followed by number of pods per plant and number of seeds per pod. It was lowest for number of days to flower. High heritability coupled with high genetic advance was found for plant height, number of branches per plant, number of pods per plant and 100 seed weight, indicating the usefulness of these traits in selection.

Khapre and Nerker (1992) studied genetic variability in pigeon pea under different cropping system. The genetic variability and nature of association for traits was studied in 7X7 half diallele of pigeon pea under three different cropping systems. The genetic variability was found to be the highest for grain yield per plant under intercrop sorghum and the lowest for days to maturity under sole crop.

Khapre *et al.* (1993) evaluated genetic variability in 32 developed strains of pigeon pea for ten traits and reported high values of phenotypic and genotypic coefficient of variation for plant height, pods per plant, grain yield per plant and harvest index.

Aher *et al.* (1998) noted wide genetic variability for plant height, plant spread, number of secondary branches per plant and days to 50 per cent flowering in 64 genotypes of pigeon pea for 10 traits and which had high heritability accompanied with high genetic advance was observed for number of secondary and primary branches per plant, followed by grain yield per plant, days to 50 per cent flowering, plant spread and plant height.

Venkateswarlu (2001) studied genetic variability in twenty eight genotypes of pigeon pea. Maximum variability was observed 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 secondary's 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.

Dodake *et al.* (2009) indicated the wide range of variability in all the characters of pigeon pea genotypes. The GCV, PCV, heritability estimates revealed that the variability in plant spread, 100 grain weight, days to 50 per cent flowering, days to maturity and seed yield per plant were heritable and additive type of gene action was operative for these characters.

Saroj *et al*. (2013) evaluated genetic variability for seventy genotypes of pigeon pea. The highest GCV was recorded for number of secondary branches/plant followed by pods/plant. Heritability in broad sense is maximum for seeds/pod and minimum for days to 50 per cent flowering. High genetic advance were observed for number of primary branches/plant, secondary branches/plant, 100 seed weight, grain yield/plant, pods/plant, plant height, days to 50 per cent flowering indicating the prevalence of additive gene action for inheritance of these traits.

Vijayalakshmi *et. al*. (2013) studied variability and heritability in pigeon pea crop. The experimental material consisted of 84 germplasm lines of pigeon pea procured from ICRISAT, Hyderabad. The 84 pigeon pea lines, three checks were evaluated for genetic and phenotypic variation and concluded, genotypes showed significant variability for all traits. The phenotypic variance was high for all traits compared to genotypic variance. Heritability (broad sense) was generally high for all traits with exception of days of pod initiation (0.0084).

Sharma *et al.* (2014) evaluated twenty varieties of pigeon pea and a wide range of variation was found for almost all these traits under study. Phenotypic variance was higher than the genotypic variance for traits *viz.*; plant height, days to flower, days to maturity, number of branches/plant, number of fruiting branches/ plant and seed yield/plant. High estimates of heritability along with high genetic advance was recorded for number of seeds/pod, number of pods/plant, plant height, days to flowering and days to maturity.

Rao and Rao (2015) revealed significant difference among fifty four germplasm lines of pigeon pea for all characters studied. The magnitude of PCV and GCV was moderate to high for pods per plant, seed yield and primary branches per plant. High heritability was recorded for days to 50 per cent flowering, seed yield per plant, number of pods per plant, test weight and plant height. High heritability combined with high genetic advance was recorded for number of pods per plant and seed yield per plant indicating that these characters are controlled by additive gene effect and phenotypic selection of these characters would be effective for further breeding purpose.

CORRELATION STUDIES

Balyan and Sudhakar (1985) studied the nature of genetic variability, character association and direct and indirect contributions of different traits to grain yield in genotypes of early maturity groups in pigeon pea. Plant height, days to maturity, primary branches, secondary branches, pods per plant, seeds per pod and 100 seed weight showed positive and significant association with yield per plot.

Bhongale and Raut (1987) evaluated eighty genotypes of pigeon pea for 12 different characters and found that grain yield was significantly correlated with important yield contributing traits *viz.*; height, branches per plant, pod number, pod weight and seed per pod. These components were positively correlated with each other and therefore, the selection based on these characters could be effective in breeding for higher yield in arhar.

Patil *et al.* (1989) indicated that seed yield was positively associated with number of branches per plant, number of pods per plant and 100 seed weight in twenty-two genotypes of pigeon pea.

Khapre and Nerkar (1992) studied character association in pigeon pea under different cropping system. The nature of association for 14 traits was studied in 7X7 half diallel of pigeon pea under three different cropping systems. The total biomass per plant had shown highest significant and positive association with grain yield under all the three cropping systems. The magnitude of association was cropping system specific. The studies revealed that the traits like days to maturity, plant height, number of pods per plant and total biomass per plant had shown greater variation and significant positive association with grain yield in all the cropping systems need greater concentration for improvement for pigeon pea.

Salunke *et al*. (1995) studied correlation in 54 genotypes of pigeon pea (*C. cajan*), grown at Rahuri during kharif 1993-94. Seed yield/plant was significantly and positively associated with pods/plant, primary and secondary branches, plant spread, plant height, and hundred seed weight. Seed yield/plant had a strong negative association with seeds/pod. The yield components days to 50 per cent flowering, days to maturity, plant height, plant spread, primary branches, secondary branches and 100 seed weight were positively and significantly associated with each other. Pods/plant was positively and significantly associated with primary branches, secondary branches, plant height, plant spread.

Gowda *et al.* (1996) noted that grain yield had positive and significant association with number of pods per plant, plant height, number of seeds per pod and hundred seed weight both at phenotypic and genotypic levels. Thus for improving grain yield, characters such as number of pods per plant, hundred seed weight, number of seeds per pods, pod length, plant height and days to 50 per cent flowering should be given due importance.

Paul *et al.* (1996) reported that phenotypic yield was positively and significantly correlated with number of pods per plant, dry matter at maturity and number of secondary branches in 28 diverse hybrids of pigeon pea, but at genotypic level the association was highest for dry matter at maturity.

Aher *et al.* (1998) evaluated 64 genotypes of pigeon pea for 10 traits. All the characters studied showed significant positive correlation with grain yield and also with each other.

Sarsamkar *et al.* (2007) noticed positive and significant association between yield and yield contributing characters *viz.*, days to maturity, 100 seed weight and pods per plant in eight parents and twelve F_2's of pigeon pea genotypes. The study indicated that the days to maturity, 100 seed weight and number of pods per plant should be given maximum weightage while marking selections to improve the yield.

Dodake *et al.* (2009) noticed that the grain yield was positively and significantly correlated with days to 50 per cent flowering, plant spread and number of pods per plant in twenty one pigeon pea genotypes.

Sawant *et al.* (2009) studied the character association, path coefficient analysis and genetic diversity in fifty six genotypes of pigeon pea for 11 characters. The correlation studies revealed that the genotypic correlation coefficients were higher than corresponding phenotypic coefficients. Grain yield showed significant positive correlation with plant spread, number of secondary branches per plant, number of pods per plant and days to maturity.

Sodavadiya *et al.* (2009) reported that the seed yield per plant had significant and positive association with days to 50 per cent flowering, days to maturity, number of branches per plant, number of pods per plant and 100 seed weight at both genotypic as well as phenotypic levels. The characters like 100 seed weight, days to maturity and pod length exerted high direct effects on seed yield, while 100 seed weight and days to maturity also contributed indirectly towards seed yield per plant through most of the characters. Thus, based on present study days to maturity, number of pods per plant and 100 seed weight were emerged as the most important components of seed yield in pigeon pea.

Bhadru (2010) carried out an investigation in 55 white seed coated pigeon pea lines to understand the association among the yield components and their direct and indirect effects on the seed yield. The characters association studies indicated that number of pods, secondary branches and primary branches per plant and plant spread showed significantly positive correlation with seed yield at genotypic and phenotypic levels.

Kanade *et al.* (2010) evaluated forty genotypes of pigeon pea for correlation. The attribute days to 50 per cent flowering showed significantly positive correlation with 100-seed weight. Days to maturity showed significantly negative association with seed yield (-0.316), while it was significantly and positively correlated with number of primary branches.

Saroj *et al.* (2013) revealed that pods/plant, 100-seed weight, days to 50 per cent flowering, primary branches and secondary branches had maximum direct effect resulted significantly positive correlation with grain yield/plant. These traits can be used to improve the grain yield of pigeon pea.

Vijayalakshmi *et al.* (2013) studied 84 germplasm lines of pigeon pea procured from ICRISAT, Hyderabad. They evaluated 84 pigeon pea lines, three checks for genetic and phenotypic variation, character association among the grain yield & its component traits. The result revealed that the genotypic correlation of all traits were positively correlated with total yield except days of pod initiation, and also the phenotypic correlation of all traits were positively correlated with total yield, except days of pod initiation, pod length and 100 seed weight. The analysis of variance showed presence of highly significant differences among the all traits. The major advantages of phenotypic and genotypic correlation between yield and its contributing characters were basic and foremost important for plant selection. In this study total plant yield, number of seeds per plant and number of pods per plants have been identified as selection criteria for obtaining good parental lines in a pigeon pea breeding program.

Kumara *et al*. (2014) observed that correlation at the phenotypic level, the seed yield had shown the positive and significant association with the other component traits like number of pods per plant, secondary branches, 100 seed weight and days to 80 per cent maturity which reveals that selection based on these traits would ultimately improve the seed yield in advanced genotypes of pigeon pea.

Sharma *et al.* (2014) noted correlation in twenty varieties of pigeon pea. Correlation studies revealed that the seed yield was positively correlated with number of seeds per plant, plant height and 100 seed weight. Therefore, these traits would be suitable selection criteria for improvement of seed yield in pigeon pea.

PATH COEFFICIENT ANALYSIS

Wright (1921) and Dewey and Lu (1959) developed Path coefficient analysis, which is standardized partial regression analysis. Path coefficient analysis permits the partitioning of correlation coefficients into direct and indirect effects and gives a more realistic relationship of the characters and helps in identifying the effective components. The available literature on path analysis of seed yield with their component traits in pigeon pea and other related pulses are briefly reviewed.

Vange and Moses (2009) evaluated 29 new pigeon pea genotypes and a local variety for genetic path coefficient analysis among the yield and yield component traits. The path coefficient revealed that dry pod weight gave the highest direct effect on dry grain yield, followed by pod length and number of pods per plant. In this study dry pod weight, pod length and number of pods had been identified as selection criteria for obtaining good parental lines in a pigeon pea breeding program.

Chandirakala and Subbaraman (2010) revealed that 100 seed weight, days to maturity, days to 50 per cent flowering, pod length and seeds per pod had high positive direct effect on seed yield in path coefficient analysis. It was inferred that for improving seed yield in pigeon pea, due emphasis should be given on characters *viz*., branches per plant, clusters per plant, pods per plant, seeds per plant and 100 seed weight.

Sreelakshmi *et al.* (2010) studied variability, correlation, path analysis in drought tolerant genotypes of pigeon pea. Sufficient variability was observed in the drought tolerant pigeon pea genotypes for the traits under study. Most of the yield contributing characters showed significant positive correlation whereas, number of primary branches per plant showed significant negative correlation with seed yield. Days to maturity had maximum direct effect on seed yield followed by number of pods per plant and plant height and number of secondary branches which had negative direct effect on seed yield. Number of secondary branches per plant, number of pods per plant and days to maturity were identified as important yield components and hence, selection should be focused on these traits to improve yield in drought tolerant genotypes of pigeon pea.

Rao *et al.* (2013) studied path analysis in pigeon pea. The genotypic path analysis revealed that number of pods per plant had the high positive direct effect (0.901) on seed yield followed by harvest index (0.651), 100 seed weight (0.498), primary branches (0.412) and days to maturity (0.322), while remaining traits recorded low direct effect on seed yield. Days to flowering recorded negative direct effect on seed yield but indirect effects through plant height, numbers of pods per plant and test weight were positive. The plant height and seed per pod had negligible positive direct effect on seed yield. The indirect effects of all the characters under study via number of pods were observed to be high.

Saroj *et al*. (2013) reported path analysis in pigeon pea. Path coefficient analysis (genotypic and phenotypic) revealed that pods/plant, 100-seed weight, days to 50 per cent flowering, primary branches and secondary branches had maximum direct effect resulted significantly positive correlation with grain yield/plant. These traits can be used to improve the grain yield of pigeon pea.

Thanki and Sawargaonkar (2013) noticed that number of pods per plant, 100-seed weight and harvest index made maximum direct contribution towards seed yield per plant. The correlation of number of pods per plant and harvest index were also significant and positive which were reflected in path analysis as high direct effects. In addition to this, number of branches per plant and plant height contributed indirectly via number of pods per plant towards seed yield per plant.

Garje *et al*. (2014) revealed that number of pods per plant had maximum direct effect on seed yield followed by number of cluster per plant and number of secondary branches per plant in green gram.

CHAPTER III

MATERIAL AND METHODS

The information pertaining to the experimental details and analytical methodology followed during the present investigation entitled "Evaluation of Early Genotypes of Pigeon Pea (*Cajanus cajan* (L.) Millsp.)" has been presented below.

3.1 Experimental site

The present investigation was carried out at Botany Farm, Department of Agricultural Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra state during the November, 2014 to March, 2015.

Geographically, Dapoli is situated in the tropical region on the 17^0 45′ North latitude and 73^0 12′ East longitude having elevation of 250 meters above the mean sea level with warm and humid conditions throughout the year. The mean annual precipitation is 3500-4000 mm which is generally received during the month from June to October at the location. The soil of the experimental site was lateritic.

3.2 Experimental material

The material for the present study comprised of 34 genotypes. The 34 genotypes were collected from the ICRISAT, Hyderabad. The list of genotypes is given in Table 1

Table 1. List of genotypes

Sr. no.	Genotype	Sr. no.	Genotype
1	ICPL 11249	**18**	ICPL 20333
2	ICPL 11263	**19**	ICPL 20335
3	ICPL 20341	**20**	ICPL 20329
4	ICPL 11252	**21**	ICPL 20325
5	ICPL 11255	**22**	ICPL 20328
6	ICPL 20338	**23**	ICPL 20326
7	ICPL 20340	**24**	ICPL 12335
8	ICPL 20336	**25**	ICPL 12336
9	ICPL 11256	**26**	ICPL 12337
10	ICPL 11259	**27**	ICPL 12338
11	ICPL 11298	**28**	ICPL 12339
12	ICPL 11318	**29**	ICPL 88039
13	ICPL 11300	**30**	ICP 8863
14	ICPL 11285	**31**	ICPL 87119
15	ICPL 11242	**32**	ICP 7035
16	ICPL 11244	**33**	ICPH 2671
17	ICPL 11245	**34**	ICPH 2740

3.3 Methodology

3.3.1 Experimental details

The experiment was conducted in Randomized Block Design (RBD) with three replications during Rabi 2014-15 .The plot size was 1.5m X 3m and the seeds were sown at spacing of 30cm X 20cm.

3.3.2 Cultural practices

The experiment was conducted at the normal fertility level on lateritic loam soil. The preliminary tillage operations were carried out properly in order to bring the soil at fine tilth. The total fertilizer dose applied @ 25 kg N: 50 kg P_2O_5: 50 kg K_2O per hectare. The operation like thinning was done within 10 days after sowing so as to maintain one plant per hill. Other cultural practices were carried out as per the standard recommendations.

3.4 Observations recorded

3.4.1 Sampling of plants:

Five plants were selected at random in each genotype in each of the three replications for recording detailed observations.

3.4.2. Characters studied:

i. Plant height (cm)
ii. Days to initiation of flowering
iii. Days to 50 percent flowering
iv. Days to maturity
v. Number of primary branches per plant
vi. Number of pods per plant
vii. Pod length (cm.)
viii. Pod breadth (mm.)
ix. Number of seeds per pod
x. Hundred seed weight (g)
xi. Grain yield per plant (g)
xii. Straw yield per plant (g)
xiii. Harvest Index

3.4.3. Methods of recording observations:

The characters were studied on the individual plant basis. The procedure adopted in recording the observations on different characters is given below:

1. **Plant height (cm):**

Height was measured from the base to the tip of the main branch of plant and was recorded in centimeter.

2. **Days to initiation of flowering:**

The number of days for initiation of flowering was recorded from the date of sowing till initiation of flowering.

3. **Days to 50 percent flowering:**

Days to 50 per cent flowering were recorded as the number of days from sowing to the day when 50 per cent of the plants in a row showed flowering.

4. **Days to maturity:**

Days to maturity were recorded as the number of days from sowing to the day when more than 90 per cent of the plants in a row showed maturity.

5. **Number of primary branches per plant:**

Number of primary branches per plant was counted as the total number of primary branches on the main stem.

6. **Number of pods per plant:**

Number of pods per plant was counted as the total number of pods present on the plant at the time of harvest.

7. **Pod length (cm):**

Pod length was measured in cm from the base to the tip of the pod.

8. **Pod breadth (mm):**

Pod breadth was measured in mm in the centre of pod.

9. Number of seeds per pod:

Number of seeds was counted from each of the selected ten pods and mean of these pods were calculated as the number of seeds per pod.

10. Hundred seed weight (g):

Weight of the randomly selected hundred seeds was recorded in gram.

11. Grain yield per plant (g):

Grain yield per plant was recorded in gram as the weight of the total seeds per plant.

12. Straw yield per plant (g):

Randomly selected plants, after picking the pods were uprooted and dried in sunlight. Dried plants were weighed and average weight was recorded as straw yield in gram.

13. Harvest index:

The biological yield per plant was recorded and grain yield per plant was recorded, then the harvest index was calculated as:

$$H.I. = Y_{eco.} / Y_{bio.} \times 100$$

3.5 Statistical analysis

The data available on individual plant characters were subjected to the method of analysis of variance commonly applicable to the randomized block design (Panse and Sukhatme, 1985). The analysis of variance was done as given below.

3.5.1 Analysis of variance (ANOVA)

Source of variation	d.f.	SS	MSS	'F'
Replication	(r-1)	RSS	RMS	RMS/ EMS
Genotype	(g-1)	GSS	GMS	GMS/EMS
Error	(r-1)(g-1)	ESS	EMS	
Total	(rg-1)			

Where,

r = Number of replications

g = Number of genotypes

3.5.2 Estimation of statistical parameters

i) Mean

Mean value for each character was worked out by dividing the total by corresponding number of observations.

$$\overline{X} = \frac{\Sigma X_i}{n}$$

Where, $\overline{X}$ = Mean of the character

ΣX_i = Total of the character

n = Number of observation

ii) Range

The lowest and the highest value from the mean of each character were taken as the range of that character.

iii) Standard error of mean

$$SEm\pm = \sqrt{\sigma_e^2 / r}$$

Where, σ_e^2 = Error mean sum of squares

r = Number of replications

vi) Critical difference (CD at 5%)

CD between any two means

$CD =$ SEd × $t_{0.05}$(r-1) (g-1) d.f.

Where, SEd = Standard error of difference between any two means

g = Number of genotypes

r = Number of replications

d.f. = Degrees of freedom

t = Table 't' value at 5 per cent level for error d.f.

3.5.3 Estimation of genetic parameters

A) Estimation of variance

The environmental (σ_e^2), phenotypic (σ_p^2) and genotypic (σ_g^2) variances were sum of squares from ANOVA table calculated by utilizing the respective mean.

i) Environmental variance

$$\sigma_e^2 = EMS$$

ii) Genotypic variance

$$\sigma_g^2 = \frac{GMS - EMS}{r}$$

iii) Phenotypic variance

$$\sigma_p^2 = \sigma_g{}^2 + \sigma_e{}^2$$

Where, GMS = Genotypic mean sum of squares

EMS = Error mean sum of squares

r = Number of replications

B) Estimation of coefficient of variation

The genotypic and phenotypic coefficients of variations were calculated as per the formulae given by Burton and De Vane (1953).

i. Genotypic coefficient of variation (GCV)

$$GCV(\%) = \frac{\sqrt{\sigma_g^2}}{\overline{X}} \times 100$$

ii. Phenotypic coefficient of variation (PCV)

$$PCV(\%) = \frac{\sqrt{\sigma_p^{\ 2}}}{\overline{X}} \times 100$$

Where, $\sigma_g^{\ 2}$ = Genotypic variance

$\sigma_p^{\ 2}$ = Phenotypic variance

$\overline{X}$ = Mean of the characters

C) Estimation of broad sense heritability (h^2bs)

Heritability in broad sense estimated for various characters by the formulae suggested by Lush (1949).

$$h^2bs(\%) = \frac{\sigma_g^{\ 2}}{\sigma_p^{\ 2}} \times 100$$

Where, $\sigma_g^{\ 2}$ = Genotypic variance

$\sigma_p^{\ 2}$ = Phenotypic variance

D) Estimation of genetic advance (GA)

The genetic advance was calculated in per cent by the formula suggested by Johnson et al. (1955).

a) Genetic advance

$$GA = \frac{\sigma_g^2}{\sigma_p^2} \times \sigma_p \times k$$

b) GA as percentage of mean

$$GAM = \frac{GA}{\overline{X}} \times 100$$

Where, σ_p^2 = Phenotypic variance

σ_g^2 = Genotypic variance

σ_p = Phenotypic standard deviation

k = Selection differential at 5 per cent selection intensity (2.06)

$\overline{X}$ = Mean of the character

3.6 Estimation of correlation coefficient

Analysis of co-variance was carried out by taking two characters at a time and plot error was used as environmental co-variance. The phenotypic and genotypic co-variances were derived as detailed below.

ANCOVA for phenotypic and genotypic co-variance

Source	d.f.	Mean products
Replication	(r-1)	-
Treatments	(t-1)	GMP
Error	(r-1) (t-1)	EMP
Total	(rt-1)	-

Where, r = Number of replications

t = Number of treatments

GMP = Genotypic mean sum of products

EMP = Error mean sum of products

The genotypic and phenotypic co-variances were worked out as per the formulae given by Singh and Chaudhary (1977).

Environmental co-variance = $\left(C_o V_e x_1 \ x_2\right) = EMP$

Genotypic co-variance = $\left(C_o V_g x_1 x_2\right) = \dfrac{GMP - EMP}{r}$

Phenotypic co-variance = $\left(C_o V_p x_1 x_2\right) = \left(C_o V_e x_1 x_2\right) + \left(C_o V_g x_1 x_2\right)$

The appropriate variances and co-variances were used for calculating phenotypic and genotypic correlation coefficients (Johnson et al., 1955).

a) Phenotypic correlation coefficients (rp) were derived as

$$rpx_1 x_2 = \frac{C_o V_p x_1 x_2}{\sqrt{(\sigma^2_{p1})(\sigma^2_{p2})}}$$

Where, rpx_1x_2 = Phenotypic correlation between character x_1 and x_2

$C_o V_p x_1 x_2$ =Phenotypic co-variance between character x_1 and x_2

σ^2_{p1} and σ^2_{p2} = Phenotypic variance of character x_1 and x_2, respectively

b) Genotypic correlation coefficients (rg) were derived as

$$rgx_1 x_2 = \frac{C_o V_g x_1 x_2}{\sqrt{\left(\sigma^2_{g1}\right)\left(\sigma^2_{g2}\right)}}$$

Where, $rgx_1 x_2$ = Genotypic correlation between character x_1 and x_2

$C_o V_g x_1 x_2$ = Genotypic co-variance between character x_1 and x_2

σ^2_{g1} and σ^2_{g2} = Genotypic variance of character x_1 and x_2 respectively

The significance of phenotypic and genotypic correlation coefficients were tested by using 't' test.

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

Where, r = Correlation coefficients

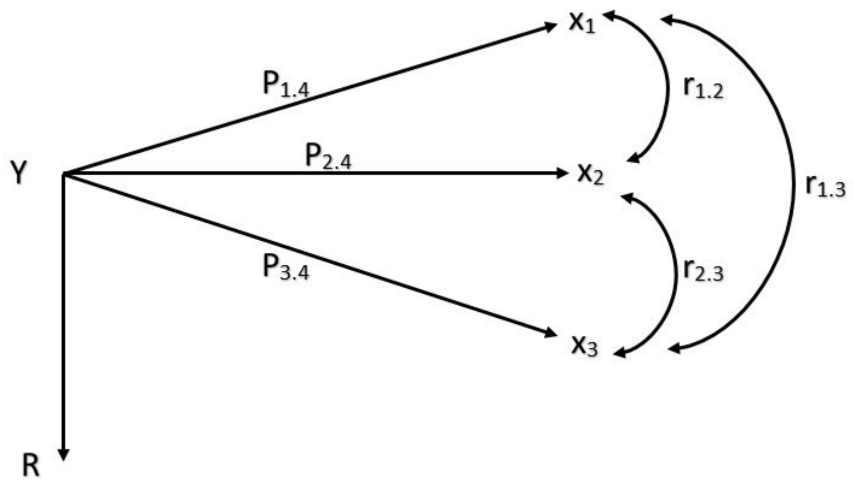
n = Total number of observations

The calculated 't' value is tested with table 't' value for respective (n-2) degrees of freedom for significance.

3.7 Path coefficient analysis

To establish a cause and effect relationship, the genotypic and phenotypic correlation coefficients were partitioned in direct and indirect effect by path analysis as suggested by Dewey and Lu (1959). The first step in path analysis is to prepare a path diagram based on cause and effect relationship.

The concept behind this is that yield is the function of various components like x_1, x_2, x_3 then these components show following type of association with one another.



From this figure, it is obvious that yield is the result of x_1, x_2 and x_3 and some other undefined factors designated by 'R'. The double arrowed lines indicate mutual association as measured by correlation coefficients and the single arrowed line represented direct influence as measured by path coefficients Pij.

Path coefficients were obtained by solving a set of simultaneous equation of the form,

$$r_{ny} = P_{ny} + r_{n2} + 4n_2P_y + 4n_3 + \ldots\ldots$$

Where,

r_{ny} = Represented correlation between one component and yield

P_{ny} = Represented path coefficient between one component and yield

r_{n2} = Represented correlation between that character and each of the other yield components in turn

Matrix A Matrix B

$$A = \begin{bmatrix} r_{1y} \\ r_{2y} \\ r_{ny} \end{bmatrix} \qquad B = \begin{bmatrix} 1 & r_{1.2} & r_{1.3} \ldots\ldots\ldots\ldots r_{1n} \\ r_{2.1} & 1 & r_{2.3} \ldots\ldots\ldots\ldots r_{2n} \\ r_{n1} & r_{n2} & r_{n3} \ldots\ldots\ldots\ldots 1 \end{bmatrix}$$

Where, $r_{1.2}$ = $r_{1.2}$ and so on

r_{1y} = Correlation between one component character and yield

The 'B' matrix (P_{ij}) were obtained as

$$(P_{ij}) = A \times (B^{-1})$$

The indirect effect of a particular character through other characters was obtained by multiplication of direct path and particular correlation coefficients between these characters separately.

Indirect effect = $r_{ij} \times P_{ij}$

Where, $i = 1$ to n

$j = 1$ to n

$P_{ij} = P_1Y_1, P_2Y_2, ----P_nY_n$

Path coefficient (P_{ij}), correlation coefficient (r_{ij}) and residual factor (s) were diagrammatically presented.

The residual factors i.e. variation in yield unaccounted for by these association was calculated from the following formula,

$$\text{Residual factor (x)} = 1 - R^2$$

Where,

$$R^2 = P_{1y}r_{1y} + P_{2y}r_{2y} + P_{3y}r_{3y}....... + P_{ny}r_{ny}$$

Where,

$P_{1y}, P_{2y}........ P_{ny}$ = Path values

$r_{1y}, r_{2y}........ r_{ny}$ = Correlation coefficients

CHAPTER IV

EXPERIMENTAL RESULTS

An experiment entitled, "Evaluation of Early Genotypes of Pigeon Pea (*Cajanus cajan* (L.) Millsp.)" was undertaken at the Botany farm, Department of Agricultural Botany, College of Agriculture, Dapoli during *Rabi*, 2014-15. The results of the experiment are presented in this chapter under the following headings.

4.1 Genetic variability

4.2 Correlation

4.3 Path analysis

4.1 Genetic variability

4.1.1 Analysis of variance

The results of analysis of variance are presented in Table 2. The mean sums of squares among the genotypes were significant for all the thirteen characters under study. It showed that all these characters have significant variation. The genotype and error mean sum of squares were further used for analysis of genotypic and phenotypic variances.

Table 2. Analysis of variance for the different characters studied in Pigeon pea

Sr. No.	Characters	Mean sum of squares		
		Replication	Treatment	Error
1.	**Plant height (cm)**	734.030	702.909*	58.897
2.	**Days to initiation of flowering**	152.529	9695.578*	1306.804
3.	**Days to 50 per cent of flowering**	57.020	8893.333*	790.314
4.	**Days to maturity**	64.647	7214.627*	806.020
5.	**Number of primary branches per plant**	31.809	139.287*	1.745
6.	**Number of pods per plant**	3534.512	60779.212*	417.328
7.	**Pod length (cm)**	3.526	28.110*	16.509
8.	**Pod breadth (mm)**	4.247	65.162*	1.186
9.	**Number of seeds per pod**	1.602	32.006*	17.163
10.	**Hundred seed weight (g)**	1.998	334.148*	23.722
11.	**Grain yield per plant (g)**	12.650	846.118*	64.910
12.	**Straw yield per plant (g)**	1350.580	1294.350*	173.980
13.	**Harvest index**	88.376	2592.834*	315.951

* Significant at 5% level
** Significant at 1% level

4.1.2 Mean performance and range of variability

The mean values, range, general mean, standard error and critical difference in thirty-four genotypes of pigeon pea for thirteen characters are presented in Table 3.

1. Plant height (cm)

The general mean for plant height was 65.93 cm. Plant height varied from 61.47 to 70.43 cm. Among the thirty-four genotypes, seventeen genotypes registered more height than the general mean, while seventeen genotypes were shorter than the average. The tallest genotype among the studied population was ICPH 2671 (70.43 cm) followed by ICPH 2740 (69.90 cm) and ICP 7035 (69.50), while the dwarfest genotype was ICPL 20340 (61.47 cm) followed by ICPL 11318 (62.30 cm), ICPL 11255 (62.47) and ICPL 11256 (62.90cm).

Table 4 . Classification of genotypes for plant height (cm)

Dwarf	Medium	Tall
ICPL 11249	ICPL 11298	ICPL 20329
ICPL 11263	ICPL 11300	ICPL 20328
ICPL 20341	ICPL 11242	ICPL 20326
ICPL 11252	ICPL 11244	ICPL 12337
ICPL 11255	ICPL 11245	ICPL 12338
ICPL 20338	ICPL 20333	ICPL 12339
ICPL 20340	ICPL 20335	ICP 8863
ICPL 20336	ICPL 20325	ICPL 87119
ICPL 11256	ICPL 12336	ICP 7035
ICPL 11259	ICPL 88039	ICPH 2671
ICPL 11318		ICPH 2740
ICPL 11285		
ICPL 12335		
Total-13 Frequency-38.23%	**Total-10 Frequency-29.41%**	**Total-11 Frequency-32.35%**

Classification of genotypes (Table 4), based on general mean and critical difference at 5 per cent level revealed that ten genotypes had their performance near the general mean with 29.41 per cent frequency. Eleven genotypes were grouped under tall category, while thirteen genotypes were in dwarf category with 32.35 and 38.23 per cent frequency respectively.

2. Days to initiation of flowering

Days to initiation of flowering ranged from 57 to 89 days with the general mean of 67.03 days. Among the thirty-four genotypes studied, twenty-one showed flower initiation earlier than general mean while thirteen genotypes come to flower initiation later than the general mean. It was observed from the table that the minimum days required for initiation of flowering were in the genotypes ICPL 11249 and ICPL 11263 (57 days). Maximum days required for this character was in the genotype ICP 8863 and ICPL 87119 (89 days) followed by genotype ICPH 2740 (84.33). However, the classification of genotypes (Table 5) showed that, seven genotypes were in late group and ten genotypes were in early group with frequency 20.58 and 29.41 per cent respectively, while rest of the seventeen genotypes were in mid-late group having 50 per cent frequency.

Table 5 . Classification of genotypes for days to initiation of flowering

Early	Mid-late	Late
ICPL 11249	ICPL 11256	ICPL 12336
ICPL 11263	ICPL 11259	ICPL 12339
ICPL 20341	ICPL 11300	ICP 8863
ICPL 11252	ICPL 11285	ICPL 87119
ICPL 11255	ICPL 11242	ICP 7035
ICPL 20338	ICPL 11244	ICPH 2671
ICPL 20340	ICPL 11245	ICPH 2740
ICPL 20336	ICPL 20333	
ICPL 11298	ICPL 20335	
ICPL 11318	ICPL 20329	
	ICPL 20325	
	ICPL 20328	
	ICPL 20326	
	ICPL 12335	
	ICPL 12337	
	ICPL 12338	
	ICPL 88039	
Total-10 Frequency-29.41%	**Total-17 Frequency-50%**	**Total-7 Frequency-20.58%**

3. Days to 50 per cent flowering

The general mean for days to 50 per cent flowering was 77.63 days. The genotypes varied significantly for this character and it ranged from 65.33 to 97 days.

Table 6. Classification of genotypes for days to 50 per cent flowering

Early	Mid-late	Late
ICPL 11249	ICPL 11318	ICPL 12335
ICPL 11263	ICPL 11300	ICPL 12336
ICPL 20341	ICPL 11285	ICPL 12337
ICPL 11252	ICPL 11242	ICPL 12338
ICPL 11255	ICPL 11244	ICPL 12339
ICPL 20338	ICPL 11245	ICPL 88039
ICPL 20340	ICPL 20333	ICP 8863
ICPL 20336	ICPL 20335	ICPL 87119
ICPL 11256	ICPL 20329	ICP 7035
ICPL 11259	ICPL 20325	ICPH 2671
ICPL 11298	ICPL 20328	ICPH 2740
	ICPL 20326	
Total-11 Frequency-32.35%	**Total-12 Frequency-35.29%**	**Total-11 Frequency-32.35%**

Among thirty-four genotypes, twenty-one genotypes showed 50 per cent flowering earlier than general mean while thirteen genotypes showed 50 per cent flowering later than general mean. The minimum days required for 50 per cent flowering were in the genotypes ICPL 11255 and ICPL 20338 (65.33 days) followed by ICPL 20340 (65.67 days), while maximum days required for this character was found in the genotype ICP 8863 (97 days) followed by ICPL 87119 (94.67 days). Classification of genotypes (Table 6) showed that, eleven genotypes were in early and late group with frequency 32.35 per cent and twelve genotypes were in mid late group with 35.29 per cent frequency.

4. Days to maturity

The general mean for days to maturity for the genotypes was 117.35 days with a range of variation from 107.33 to 140.67 days.

Table 7 . Classification of genotypes for days to maturity

Early	Mid-late	Late
ICPL 11249	ICPL 11298	ICPL 12335
ICPL 11263	ICPL 11318	ICPL 12336
ICPL 20341	ICPL 11300	ICPL 12337
ICPL 11252	ICPL 11285	ICPL 12338
ICPL 11255	ICPL 11242	ICPL 88039
ICPL 20338	ICPL 11244	ICP 8863
ICPL 20340	ICPL 11245	ICPH 2671
ICPL 20336	ICPL 20333	ICPH 2740
ICPL 11256	ICPL 20335	
ICPL 11259	ICPL 20329	
	ICPL 20325	
	ICPL 20328	
	ICPL 20326	
	ICPL 12339	
	ICPL 87119	
	ICP 7035	
Total-10 Frequency-29.41%	**Total-16 Frequency-47.05%**	**Total-8 Frequency-23.52%**

Sixteen genotypes took more days to maturity than the general mean while eighteen took lesser days to maturity than general mean. ICPL 11249 and ICPL 20338 (107.33 days) were the early maturing lines followed by ICPL 11255 (107.67 days), while ICPH 2740 (140.67 days) was latest maturing genotype followed by ICPL 12335 (134.67 days). Classification of genotypes (Table 7) showed that ten genotypes were found in early group with 29.41 per cent frequency and eight in late group with 23.52 per cent frequency whereas remaining sixteen genotypes in the mid-late group having 47.05 per cent frequency.

5. Number of primary branches per plant

The range of variation was in between 3.93 to 7.90 for number of primary branches per plant with general mean of 5.80.

Table 8. Classification of genotypes for number of primary

branches per plant

Low	Medium	High
ICPL 11249	ICPL 20341	ICPL 11245
ICPL 11263	ICPL 20338	ICPL 12335
ICPL 11252	ICPL 11298	ICPL 12336
ICPL 11255	ICPL 11244	ICPL 12337
ICPL 20340	ICPL 20333	ICPL 12338
ICPL 20336	ICPL 20329	ICPL 12339
ICPL 11256	ICPL 20325	ICPL 88039
ICPL 11259		ICP 8863
ICPL 11318		ICPL 87119
ICPL 11300		ICP 7035
ICPL 11285		ICPH 2671
ICPL 11242		ICPH 2740
ICPL 20335		
ICPL 20328		
ICPL 20326		
Total-15 Frequency-44.11%	**Total-7 Frequency-20.58%**	**Total-12 Frequency-35.29%**

Among the genotypes, thirteen genotypes had more number of primary branches than the general mean while twenty-one genotypes had lesser number of primary branches than general mean. Genotype ICPH 2671 and ICP 7035 recorded maximum primary branches per plant i.e. 7.90 and 7.80, respectively while, ICPL 11285 (3.93) showed minimum primary branches per plant. Classification of genotypes (Table 8) showed that fifteen genotypes were grouped under low category with 44.11 per cent frequency, twelve genotypes were under high category with 35.29 per cent frequency and rest of the seven genotypes were found in medium group with 20.58 per cent frequency.

6. Number of pods per plant

The average number of pods per plant was 67.77. It ranged between 32.60 to 111.67 number of pods per plant.

Table 9. Classification of genotypes for number of pods per plant

Low	Medium	High
ICPL 11249	ICPL 11244	ICPL 20325

ICPL 11263 ICPL 20341 ICPL 11252 ICPL 11255 ICPL 20338 ICPL 20340 ICPL 20336 ICPL 11256 ICPL 11259 ICPL 11298 ICPL 11318 ICPL 11300 ICPL 11285 ICPL 11242 ICPL 20335	ICPL 11245 ICPL 20333 ICPL 20329	ICPL 20328 ICPL 20326 ICPL 12335 ICPL 12336 ICPL 12337 ICPL 12338 ICPL 12339 ICPL 88039 ICP 8863 ICPL 87119 ICP 7035 ICPH 2671 ICPH 2740
Total-16 **Frequency-47.05%**	**Total-4** **Frequency-11.76%**	**Total-14** **Frequency-41.17%**

Sixteen genotypes had more number of pods per plant than the average while eighteen genotypes had less number of pods per plant than average. The maximum number of pods per plant was observed in ICP 7035 (111.67) followed by ICPL 88039 (105.03) while ICPL 11256 (32.60) showed lesser number of pods per plant among the thirty-four genotypes studied. The classification of genotypes (Table 9) revealed that sixteen genotypes were in low group with 47.05 per cent frequency, fourteen genotypes were in high group with 41.17 per cent frequency and the remaining four genotypes were in medium group with 11.76 per cent frequency.

7. Pod length (cm)

For the character pod length, genotypes were found to be varying from 3.93 to 5.72 cm with a mean value of 4.79 cm. sixteen genotypes had shorter and eighteen genotypes had longer pods than the average. The maximum pod length was noticed in ICPL 20325 (5.72 cm) followed by ICPL 20326 (5.67 cm) and ICPL 11242 (5.53 cm) while the minimum pod length was noticed in ICPL 20340 (3.93 cm). Classification of genotypes (Table 10), based on general mean and critical difference at 5 per cent level revealed that most of the genotypes (31) had their performance near the general mean with 91.17 per cent frequency. Only three genotype *ie.* ICPL 8863, ICPH 2740 and ICPL 20340 were grouped under short category and two genotypes were in long category with 8.82 and 5.88 per cent frequency, respectively.

Table 10. Classification of genotypes for pod length (cm)

Low	Medium	High
ICPL 8863	ICPL 11249	ICPL 20325
ICPH 2740	ICPL 11263	ICPL 20326
ICPL 20340	ICPL 20341	
	ICPL 11252	
	ICPL 11255	
	ICPL 20338	
	ICPL 20336	
	ICPL 11256	
	ICPL 11259	
	ICPL 11298	
	ICPL 11318	
	ICPL 11300	
	ICPL 11285	
	ICPL 11242	
	ICPL 11244	
	ICPL 11245	
	ICPL 20333	
	ICPL 20335	
	ICPL 20329	
	ICPL 20328	
	ICPL 12335	
	ICPL 12336	
	ICPL 12337	
	ICPL 12338	
	ICPL 12339	
	ICPL 88039	
	ICPL 87119	

	ICP 7035 ICPH 2671	
Total-3 **Frequency-8.82%**	**Total-29** **Frequency-85.29%**	**Total-2** **Frequency-5.88%**

8. Pod breadth (mm)

For the character pod breadth, the genotype were found to be varying from 5.00 to 8.13 mm with mean value of 6.45 mm. seventeen genotypes had more breadth and remaining seventeen genotypes had lesser breadth than the average.

Table 11. Classification of genotypes for pod breadth (mm)

Low	Medium	High
ICPL 11249 ICPL 11263 ICPL 20341 ICPL 11252 ICPL 11255 ICPL 20338 ICPL 20340 ICPL 20336 ICPL 11256 ICPL 11259 ICPL 11318 ICPL 11242 ICPL 20326 ICPL 12336	ICPL 11298 ICPL 11285 ICPL 11244 ICPL 20328 ICPL 12335	ICPL 11300 ICPL 11245 ICPL 20333 ICPL 20335 ICPL 20329 ICPL 20325 ICPL 12337 ICPL 12338 ICPL 12339 ICPL 88039 ICP 8863 ICPL 87119 ICP 7035 ICPH 2671 ICPH 2740
Total-14 **Frequency-41.17%**	**Total-5** **Frequency-14.70%**	**Total-15** **Frequency-44.11%**

The maximum pod breadth was noticed in ICP 7035 (8.13 mm) followed by the genotypes ICPL 88039 (7.87 mm) and ICPL 12339 (7.53 mm), while the minimum pod breadth was noticed in ICPL 20338 (5.00

mm) followed by ICPL 11249 (5.20 mm), ICPL 11263 (5.23 mm) and ICPL 20341 (5.27 mm). The classification of genotypes (Table 11) revealed that fourteen genotypes were grouped in less breadth category with frequency 41.17 per cent and fifteen genotypes were grouped in more breadth category with frequency 44.11 per cent, while the remaining five genotypes were grouped in medium group with frequency 14.70 per cent.

9. Number of seeds per pod

The general mean for number of seeds per pod was 3.89. The range of variation in genotypes for this character was from 2.87 to 5.80. Thirteen genotypes had more and twenty-one genotypes had lesser number of seeds per pod than the mean value. Genotypes ICPL 11285 (5.80) and ICPL 11300 (5.47) recorded higher number of seeds per pod while ICP 8863 (2.87) recorded minimum number of seeds per pod followed by ICPL 12335 (3.13). The classification of genotypes (Table 12) revealed that, only one genotype ICP 8863 was grouped in low category and three genotypes were grouped in high category with frequency 2.94 and 8.82 per cent respectively, while remaining thirty genotypes were grouped in medium category with 88.23 per cent frequency.

Table 12. Classification of genotypes for number of seeds per pod

Low	Medium	High
ICP 8863	ICPL 11249	ICPL 11300
	ICPL 11263	ICPL 11285
	ICPL 20341	ICPL 20325
	ICPL11252	
	ICPL 11255	
	ICPL 20338	
	ICPL 20340	
	ICPL 20336	
	ICPL 11256	
	ICPL 11259	
	ICPL 11298	

	ICPL 11318 ICPL 11242 ICPL 11244 ICPL 11245 ICPL 20333 ICPL 20335 ICPL 20329 ICPL 20328 ICPL 20326 ICPL 12335 ICPL 12336 ICPL 12337 ICPL 12338 ICPL 12339 ICPL 88039 ICPL 87119 ICP 7035 ICPH 2671 ICPH 2740	
Total-1 **Frequency-2.94%**	**Total-30** **Frequency-88.23%**	**Total-3** **Frequency-8.82%**

10. Hundred seed weight (g)

The general mean for hundred seed weight was 8.79 g. The genotypes varied from 7.17 g to 17 g for this character. Out of thirty-four genotypes fifteen genotypes had more hundred seed weight than general mean and nineteen genotypes had less hundred seed weight than general mean. The genotypes ICPL 20333, ICPL 20329 and ICPL 20325 (7.17 g) recorded the lowest hundred seed weight and the highest value for hundred seed weight was observed in genotype ICP 7035 (17 g) followed by genotype ICPH 2671 (11.33 g). Classification of genotypes (Table 13) revealed that, thirteen genotypes had lower hundred seed weight and hence, grouped as light with 38.23 per cent frequency while six genotypes grouped into heavy with 17.64 per cent frequency and rest of the fifteen genotypes were medium type with 44.11 per cent frequency.

Table 13. Classification of genotypes for hundred seed weight (g)

Low	Medium	High
ICPL 11263 ICPL 20340 ICPL 11256 ICPL 11298 ICPL 11285 ICPL 11242 ICPL 20333 ICPL 20335 ICPL 20329 ICPL 20325 ICPL 20326 ICPL 12335 ICPL 12339	ICPL 11249 ICPL 20341 ICPL 11255 ICPL 20338 ICPL 20336 ICPL 11259 ICPL 11318 ICPL 11300 ICPL 11244 ICPL 11245 ICPL 20328 ICPL 12337 ICPL 88039 ICP 8863 ICPL 87119	ICPL 11252 ICPL 12336 ICPL 12338 ICP 7035 ICPH 2671 ICPH 2740
Total-13 **Frequency-38.23%**	**Total-15** **Frequency-44.11%**	**Total-6** **Frequency-17.64%**

11. Straw yield per plant (g)

The general mean for straw yield per plant was 36.97 g. the genotypes varied from 29.53 g to 44.30 g for this character. Out of thirty-four genotypes seventeen genotypes had more straw yield per plant than the general mean and remaining seventeen genotypes had less straw yield than the general mean. The genotype ICPL 11255 (29.53 g) recorded lowest straw yield per plant and the highest value for straw yield per plant was observed in genotype ICPL 12339 (44.30 g) followed by genotype ICPL 88039 (43.13 g). Classification of genotypes (Table 14) revealed that ten genotypes had less straw yield per plant and hence grouped as light with 29.41 per cent frequency while nine genotypes had more straw yield per plant and hence grouped as heavy with frequency 26.47 per cent and rest of the fifteen genotypes were medium type with 44.11 per cent frequency.

Table 14. Classification of genotypes for straw yield per plant (g)

Low	Medium	High
ICPL 11249	ICPL 11263	ICPL 12335
ICPL 20341	ICPL 11252	ICPL 12336
ICPL 11255	ICPL 11259	ICPL 12337
ICPL 20338	ICPL 11318	ICPL 12338
ICPL 20340	ICPL 11300	ICPL 12339
ICPL 20336	ICPL 11285	ICPL 88039
ICPL 11256	ICPL 11242	ICP 8863
ICPL 11298	ICPL 11244	ICPL 87119
ICPL 11245	ICPL 20335	ICPH 2740
ICPL 20333	ICPL 20329	
	ICPL 20325	
	ICPL 20328	
	ICPL 20326	
	ICP 7035	
	ICPH 2671	
Total-10 Frequency-29.41%	**Total-15 Frequency-44.11%**	**Total-9 Frequency-26.47%**

12. Harvest index

The general mean for the harvest index was 17.59. The genotypes varied from 11.74 to 31.85 for this character. Out of thirty-four genotypes fourteen genotypes had more harvest index than the general mean and rest twenty genotypes has less harvest index than the general mean. Maximum harvest index was observed in ICPL 20349 (31.85) followed by ICPL 20326 (27.28). Genotype ICPL 12335 (11.74) recorded minimum harvest index. Classification of genotypes (Table 15) revealed that twelve genotypes were grouped into low category with frequency 35.29 per cent, nine genotypes were grouped into high category with frequency 26.47 per cent and rest of the thirteen genotypes were grouped in medium category with frequency 38.23 per cent.

Table 15. Classification of genotypes for harvest index

Low	Medium	High
ICPL11249	ICPL 20341	ICPL 11298
ICPL 11263	ICPL 11252	ICPL 11318
ICPL 20338	ICPL 11255	ICPL 11242
ICPL 20340	ICPL 20336	ICPL 11244
ICPL 11256	ICPL 11259	ICPL 20333
ICPL 12335	ICPL 11300	ICPL 20329
ICPL 12336	ICPL 11285	ICPL 20325
ICPL 12337	ICPL 11245	ICPL 20328
ICPL 12338	ICPL 20335	ICPL 20326
ICPL 12339	ICP 8863	
ICPL 88039	ICP 7035	
ICPL 87119	ICPH 2671	
	ICPH 2740	
Total-12 Frequency-35.29%	**Total-13 Frequency-38.23%**	**Total-9 Frequency-26.47%**

13. Grain yield per plant (g)

The general mean for grain yield per plant was 7.99 g. The variability for grain yield in genotypes ranged from 4.67 g to 17.17 g. Fourteen genotypes showed higher grain yield per plant than average, while remaining twenty genotypes recorded lower grain yield per plant than average. Maximum grain yield per plant was observed in ICPL 20329 (17.17 g) followed by genotype ICPL 20326 (13.87 g). Genotype ICPL 20340 (4.67 g) recorded minimum grain yield per plant. Classification of genotypes (Table 16) revealed that fourteen genotypes had lower grain yield per plant and hence grouped as low with 41.17 per cent frequency, while eight genotypes had higher grain yield per plant and hence grouped as heavy with 23.52 per cent frequency and rest of the twelve genotypes were medium type with 35.29 per cent frequency.

Table 16. Classification of genotypes for grain yield per plant (g)

Low	Medium	High
ICPL 11249	ICPL 20336	ICPL 11318
ICPL 11263	ICPL 11298	ICPL 11242
ICPL 20341	ICPL 11300	ICPL 11244
ICPL 11252	ICPL 11285	ICPL 20333
ICPL 11255	ICPL 11245	ICPL 20329
ICPL 20338	ICPL 20335	ICPL 20325
ICPL 20340	ICPL 12336	ICPL 20328
ICPL 11256	ICPL 88039	ICPL 20326
ICPL 11259	ICP 8863	
ICPL 12335	ICP 7035	
ICPL 12337	ICPH 2671	
ICPL 12338	ICPH 2740	
ICPL 12339		
ICPL 87119		
Total-14 **Frequency- 41.17 %**	**Total-12** **Frequency-35.29%**	**Total-8** **Frequency-23.52%**

4.1.3 Components of variation

The total variation of the generation was partitioned into genotypic, phenotypic and environmental variance. The estimates of variance due to these three components for thirteen characters are presented in Table17 and Fig. 1.

Table 17. Estimates of phenotypic (σ^2p), genotypic (σ^2g) and environmental (σ^2e) variance of pigeon pea

Sr. No.	Characters	σ^2p	σ^2g	σ^2e
1.	**Plant height (cm)**	7.695	6.802	0.892

2.	**Days to initiation of flowering**	111.135	91.335	19.800
3.	**Days to 50 per cent of flowering**	97.814	85.840	11.774
4.	**Days to maturity**	81.016	68.804	12.212
5.	**Number of primary branches per plant**	1.424	1.398	0.026
6.	**Number of pods per plant**	618.146	611.823	6.323
7.	**Pod length (cm)**	0.450	0.200	0.250
8.	**Pod breadth (mm)**	0.670	0.652	0.018
9.	**Number of seeds per pod**	0.496	0.236	0.260
10.	**Hundred seed weight (g)**	3.614	3.255	0.359
11.	**Grain yield per plant (g)**	9.202	8.218	0.983
12.	**Straw yield per plant (g)**	14.831	12.195	2.636
13.	**Harvest index**	29.381	24.594	4.787

The phenotypic, genotypic and environmental variances for various characters ranged from 0.45 to 618.14, 0.20 to 611.82 and 0.18 to 19.80 respectively. The magnitudes of phenotypic variances were greater than genotypic variances. The phenotypic variance was maximum for number of pods per plant (618.14) followed by days to initiation of flowering (111.13) while phenotypic variance was minimum for pod length (0.45) followed by number of seeds per pod (0.49). Similarly, magnitude of genotypic variance was higher for pods per plant (611.82) followed by days to initiation of flowering (91.33) while genotypic variance was minimum for pod length (0.20) followed by number of seeds per pod (0.23). The magnitude for environmental variance was higher for days to initiation of flowering (19.80) followed by days to maturity (12.12) and pod breadth (0.018) which was closely followed by number of primary branches per plant (0.026).

4.1.4 Coefficient of variation

The estimates of coefficient of variation at phenotypic level and genotypic level are given in Table 18.

In general, phenotypic coefficients of variation were greater in magnitude over the respective genotypic coefficient of variation. The character, grain yield per plant exhibited highest phenotypic coefficient of variation (37.970%), followed by number of pods per plant (36.686%), and harvest index (30.816). The remaining characters had phenotypic coefficient of variation at the tune of 21.642 per cent for hundred seed weight, 20.578 per cent for number of primary branches, 18.100 per cent for number of seeds per pod, 15.728 per cent for days to initiation of flowering, 14.027 per cent for pod length, 12.956 per cent for days to 50 per cent flowering, 12.694 per cent for pod breadth, 10.418 per cent for straw yield per plant, 7.670 per cent for days to maturity and 4.207 per cent for plant height.

Table 18. Estimates of genetic parameters for various characters of Pigeon pea

Sr. No.	Characters	PCV (%)	GCV (%)	h^2bs (%)	GA	GAM (%)
1.	**Plant height (cm)**	4.207	3.955	88.403	5.051	7.662
2.	**Days to initiation of flowering**	15.727	14.257	82.183	17.847	26.626
3.	**Days to 50 per cent of flowering**	12.956	12.137	87.758	17.879	23.422
4.	**Days to maturity**	7.669	7.068	84.926	15.746	13.418
5.	**Number of primary branches per plant**	20.578	20.386	98.144	2.413	41.604
6.	**Number of pods per**	36.686	36.498	98.977	50.692	74.800

	plant					
7.	**Pod length (cm)**	14.027	9.357	44.500	0.615	12.859
8.	**Pod breadth (mm)**	12.694	12.522	97.318	1.641	25.448
9.	**Number of seeds per pod**	18.099	12.492	47.64	0.691	17.763
10.	**Hundred seed weight (g)**	21.641	20.537	90.057	3.527	40.148
11.	**Grain yield per plant (g)**	37.97	35.883	89.312	5.581	69.859
12.	**Straw yield per pant (g)**	10.418	9.447	82.226	6.523	17.647
13.	**Harvest index**	30.816	28.194	83.707	9.346	53.138

The amount of genetic variation present in the population was worked out in terms of the genotypic coefficient of variation. The highest genotypic coefficient of variation was noticed by number of pods per plant (36.498%) followed by grain yield per plant (35.884%) while lowest genotypic coefficient of variation was exhibited by plant height (3.956%) followed by days to maturity (7.068%). The remaining characters showed genotypic coefficient of variation as harvest index (28.194%), hundred seed weight (20.537%), number of primary branches (20.387%), days to initiation of flowering (14.258%), pod breadth (12.523%), number of seeds per pod (12.493%), days to 50 per cent flowering (12.138%), straw yield per plant (9.447%) and pod length (9.357%).

4.1.5 Heritability and genetic advance

Heritability in broad sense ranged between 98.977 to 44.50 per cent. Highest heritability values were computed for the character, number of pods per plant (98.977 per cent) followed by number of primary branches (98.145 per cent) and pod breadth (97.318 per cent). The lowest heritability estimate was recorded in pod length (44.500 per cent), followed by number of seeds per pod (47.641 per cent). Other characters had heritability at the tune of 90.057 per cent for hundred seed weight 89.313 per cent for grain yield per plant, 88.403 per cent plant height, 87.758 per cent days to 50 per cent flowering, 84.926 per cent for days to maturity, 83.707 per cent for harvest index, 82.227 per cent for straw yield per plant and 82.184 per cent days to initiation of flowering.

The range of genetic advance was from 50.693 to 0.615. The highest estimate of genetic advance was noticed in character, number of pods per plant (50.693) followed by days to 50 per cent flowering (17.880), whereas lowest estimates of genetic advance was recorded in pod length (0.615) followed by number of seeds per pod (0.692). Other characters had genetic advance at the tune of 1.641 for pod breadth, 2.413 for number of primary branches per plant, 3.527 for hundred seed weight, 5.052 for plant height, 5.581 for grain yield per plant, 9.347 for harvest index, 15.747 for days to maturity and 17.848 for days to initiation of flowering.

The range of genetic advance as percentage of mean was from 7.662 to 74.801 per cent. The highest value for genetic advance as percentage of mean was reported by number of pods per plant (74.801 per cent) followed by grain yield per plant (69.859 per cent), whereas the lowest value for genetic advance as per cent of mean was recorded in plant height (7.662 per cent) followed by pod length (12.859 per cent). Other characters had genetic advance as per cent of mean at the tune of 53.139 per cent for harvest index, 41.605 per cent for number of primary branches, 40.149 per cent or hundred seed weight, 26.626 per cent for days to initiation of flowering, 25.449 per cent for pod length, 23.423 per cent for days to 50 per cent flowering, 17.763 per cent for number of seeds per pod, 17.647 per cent for straw yield per plant and 13.418 per cent for days to maturity.

4.2 Correlation

The seed yield is a complex character which depends on different independent characters and hence, it is essential to know the relationship between the yield and its component characters. Correlation analysis is useful in finding out the mutual association between yield and its component characters. The estimates of phenotypic and genotypic correlation provide an effective way of predicting response of selection and isolating desirable individuals from breeding population. To study the association of characters at phenotypic and genotypic level the correlation coefficients were computed in all possible combination among the characters. The phenotypic and genotypic correlations between thirteen characters are given in Table 19 and Table 20 respectively.

4.2.1 Phenotypic correlation coefficient

The result presented in Table 19 revealed that seed yield per plant had positive and highly significant correlation with harvest index (0.963), plant height (0.347), pod length (0.344), pod breadth (0.272), number of seeds per pod (0.220), number of pods per plant (0.197). However seed yield exhibited positive but not significant correlation with straw yield per plant (0.043), days to maturity (0.041) and days to 50 per cent flowering (0.028). Non-significant negative correlation noticed with hundred seed weight (-0.227), number of primary branches (-0.087) and days to initiation of flowering (-0.016).

The character plant height recorded highly significant positive correlation with number of pods per plant (0.771), days to 50 per cent flowering (0.738), days to initiation of flowering (0.715), pod breadth (0.697), number of primary branches (0.650), days to maturity (0.641), straw yield per plant (0.530), hundred seed weight (0.257) and harvest index (0.214). Positive but not significant correlation observed with pod length (0.009) while negative but non significant correlation was observed only with number of seeds per pod.

Days to initiation of flowering exhibited highly significant positive correlation with days to 50 per cent flowering (0.913), days to maturity (0.790), number of primary branches per plant (0.779), number of pods per plant (0.746), straw yield per plant (0.581), pod breadth (0.577) and hundred seed weight (0.421). It had highly significant but negative correlation with number of seeds per pod (-0.254) while negative non significant correlation was noticed with harvest index (-0.151) and pod length (-0.145).

Days to 50 per cent flowering exhibited highly significant and positive correlation with days to maturity (0.884), number of pods per plant (0.814), number of primary branches per plant (0.806), straw yield per plant (0.671), pod breadth (0.637) and hundred seed weight (0.352). It had highly significant negative correlation with only number of seeds per pod (-0.245) while non significant negative correlation noticed with harvest index (-0.125) and pod length (-0.104).

Days to maturity exhibited highly significant correlation with number of pods per plant (0.767), no. of primary branches per plant (0.731), pod breadth (0.581), straw yield per plant (0.578) and hundred seed weight (0.213) while highly significant and negative correlation was noticed only with number of seeds per pod (-0.264). It had non significant and negative correlation with harvest index (-0.088) and pod length (-0.087).

Number of primary branches per plant had highly significant positive correlation with number of pods per plant (0.864), pod breadth (0.670), straw yield per plant (0.596) and hundred seed weight (0.430), while highly significant and negative correlation was observed with number of seeds per pod (-0.316) and harvest index (-0.211). Non significant and negative correlation was observed only for pod length (-0.077).

Number of pods per plant recorded highly significant positive correlation with pod breadth (0.722), straw yield per plant (0.675) and hundred seed weight (0.330). It had significant but negative correlation with number of seeds per pod while non significant and positive correlation with harvest index (0.044) similarly had non significant negative correlation with pod length (-0.031).

Highly significant positive correlation of pod length was observed with number of seeds per pod (0.500), harvest index (0.331), pod breadth (0.256). It had non significant positive correlation with straw yield per plant (0.095) and non significant negative correlation with only hundred seed weight (-0.088).

Pod breadth showed highly significant positive correlation with straw yield per plant (0.554) and hundred seed weight (0.203). It had non significant positive correlation with harvest index (0.161) and non significant negative correlation with number of seeds per pod (-0.004).

Number of seeds per pod exhibited highly significant positive correlation with harvest index (0.230) while it had non significant positive correlation with straw yield per plant (0.027) while negative but non significant correlation was observed only with hundred seed weight (-0.151).

Highly significant negative correlation of hundred seed weight was recorded with harvest index (-0.244), while non significant positive correlation was observed with straw yield per plant (0.106). Straw yield per plant showed highly significant but negative correlation with harvest index (-0.200).

4.2.2 Genotypic correlation coefficient

The results summarized in Table 20 revealed that seed yield per plant had positive and highly significant correlation with harvest index (0.976), pod length (0.433), plant height (0.397), number of seed per pod (0.333), pod breadth (0.285), number of pods per plant (0.204) and days to maturity (0.076). It had positive but non significant correlation with straw yield per plant (0.085) and days to initiation of flowering (0.016) days to 50 per cent flowering (0.062). It had significant negative correlation with hundred seed weight (-0.250). It had non significant negative correlation with number of primary branches per plant (-0.094).

Plant height had highly significant positive correlation with days to 50 per cent flowering (0.852) number of pods per plant (0.829), days to initiation of flowering (0.821), days to maturity (0.742), number of primary branches per plant (0.685), straw yield per plant (0.605), hundred seed weight (0.288) and harvest index (0.275). It had non significant positive correlation with pod breadth (0.759) and pod length (0.138). Non significant negative correlation was observed with number of seeds per pod (-0.103).

Highly significant positive correlation of days to initiation of flowering was observed with days to 50 percent flowering (0.985), number of primary branches per plant (0.870), days to maturity (0.843), number of pods per plant (0.823), straw yield per plant (0.709) pod breadth (0.653) and hundred seed weight (0.470). It had highly significant negative correlation with number of seeds per pod (-0.343) while non significant negative correlated was observed for only harvest index (-0.138) and pod length (-0.127).

Days to 50 per cent flowering recorded highly significant positive correlation with days to maturity (0.931), number of pods per plant (0.871), straw yield per primary branches per plant (0.871), straw yield per plant (0.793), pod breadth (0.700) and hundred seed weight (0.357). It had highly significant negative correlation with number of seeds per pod (-0.327) while non significant negative correlation with harvest index (-0.113) and pod length (-0.110).

Positive and highly significant association of days to maturity was noticed with number of pods per plant (0.847), number of primary branches per plant (0.805), straw yield per plant (0.736), pod breadth (0.633) and hundred seed weight (0.221). It had highly significant negative correlation with number of seeds per pod (-0.325) and non significant negative correlation with pod length (-0.169) and harvest index (-0.081).

Number of primary branches per plant showed highly significant positive correlation with number of pods per plant (0.872), pod breadth (0.686) straw yield per plant (0.650) and hundred seed weight (0.471). It had noted highly significant negative correlation with number of seeds per pod (-0.445) and harvest index (-0.228) while non significant negative correlation with pod length (-0.099).

Highly significant positive association of number of pods per plant was observed with straw yield per plant (0.740) pod breadth (0.783) and hundred seed weight (0.356). However non significant positive correlation of this character was noticed with harvest index (0.044). It had highly significant negative correlation with number of seeds per pod (-0.290) while non significant negative correlation with pod length (-0.047).

Pod length recorded highly significant positive correlation with number of seeds per pod (0.530), pod breadth (0.413) and harvest index (0.403). Non significant positive correlation was observed with straw yield per plant (0.156), while non significant negative correlation with hundred seed weight (-0.116).

Pod breadth had highly significant and positive correlation with straw yield per plant (0.640) and hundred seed weight (0.224). It had non significant positive correlation with harvest index (0.164) and non significant negative correlation with number of seeds per pod (-0.012).

Highly significant positive association of number of seeds per pod was exhibited with harvest index (0.341). It had highly significant negative correlation with hundred seed weight (-0.212) while non significant negative correlation with straw yield per plant (-0.031).

Hundred seed weight had highly significant negative correlation with harvest index (-0.273) and non significant positive correlation with straw yield per plant (0.118). Straw yield per plant had non significant negative correlation with harvest index (-0.127).

4.3 Path coefficient analysis

The correlation coefficients were further partitioned in order to assess the direct and indirect effects of various characters on grain yield per plant.

4.3.1 Phenotypic correlation coefficient partitioned for path coefficient analysis

The phenotypic correlation coefficients were partitioned into direct and indirect effects are presented in Table 21 and Fig. 3 The result indicated that the character plant height had positive direct effect (0.042) on grain yield per plant. Its indirect effect via days to initiation of flowering, days to maturity, number of seeds per pod, hundred seed weight, straw yield per plant and harvest index were positive. Its indirect effect via days to 50 per cent flowering, number of primary branches per plant, number of pods per plant, pod length and pod breadth were negative. This character had positive highly significant correlation (0.347) with grain yield per plant.

The character days to initiation of flowering had positive direct effect (0.022) on grain yield per plant. It had positive indirect effects via plant height, days to maturity, pod length, number of seeds per pod, hundred seed weight and straw yield per plant, while negative indirect effects through days to 50 per cent flowering, number of primary branches per plant, number of pods per plant, pod breadth and harvest index. This character had negative non-significant correlation (-0.016) with grain yield per plant.

Days to 50 per cent flowering had negative direct effect (-0.034) on grain yield per plant. It had positive indirect effect via plant height, days to initiation of flowering, days to maturity, pod length, number of seeds per pod, hundred seed weight and straw yield per plant. It had negative indirect effect via number of primary branches per plant, number of pods per plant, pod breadth and harvest index. This character had positive non-significant correlation (0.028) with grain yield per plant.

Days to maturity had positive direct effect (0.001) on grain yield per plant. It had positive indirect effect via plant height, days to initiation of flowering, pod length, number of seeds per pod, hundred seed weight and straw yield per plant. Its indirect effect via days to 50 per cent flowering, number of primary branches, number of pods per plant, pod breadth and harvest index were negative. This character had positive non-significant correlation (0.041) with grain yield per plant.

The character number of primary branches per plant had negative direct effect (-0.032) on grain yield per plant. It had positive indirect effect via plant height, days to initiation of flowering, pod length, number of seeds per pod, hundred seed weight and straw yield per plant. It had negative indirect effect via days to 50 per cent flowering, number of pods per plant, pod breadth and harvest index. This character had negative non significant correlation (-0.087) with grain yield per plant.

The character number of pods per plant showed negative direct effect (-0.002) on grain yield per plant. Its indirect effects via plant height, days to initiation of flowering, days to maturity, pod length, number of seeds per pod, hundred seed weight, straw yield per plant and harvest index were positive. While indirect effects days to 50 per cent flowering, number of primary branches per plant, pod breadth were negative. This character had positive highly significant correlation (0.197) with grain yield per plant.

The character pod length had negative direct effect (-0.002) on grain yield per plant. Its indirect positive contribution towards seed yield came through plant height, days to 50 per cent flowering, number of primary branches per plant, number of pods per plant, straw yield per plant and harvest index. The negative indirect effects were came through days to initiation of flowering, days to maturity, pod breadth, number of seeds per pod and hundred seed weight. This character had positive highly significant correlation (0.344) with grain yield per plant.

Pod breadth had negative direct effect (-0.042) on grain yield per plant. It had positive indirect effect through plant height, days to initiation of flowering, days to maturity, number of seeds per pod, hundred seed weight, straw yield per plant and harvest index. It had negative indirect effect through days to 50 per cent flowering, number of primary branches per plant, number of pods per plant and pod length. This character had highly significant positive correlation (0.272) with grain yield per plant.

The character number of seeds per pod had negative direct effect (-0.013) on grain yield per plant. Its indirect positive contribution towards grain yield came through days to 50 per cent flowering, number of primary branches per plant, number of pods per plant, pod breadth and harvest index. The negative indirect effects were came through plant height, days to initiation of flowering, days to maturity, pod length, hundred seed weight and straw yield per plant. This character had positive highly significant correlation (0.220) with grain yield per plant.

The character hundred seed weight exhibited positive direct effect (0.003) on grain yield per plant. Its indirect effect via plant height, days to initiation of flowering, days to maturity, pod length, number of seeds per pod and straw yield per plant were positive. While its indirect effects via days to 50 per cent flowering, number of primary branches per plant, number of pods per plant, number of pods pert plant, pod breadth and harvest index were negative. This character had negative highly significant correlation (-0.227) with grain yield per plant.

Straw yield per plant showed positive direct effect (0.276) on grain yield per plant. It had positive indirect effect through plant height, days to initiation of flowering, days to maturity, number of seeds per pod and hundred seed weight. It had negative indirect effect through days to 50 per cent flowering, number of primary branches per plant, number of pods per plant, pod length, pod breadth and harvest index. This character had positive non significant correlation (0.043) with grain yield per plant.

The character harvest index exhibited positive direct effect (1.013) on grain yield per plant. Its indirect effect via plant height, days to 50 per cent flowering and number of primary branches per plant were positive .its indirect effect via days to initiation of flowering, days to maturity, number of pods per plant, pod length, pod breadth, number of seeds per pod, hundred seed weight and straw yield per plant were negative. This character had highly significant positive correlation (0.993) with grain yield per plant.

The residual effect of path analysis at phenotypic level was found to be 0.01237.

4.3.2 Genotypic correlation coefficient partitioned for path coefficient analysis

The genotypic correlation coefficients were partitioned into direct and indirect effects are presented in Table 22 and Fig. 4.

The character plant height had negative direct effect (-0.017) on grain yield per plant. Its indirect effects via days to initiation of flowering, days to maturity, number of pods per plant, pod length, number of seeds per pod, straw yield per plant and harvest index were positive and its indirect effects via days to 50 per cent flowering, number of primary branches per plant, pod breadth and hundred seed weight were negative. This character had highly significant positive correlation (0.397) with grain yield per plant.

The character days to initiation of flowering showed positive direct effect (0.398) on grain yield per plant. Its indirect effect via days to maturity, number of pods per plant, number of seeds per pod and straw yield per plant were positive. Its indirect effect via plant height,

days to 50 per cent flowering, number of primary branches per plant, pod length, pod breadth, hundred seed weight and harvest index were negative. This character had positive and non significant correlation (0.016) with grain yield per plant.

The character days to 50 per cent flowering had negative direct effect (-0.397) on grain yield per plant. Its indirect positive contribution towards grain yield per plant came through character days to initiation of flowering, days to maturity, number of pods per plant, number of seeds per pod and straw yield per plant. The negative indirect effects came through plant height, number of primary branches per plant, pod length, pod breadth, hundred seed weight and harvest index. This character had positive non significant correlation (0.062) with grain yield per plant.

The character days to maturity had positive direct effect (0.096) on grain yield per plant. Its indirect effects via days to initiation of flowering, number of pods per plant, number of seeds per pod and straw yield per plant were positive. The negative indirect effects were observed through plant height, days to 50 per cent flowering, number of primary branches per plant, pod length, pod breadth, hundred seed weight and harvest index. This character had positive highly significant correlation (0.076) with grain yield per plant.

The character number of primary branches per plant showed negative direct effect (-0.121) on grain yield per plant. Its indirect effects via days to initiation of flowering, days to maturity, number of pods per plant, number of seeds per pod and straw yield per plant were positive, while it showed negative indirect effects via number of pod length, pod breadth, hundred seed weight and harvest index. This character had negative non significant correlation (-0.094) with grain yield per plant.

Number of pods per plant had positive direct effect (0.151) on grain yield per plant. Its indirect effects via days to initiation of flowering, days to maturity and number of seeds per pod, straw yield per plant and harvest index were positive while its indirect effects plant height, days to 50 per cent flowering, number of primary branches per plant, pod length, pod breadth and hundred seed weight were negative. This character had positive highly significant correlation (0.204) with grain yield per plant.

The character pod length had positive direct effect (0.054) on grain yield per plant. Its indirect effects via days to 50 per cent flowering, number of primary branches per plant, hundred seed weight, straw yield per plant and harvest index were positive while its indirect effects via plant height, days to initiation of flowering, days to maturity, number of pods per plant, pod breadth and number of seeds per pod were negative. This character had positive highly significant correlation (0.433) with grain yield per plant.

The character pod breadth showed negative direct effect (-0.041) on grain yield per plant. Its indirect positive contribution towards grain yield per plant came through days to initiation of flowering, days to maturity, number of pods per plant, pod length, number of seeds per pod, straw yield per plant and harvest index. Its negative contribution towards grain yield per plant came through plant height, days to 50 per cent flowering, number of primary branches per plant and hundred seed weight. This character had high significant positive correlation (0.285) with grain yield per plant.

The character number of seeds per pod had negative direct effect (-0.008) on grain yield per plant. Its indirect effects via plant height, days to 50 per cent flowering, number of primary branches per plant, pod length, pod breadth, hundred seed weight and harvest index were positive while, its indirect effects via days to initiation of flowering, days to maturity, number of pods per plant and straw yield per plant were negative. The character had positive highly significant correlation (0.333) with seed yield per plant.

The character hundred seed weight had high negative direct effect (-0.040) on grain yield per plant. Its indirect effects via days to initiation of flowering, days to maturity, number of pods per plant, number of seeds per pod and straw yield per plant were positive while, its indirect effects via plant height, days to 50 per cent flowering, number of primary branches per plant, pod length, pod breadth and harvest index were negative. This character had positive highly significant correlation (0.250) with grain yield per plant.

The character straw yield per plant showed positive direct effect (0.190) on grain yield per plant. Its indirect positive contribution towards grain yield per plant came through days to initiation of flowering, days to 50 per cent flowering, days to maturity, number of pods per plant, pod length and number of seeds per pod. Its indirect negative contribution came through plant height, number of primary branches per plant, pod breadth, hundred seed weight and harvest index. This character had non significant positive correlation (0.085) with grain yield per plant.

The character harvest index had positive direct effect (0.982) on grain yield per plant. Its indirect positive contribution towards grain yield per plant came through days to 50 per cent flowering, number of primary branches per plant, number of pods per plant, pod length and hundred seed weight. Its indirect negative contribution towards grain yield per plant came through plant height, days to initiation of flowering, days to maturity, pod breadth, number of seeds per pod and straw yield per plant. This character had highly significant positive correlation (0.976) with grain yield per plant

The residual effect of path analysis at genotypic level was 0.00175.

CHAPTER V

DISCUSSION

Yield is the ultimate criterion, which a plant breeder has always to keep in mind while screening new genotype in crop plant. However, seed yield is the most complex character governed by polygenes. It is generally difficult to make selections for such a complex character directly. Therefore, greater variability among characters and in depth knowledge of the association of characters under study is prerequisite. Hence, the extent of genetic variability present in the population and knowledge of association of component characters is of vital importance in formulating effective selection programme.

The present study was, therefore, undertaken with a view to estimate the various genetic variability parameters and to examine the interrelationship of characters in genotypes of pigeon pea (*Cajanus cajan* (L.) Millsp.). The results obtained have been discussed in detail in this chapter.

5.1 General performance of Genotypes

5.1.1 Genetic variability

Genetic variability is the prime requirement for crop breeding programme. Hence, plant breeder always interested in collecting or creating variability through exploration and recombination. Moreover, plant breeder should know thoroughly the nature and expression of different characters and range of variability present in a population of crop before adopting different methods. Assessment of variability in the population therefore becomes the basic requirement for any breeding programme.

In present investigation, wide range of variation was observed among the genotypes for all the characters studied. The characters showing significant mean sum of squares for all the characters indicated the extent of variability existed in the population.

The character plant height is an important character in pigeon pea. In Konkan, pigeon pea is generally grown on rice bunds. In this case, tall varieties may not thrive well and hence dwarf varieties are preffered. The character plant height and days to initiation of flowering showed high range of variation. Genotype ICPH 2671 (70.43 cm) was the tallest and genotype ICPL 20340 (61.47 cm) was the dwarfest one, whereas genotype ICPL 11249 (57 days) and ICPL 11263 (57 days) were earliest in initiation of flowering followed by genotype ICPL 11255 (58 days) while genotype ICP 8863 and ICPL 87119 (89 days) were late in first flowering. Chandra *et al.* (1975), Dodake *et al.* (2009), Vijayalakshmi *et al*. (2013) and Sharma *et al.* (2014) also reported wide range of variation for these characters in pigeon pea. Wide genetic variability for plant height was also reported by Aher *et al.* (1998).

In the present investigation, attempt was made to find out early lines as it may help in developing short duration mechanism in genotypes by finishing life span in shorter time. Early the 50 per cent flowering, early will be the maturity. ICPL 11255 (65.33 days), ICPL 20338 (65.33 days) were earliest in 50 per cent flowering followed by ICPL 20340 (65.67 days), while ICPL 11249 and ICPL 20338 (107.33 days) found to be earliest in duration to maturity. Chandra *et al.* (1975), Dodake *et al.* (2009), Vijayalakshmi *et al.* (2013) and Sharma *et al.* (2014) reported wide range of variation for the characters associated with flowering and maturity. Aher *et al.* (1998) also found wide genetic variability for days to 50 per cent flowering.

Another important character having direct bearing on yield are number of primary branches per plant and number of pods per plant. More the branches more will be the number of pods and ultimately more will be the yield. Considerable variation was noticed in characters, number of primary branches per plant and number of pods per plant. Genotype ICPH 2671 (7.90) recorded maximum primary branches per plant, while ICP 7035 (111.67) had maximum number of pods per plant. This result is in conformation with Dodake *et al.* (2009), Vijayalakshmi *et al.* (2013), Sharma *et al.* (2014), Rao and Rao (2015) and Venketeswarlu (2001) observed maximum variability for number of pods per plant.

Pod length, pod breadth and number of seeds per pod are important yield contributing characters. More the pod length more will be the number of seed which results into more yield. For the character pod length, ICPL 20325 (5.72 cm) recorded maximum pod length while ICP 7035 (8.13 mm) had maximum pod breadth. The number of seeds per pod varied from a minimum of 2.87 in ICP 8863 to maximum of 5.80 in ICPL 11285. These results are in confirmation with Dodake *et al.* (2009), Vijayalakshmi *et al.* (2013) and Sharma *et al.* (2014).

Hundred seed weight is another important yield contributing character. Most of the pulses with bigger size of the seeds are preferred by the consumers. However, in pigeon pea both small and large size seeds are preferred by the consumers. Maximum hundred seed weight was observed for genotype ICP 7035 (17.00 g) which indicated boldness of seed and minimum was observed for ICPL 20333 (7.17 g). Similar kind of result was also observed by Dodake *et al.* (2009), Vijayalakshmi *et al.* (2013) and Sharma *et al.* (2014).

Considerable amount of variation was recorded in straw yield per plant (g) and harvest index. The genotype ICPL 12339 (44.30 g) recorded maximum straw yield per plant, while genotype ICPL 11255 (29.53 g) recorded minimum straw yield per plant. For the character harvest index, the genotype ICPL 20329 (31.85) recorded maximum harvest index, while the genotype ICPL 12335 (11.74) recorded minimum harvest index. Similar results were also recorded by Dodake *et al.* (2009), Vijayalakshmi *et al.* (2013) and Sharma *et al.* (2014).

The genetic variability for complex variable like seed yield per plant, which is dependent on several plant characters, makes the breeder to broaden the genetic variability through breeding and selection. ICPL 20329 recorded highest grain yield per plant (17.17 g), whereas genotype ICPL 20340 (4.67) recorded lowest grain yield per plant. Similar kind of results were recorded by Dodake *et al.* (2009), Vijayalakshmi *et al.* (2013), Sharma *et al.* (2014) and Rao and Rao (2015). Khapre and Nerkar (1992) found highest genetic variability for grain yield per plant under intercrop sorghum.

5.2.2 Components of variation

The total variability in each of the eleven characters could be partitioned into three components *viz*., phenotypic, genotypic and environmental variation. This helps to determine heritable and non-heritable portion of variation in respect of characters under study. In present investigation genotypic variances were relatively smaller than phenotypic variances (Table 17).

Maximum phenotypic variance for thirty-four genotypes was found in number of pods per plant (618.14) followed by days to initiation of flowering (111.13), days to 50 per cent flowering (97.814), days to maturity (81.016), harvest index (29.381), straw yield per plant (14.831). Pod length (0.45) indicated lower magnitude of phenotypic variance. Similarly, maximum genotypic variance was observed in number of pods per plant (611.82) followed by days to initiation of flowering (91.33), days to 50 per cent flowering (85.840), days to maturity (68.804), while number of primary branches per plant (1.398), pod breadth (0.652) and number of seeds per pod (0.236) and pod length (0.200) had very low genotypic variance. These results are in conformity with those observed by Vijayalakshmi *et al.* (2013) in pigeon pea for most of the yield contributing characters.

The estimated data on genetic parameters revealed that genotypic and phenotypic variances were high for days to initiation of flowering indicating wide variability for this character. High values of genotypic and phenotypic variance for days to initiation of flowering were also reported by Chandra *et al.* (1975) and Sharma *et al.* (2014).

5.2.3 Coefficient of variation

A unit free tool of evaluation is highly essential for comparing the characters measured in diverse units. Unlike the variance, coefficient of variation provides an excellent means for such need. Phenotypic value being the aggregate of genotypic effect and environmental influence. Selection solely based on external parameters may be misleading. Thus, in comparison with its phenotypic counterpart, genotypic coefficient of variation is more precise and true indicator of extent of genetic variability in population.

It can be discussed from the present investigation that, PCV was found to be higher than genotypic coefficient of variation for all the traits studied. It was found that the characters exhibited maximum magnitude of phenotypic coefficient of variation were grain yield per plant (37.97%), number of pods per plant (36.686%), harvest index (30.816%), hundred seed weight (21.64%), number of primary branches per plant (20.57%), number of seeds per pod (18.099%), and days to initiation of flowering (15.727%) whereas least magnitude of phenotypic coefficient of variation was recorded for the characters days to 50 per cent flowering (12.956%), pod breadth (12.694%), straw yield per plant (10.418%), days to maturity (7.669%) and plant height (4.027%). Highest value of genotypic coefficient of variation was registered for number of pods per plant (36.498%), harvest index (28.194%), hundred seed weight (20.527%), number of primary branches per plant (20.386%) and days to initiation of flowering (14.257%). The character plant height (3.955%) exhibited minimum genotypic coefficient of variation followed by days to maturity (7.068%), pod length (9.357%) and straw yield per plant (9.447%). These results are in agreement with Rathanaswamy *et al.* (1973), Shoram (1983), Balyan and Sudhakar (1985), Khapre *et al.* (1993) and Rao and Rao (2015) in pigeon pea.

5.2.4 Heritability and genetic advance

Heritability gives an idea about the contribution of genotype in the expression of the character as it were the true component that transfers to the next generation and accordingly the selection pressure could be applied on such characters. Similarly, genetic advance gives the idea about selection advantage.

In present study, high estimates of broad sense heritability were observed for all the characters studied. Heritability estimates was highest for number of pods per plant (98.977%) followed by number of primary branches per plant (98.144%), pod breadth (97.318%), hundred seed weight (90.057%) and grain yield per plant (89.312%). Heritability estimates for other characters like days to initiation of flowering, straw yield per plant, harvest index, days to maturity, days to 50 per cent flowering and plant height ranged between 82.183 to 88.403 per cent. These results are in agreement with Rathanaswamy *et al.* (1973), Patil *et al.* (1989) and Rao and Rao (2015) in pigeon pea.

Genetic advance is a measure of expected progress under selection scheme. At present investigation, the genetic advance ranged between 0.615 in pod length to 50.692 in number of pods per plant. The estimates of genetic advance as per cent of mean ranged from 7.662 per cent in plant height to 74.800 per cent in number of pods per plant. Higher estimates of genetic advance as per cent of mean was recorded by number of pods per plant (74.800%), grain yield per plant (69.859%), harvest index (53.138%), number of primary branches per plant (41.604%) and hundred seed weight (40.148%) indicated the role of selection for improvement of these characters. Low genetic advance as per cent of mean was recorded in plant height (7.662%), pod length (12.859%), days to maturity (13.418%), straw yield per plant (17.647%) and number of seeds per pod (17.763%).

Broad sense heritability gives an idea about the portion of observed variability attributable to genetic differences. Heritability alone provides no information on the amount of genetic progress that would result from the selection. High heritability estimates along with high genetic advance as percent were noticed for number of pods per plant (98.977%, 50.692%), days to 50 per cent flowering (87.798%, 17.879%), days to maturity (84.926%, 15.746%) and days to initiation of flowering (82.183%, 17.847%). It is therefore advocated to use appropriate selection procedure for improvement of these characters in general and yield in particular since high heritability coupled with high genetic advance reveals the presence of lesser environmental influence and prevalence of additive gene action in their expression. Similar kinds of results were also reported by Shoram (1983) for pods per plant in pigeon pea. Sharma *et al.* (2014), Rao and Rao (2015) also reported high heritability along with high genetic advance for number of pods per plant. High heritability estimates with low genetic advance as percent of mean were indicated by the characters pod breadth, straw yield per pant, days to maturity and plant height suggested the influence of non-additive gene action. Therefore, improvement of the traits which are having high heritability along with high genetic advance would be more effective if the selection pressure in the present material could be rigorously applied.

5.3 Correlation

Correlation studies at phenotypic and genotypic levels were made to resolve the degree and nature of association between yield and yield components. The knowledge of correlation is helpful in determining the relationship between yield and yield contributing characters. In the present investigation correlation studies at phenotypic and genotypic levels were made to determine the direction and magnitude of association between the characters (Table 19 and Table 20).

In the present studies, at phenotypic level, plant height showed highly significant correlation in positive direction with number of pods per plant, days to 50 per cent flowering, days to initiation of flowering, pod breadth, number of primary branches per plant, days to maturity, straw yield per plant, grain yield per plant, hundred seed weight, harvest index. The results also revealed comparatively higher degree of genotypic correlation coefficients than their phenotypic counterparts in all the characters. Studies indicated highly significant positive correlation of plant height with characters days to 50 per cent flowering, number of pods per plant, days to initiation of flowering, pod breadth, days to maturity, number of primary branches per plant, straw yield per plant, grain yield per plant, hundred seed weight and harvest index at genotypic level. Balyan and Sudhakar (1985), Bhongale and Raut (1987), Khapre and Nerker (1992), Salunke *et al*. (1995), Gowda *et al.* (1996), Aher *et al*. (1998) and Sharma *et al*. (2014) reported positive correlation of plant height with seed yield in pigeon pea.

Days to initiation of flowering showed highly significant positive correlation with days to 50 per cent flowering, days to maturity, number of primary branches per plant, number of pods per plant, straw yield per plant, pod breadth, hundred seed weight and highly significant but negative association only with number of seeds per pod at phenotypic level. At genotypic level, days to initiation of flowering had shown highly significant positive correlation with days to 50 per cent flowering, number of primary branches, days to maturity, number of pods per plant, straw yield per plant, pod breadth, hundred seed weight while highly significant negative association with number of seeds per pod. Aher *et al.* (1998) reported association of days to first flowering with grain yield in positive direction in pigeon pea.

Days to 50 per cent flowering showed highly significant positive correlation with days to maturity, number of pods per plant, number of primary branches per plant, straw yield per plant, pod breadth and hundred seed weight, however it had highly significant negative correlation noticed with number of seeds per pod at phenotypic level. At genotypic level, days to 50 per cent flowering had shown highly significant positive correlation with days to maturity, number of pods per plant, number of primary branches per plant, straw yield per plant, pod breadth, hundred seed weight, while negative significant correlation was observed with number of seeds per pod. Salunke *et al.* (1995), Dodake *et al.* (2009) and Sodavadiya *et al.* (2009) reported the significant positive correlation of this character with grain yield per plant which is contradictory to present investigation.

Days to maturity showed positive and highly significant association with number of pods per plant, number of primary branches per plant and hundred seed weight while it had negative and highly significant association with only number of seeds per pod at phenotypic level. At genotypic level, days to maturity had shown highly significant positive correlation with number of pods per plant, number of primary branches per plant, straw yield per plant, pod breadth, hundred seed weight and grain yield per plant. Kanade *et al.* (2010) reported the significantly negative association with grain yield which is contradictory to present investigation while Balyan and Sudhakar (1985), Khapre and Nerkar (1992) and Salunke *et al.* (1995) reported the significant and positive association of days to maturity with grain yield per plant.

Number of primary branches per plant indicated highly significant positive correlation with number of pods per plant, pod breadth, straw yield per plant and hundred seed weight while highly significant negative correlation was observed with number of seeds per pod and harvest index at phenotypic level. It showed highly significant positive correlation with number of pods per plant, pod breadth, straw yield per plant and hundred seed weight while it had noted highly significant negative correlation with number of seeds per pod and harvest index at genotypic level. Patil *et al.* (1989) indicated that grain yield was positively associated with number of branches per plant which is contradictory to present result.

Studies indicated highly significant positive association of number of pods per plant both at phenotypic and genotypic level with seed yield per plant, while that of negative significant association was noticed with number of seeds per pod at both phenotypic level and genotypic level. Gowda *et al.* (1996), Paul *et al.* (1996), Aher *et al.* (1998) and Bhadru *et al.* (2010) noted the positive and significant association of grain yield per plant with number of pods per plant

Pod length showed highly significant positive association with number of seeds per pod, pod breadth, harvest index and seed yield per plant at genotypic level, while it had noted highly significant positive correlation with number of seeds per pod, harvest index and pod breadth at phenotypic level. Analogous results were reported by Gowda *et al.* (1996) and Aher *et al.* (1998).

Pod breadth showed highly significant positive association with straw yield per plant, hundred seed weight and grain yield per plant at both phenotypic level and genotypic level. Analogous results were reported by Aher *et al.* (1998).

Number of seeds per pod showed highly significant positive correlation with harvest index and grain yield per plant at both phenotypic and genotypic level. It has highly significant negative correlation with hundred seed weight at genotypic level. Analogous results were reported by Balyan and Sudhakar (1985), Bhongale and Raut (1987), Gowda *et al.* (1996), Aher *et al.* (1998) and Sharma *et al.* (2014).

Hundred seed weight showed highly significant negative correlation with harvest index at both phenotypic and genotypic level. Patil *et al.* (1989), Salunke *et al.* (1995), Gowda *et al.* (1996) and Sodavadiya *et al.* (2009) reported significant and positive association of hundred seed weight with grain yield per plant but it is contradictory to present investigation.

Straw yield per plant showed highly significant negative correlation with harvest index.

For seed yield per plant most of the character namely harvest index, plant height, pod length, pod breadth, number of seeds per pod, number of pods per plant had shown positive association both at phenotypic and genotypic level. Whereas at genotypic level, seed yield per plant had shown significant positive correlation with days to maturity. This clearly indicates the role of these characters for expression of yield. As it mean for improving the yield focus on these characters by adopting proper selection methodology.

5.4 Path analysis

Correlation does not provide exact picture of the direct and indirect causes of such association, which can be understand through path analysis. Direct selection of any character is useful when its direct effect is more or less the same magnitude as that of total effect and indirect selection is practiced when its indirect effect is responsible for bringing total effect. Thus path coefficient analysis is very useful tool to point out the important yield components which can be utilized for recommending selection indices. This gives the clear picture of the direct and indirect effects of the various traits on yield (Dewey and Lu, 1959).

The character plant height had positive direct effect on yield per plant at phenotypical level and negative direct effect at genotypic level. It had positive indirect effect on yield through days to initiation of flowering, days to maturity, number of seeds per pod, straw yield per plant and harvest index at both phenotypic and genotypic level. Sreelakshmi *et al.*(2010) reported plant height had maximum direct effect on grain yield per plant while Rao *et al.* (2013) reported negligible positive direct effect of plant height on grain yield per plant.

Days to initiation of flowering had significant positive correlation at both genotypic level and phenotypic level. Its indirect effect via days to maturity, number of seeds per pod, straw yield per plant was positive. Rao *et al.* (2013) reported days to flowering had negative direct effect on seed yield but indirect effects through plant height, number of pods per plant, test weight were positive. The character days to 50 per cent flowering had negative direct effect at both phenotypic and genotypic level. It had positive indirect effect on yield through days to initiation of flowering, days to maturity, number of seeds per pod and straw yield per plant at phenotypic and genotypic level. Chandirakala and Subbaraman (2010) and Saroj *et al.* (2010) reported days to 50 per cent flowering had high positive direct effect on grain yield per plant. Days to maturity had direct positive effect on yield per plant at both phenotypic and genotypic level. It had positive indirect effect on yield through days to initiation of flowering, number of seeds per pod, straw yield per plant at phenotypic and genotypic level. Chandirakala and Subbaraman (2010) and Sreelakshmi *et al.* (2010) revealed that days to maturity had positive direct effect on grain yield per plant.

Number of primary branches per plant had negative direct effect on yield per plant at both phenotypic and genotypic level. Indirect and positive effect through days to initiation of flowering, days, number of seeds per pod, straw yield per plant at phenotypic and genotypic level were noticed for these characters. Sreelakshmi *et al.* (2010) reported that number of primary branches per plant had negative correlation with grain yield per plant. Saroj *et al.* (2010) reported that number of primary branches per plant had positive direct effect on grain yield per plant.

Number of pods per plant had high positive direct effect at genotypic level while negative direct effect at phenotypic level on yield per plant. It had high positive indirect effect through days to initiation of flowering, days to maturity, number of seeds per pod, straw yield per plant and harvest index at phenotypic and genotypic level. Vange and Egbe Moses (2009), Sreelakshmi *et al.* (2010), Thanki and Sawargaonkar (2013), Garje *et al.* (2014) reported positive direct effect of number of pods per plant on grain yield per plant. Pod length had negative direct effect at phenotypic and positive direct effect at genotypic level. It had positive indirect effect through days to 50 per cent flowering, number of primary branches per plant, straw yield per plant, harvest index at both phenotypic and genotypic level. Vange and Moses (2009), Chandirakala and Subbaraman (2010) revealed that pod length gave positive direct effect on grain yield per plant. Pod breadth had negative direct effect on grain yield per plant at both phenotypic and genotypic level. It had positive indirect effect via days to initiation of flowering, days to maturity, number of seeds per pod harvest index. Number of seeds per pod had negative direct effect at phenotypic level and genotypic level on yield per plant. It had positive indirect effect on yield per plant through number of primary branches per plant, pod breadth, harvest index. Chandirakala and Subbaraman (2010) revealed that number of seeds per pod had positive direct effect on grain yield per plant. Hundred seed weight had positive direct effect at phenotypic and negative direct effect at genotypic level on yield per plant. It had positive indirect effects days to initiation of flowering, days to maturity, number of seeds per pod and straw yield per plant at phenotypic and genotypic level. Saroj *et al.* (2010), Thanki and Sawargaonkar (2010), Rao *et al.* (2013) revealed that hundred seed weight had positive direct effect on grain yield per plant.

The character straw yield per plant showed positive direct effect on grain yield per plant at both phenotypic and genotypic level. It had positive indirect contribution via days to initiation of flowering, days to maturity, number of seeds per pod at phenotypic and genotypic level. The character harvest index had positive direct effect on grain yield per plant at both phenotypic and genotypic level. It had positive indirect contribution via days to 50 per cent flowering, number of primary branches per plant. Thanki and Sawargaonkar (2010) reported that the hundred seed weight had positive direct effect on grain yield per plant.

Residual effect values at both genotypic and phenotypic level is very low for most of the characters have been studied. As it were the results were almost full proof for drawing interpretations.

5.5 Ranking and selection

Most of the genotypes under investigation had variation for various characters. As no single genotype had all the promising characters, it would be better to isolate the genotypes having more number of desirable traits. List of Promising genotype is denoted in Table 23.

Table 23. Promising genotypes of Pigeon pea.

Genotype	Seed yield per plant (g)	Number of pods per plant	Number of seeds per pod	Plant height (cm)	Number of primary branches per plant	Genotype rank
ICPL 20329	17.17	71.37	4.00	68.57	5.60	I
ICPL 20326	13.87	98.03	4.00	68.33	4.83	II
ICPL 20328	12.43	88.80	4.00	69.40	5.43	III
ICPL 11318	11.80	58.10	4.00	62.30	5.55	IV
ICPL 20325	11.67	73.07	5.07	66.97	5.67	V
ICPL 11242	11.50	54.63	3.87	65.77	4.80	VI
ICPL 20333	10.93	69.40	3.87	67.43	5.87	VII
ICPL 11244	9.80	65.90	3.93	66.10	5.67	VIII
ICPL 11298	9.13	54.37	3.87	64.73	5.63	IX
ICPL11285	8.77	34.93	5.80	63.57	3.93	X
ICPL 11245	8.67	66.27	3.87	67.23	6.10	XI
ICPL 20335	8.57	52.50	3.53	65.60	4.90	XII
ICP 7035	8.47	111.67	3.80	69.50	7.80	XIII
ICPL 11300	8.10	54.97	5.47	66.33	5.00	XIV
ICPH 2671	7.73	98.57	3.64	70.43	7.90	XV

However, on the basis of performance of yield and important yield attributing characters, genotypes can be selected (Table 23) for studies. The characters with high variability, relative economic importance and their strong association with seed yield per plant were selected for evaluation of promising genotypes having more worth for exploitation in further generations.

CHAPTER VI

SUMMARY AND CONCLUSION

The present investigation entitled, "Evaluation of Early Genotype of Pigeon Pea (*Cajanus cajan* (L.) Millsp.)" was undertaken with the following objectives

1. To study the range of genetic variability present in yield and yield components of pigeon pea crop
2. To find out association between yield and yield contributing characters
3. To identify promising cultures

The material for the present study comprised of thirty-four genotypes of pigeon pea collected from ICRISAT, Hyderabad. Twenty-five plants per genotype per replication were sown. Observations were recorded on thirteen characters *viz*., plant height, days to initiation of flowering, days to 50 per cent flowering, days to maturity, number of primary branches per plant, number of pods per plant, pod length, pod breadth, number of seeds per pod, hundred seed weight, straw yield per plant, harvest index and grain yield per plant.

The analysis of variance revealed significant variation among the genotypes for all the characters studied. The estimates of mean sum of squares showed comparatively wide range of variation for the characters number of pods per plant and days to initiation of flowering, while the lowest variation was recorded for pod length.

Among the genotypes, ICPL 20340 was the dwarfest, while genotype ICPH 2671 was the tallest. ICPL 11249 and ICPL 11263 were earliest to days to initiation of flowering while ICPL 11255 and ICPL 20338 were earliest in days to 50 per cent flowering; ICPL 11249 and ICPL 20338 were earliest to attain the maturity. Maximum number of primary branches per plant was recorded in genotype ICPH 2671.

The genotype ICP 7035 recorded maximum number of pods per plant. The genotype ICPL 20325 showed maximum value for pod length. The genotype ICPL 7035 showed maximum value for pod breadth whereas maximum number of seeds per pod was recorded in ICPL 11285. The genotype ICPL 20329 (17.17 g) recorded maximum grain yield per plant. The genotype ICP 7035 recorded maximum hundred seed weight. The genotype ICPL 11339 recorded maximum straw yield per plant whereas maximum harvest index was recorded in ICPL 20329.

The estimates of phenotypic, genotypic and environmental variances revealed that phenotypic variances were higher than genotypic variances for all the characters studied. Most of the characters showed comparatively higher estimates of environmental variance indicating the influence of environment on those characters.

In general, phenotypic coefficient of variation was higher in magnitude over the respective genotypic coefficient of variation for all the characters studied. Different characters showed varying per cent of coefficient of variation at both phenotypic and genotypic levels. High genotypic and phenotypic coefficients of variation were observed for the characters, number of pods per plant, grain yield per plant, harvest index, hundred seed weight and number of primary branches per plant while these were low for the characters plant height, days to maturity and straw yield per plant.

Appreciable heritability values were observed for the characters under study. Highest heritability estimates were recorded for number of pods per plant, number of primary branches per plant, pod breadth, hundred seed weight and grain yield per plant.

Genetic advance was found to be highest for number of pods per plant. The characters number of pods per plant, grain yield per plant, harvest index, number of primary branches per plant and hundred seed weight showed comparatively higher estimates of genetic advance as per cent of mean.

High estimates of heritability coupled with higher genetic advance as per cent of mean was observed for number of pods per plant, days to 50 per cent flowering, days to maturity and days to initiation of flowering thus indicating the role of additive gene action in the expression of these characters.

In the present investigation, the genotypic correlation coefficients were higher in magnitude than their phenotypic counterparts for most of the characters. Harvest index, plant height, pod length, pod breadth, number of seeds per pod and number of pods per plant exhibited highly significant positive correlation with grain yield per plant at both phenotypic and genotypic levels. The character days to maturity had significant positive correlation with grain yield per plant only at genotypic level.

Path coefficient analysis revealed that the characters *viz*., days to initiation of flowering, days to maturity, straw yield per plant, harvest index had positive direct effect on grain yield at both phenotypic and genotypic levels while days to 50 per cent flowering, number of primary branches, pod breadth, number of seeds per pod exhibited negative direct effect on grain yield per plant at both phenotypic and genotypic level. Number of pods per plant and pod length exhibited negative direct effect on grain yield per plant at phenotypic level and positive direct effect on seed yield per plant at genotypic level. Hundred seed weight exhibited positive direct effect on grain yield per plant at phenotypic level whereas exhibited negative direct effect on grain yield per plant at genotypic level.

CONCLUSION

By and large, wide range of variation was noticed in genotypes of pigeon pea. The characters *viz*., number of pods per plant, grain yield per plant, harvest index, hundred seed weight and number of primary branches per plant showed comparatively higher estimates of genotypic and phenotypic coefficients of variation indicating high level of variability and ample scope for effective improvement. These characters also had higher estimates of heritability coupled with high genetic advance as per cent of mean indicated additive gene action. Correlation studies revealed strong positive association of seed yield per plant with harvest index, pod length and plant height, number of seeds per pod, pod breadth and number of pods per plant both at phenotypic and genotypic levels, which suggested to pay attention to these characters along with yield. The path analysis studies indicated that the characters plant height, days to initiation of flowering, days to maturity, number of pods per plant, pod length, hundred seed weight, straw yield per plant and harvest index had direct bearing on seed yield per plant in pigeon pea population under study.

The genotypes ICPL 20329, ICPL 20326, ICPL 20328, ICPL 11318, ICPL 20325, ICPL 11242 and ICPL 20333 are observed as promising genotypes in the studied population as these genotypes performed well for most of the important quantitative traits, need to be tested in adaptive trials for incorporating in stability analysis and coming programme as well.

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APPENDIX - II

Meteorological data of the crop season *Rabi*, 2014-15

MW No.	Date		Temperature (^{0}C)		RH (%)		Wind speed (km/h)	Total rainfall (mm)	Rainy days
	From	To	Max.	Min.	Morn.	Even.			
45	05-11-2014	11-11-2014	33.9	17.2	89	58	2.4	0.0	0
46	12-11-2014	18-11-2014	32.3	21.5	91	65	2.6	4.4	1
47	19-11-2014	25-11-2014	33.3	18.8	88	51	2.1	0.0	0
48	26-11-2014	02-12-2014	33.2	14.4	87	39	2.2	0.0	0
49	03-12-2014	09-12-2014	33.2	19.0	88	36	2.3	0.0	0
50	10-12-2014	16-12-2014	31.8	17.4	88	57	2.6	0.2	0
51	17-12-2014	23-12-2014	31.3	12.6	82	39	3.0	0.0	0
52	24-12-2014	31-12-2014	30.2	13.0	86	44	2.6	0.0	0
1	01-01-2015	07-01-2015	29.1	15.0	84	51	2.6	0.0	0
2	08-01-2015	14-01-2015	30.4	9.6	83	44	2.6	0.0	0
3	15-01-2015	21-01-2015	30.5	11.7	87	55	2.5	0.0	0
4	22-01-2015	28-01-2015	29.4	14.5	90	66	3.4	0.0	0
5	29-01-2015	04-02-2015	32.4	14.1	89	52	3.1	0.0	0
6	05-02-2015	11-02-2015	32.0	12.7	91	41	3.1	0.0	0
7	12-02-2015	18-02-2015	33.0	12.0	87	44	3.2	0.0	0
8	19-02-2015	25-02-2015	33.4	14.0	88	43	3.3	0.0	0
9	26-02-2015	04-03-2015	28.8	14.5	90	64	4.5	60.4	2
10	05-03-2015	11-03-2015	31.4	15.1	87	58	4.0	0.0	0
11	12-03-2015	18-03-2015	30.2	13.1	88	64	4.1	0.0	0
12	19-03-2015	25-03-2015	29.3	15.2	84	66	3.2	0.0	0
13	26-03-2015	01-04-2015	33.0	12.0	89	58	4.5	0.0	0

APPENDIX I

ABBREVIATIONS USED

ANCOVA	:	Analysis of covariance
ANOVA	:	Analysis of variance
@	:	At the rate of
CD	:	Critical difference
cm	:	Centimeter (s)
^{0}C	:	Degree Celsius
d.f.	:	Degrees of freedom
EMS	:	Error mean sum of square
Fig.	:	Figure
et al.	:	And others
g	:	Gram
GAM	:	Genetic advance as percentage of mean
GCV	:	Genotypic coefficient of variation
h^2	:	Heritability (broad sense)
i.e.	:	That is
MSS	:	Mean sum of squares
MW	:	Meteorological week
PCV	:	Phenotypic coefficient of variation
%	:	Per cent
S.E.	:	Standard error
via	:	Through
viz.,	:	Namely
SS		Sum of squares
GMS	:	Genotypic mean sum of squares

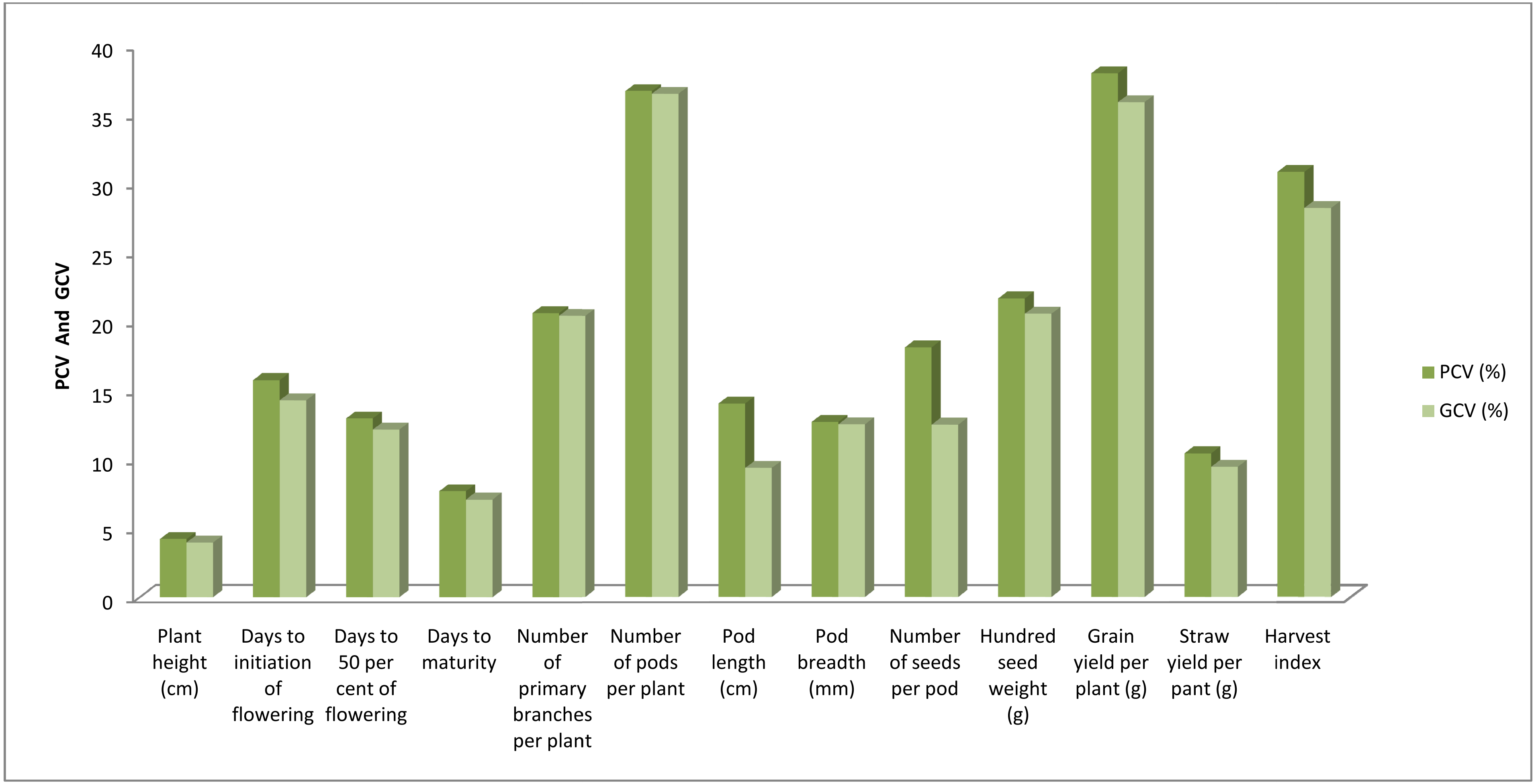

Fig. 1 Phenotypic and genotypic coefficient of variation in Pigeon pea

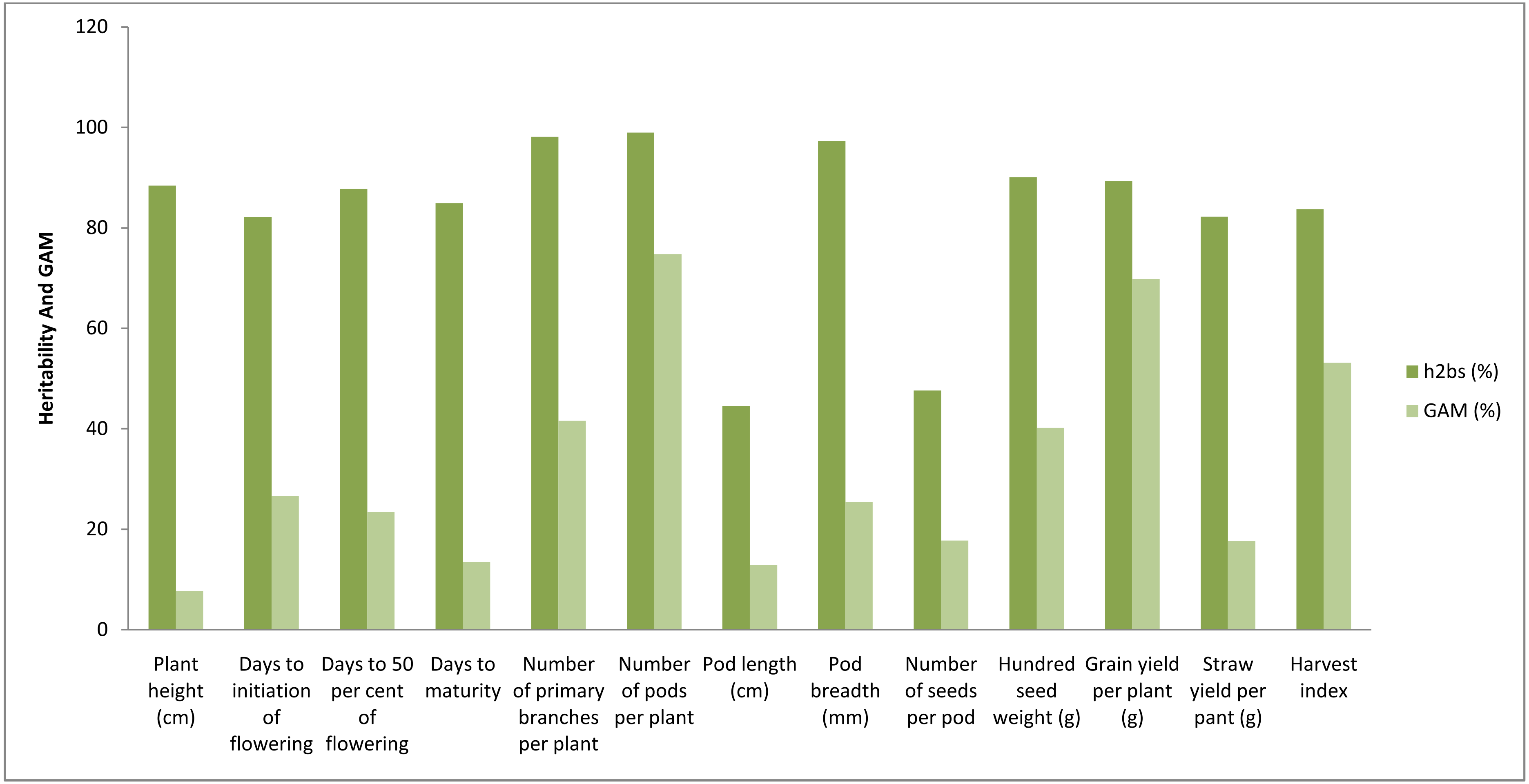

Fig. 2 Heritability and genetic advance as per cent of mean in Pigeon pea

Plate I : General view of field plot

Plate II : Height variation in pigeon pea

ICPL 20329

ICPL 20326

ICPL 20328

ICPL 11318

Plate V :Superior genotypes

Plate III : variation in pod length

Plate IV : Variation in number of seeds per pod

Table 19. Estimates of phenotypic correlation coefficient between different characters in pigeon pea

	Plant height (cm)	Days to initiation of flowering	Days to 50 per cent flowering	Days to maturity	No. of primary branches per plant	No. of pods per plant	Pod length (cm)	Pod breadth (mm)	No. of seeds per pod	Hundred seed weight (g)	Straw yield per plant (g)	Harvest index	Grain yield per plant (g)
Plant height (cm)	-	0.715**	0.738**	0.641**	0.650**	0.771**	0.009	0.697**	-0.103	0.257**	0.530**	0.214*	0.347**
Days to initiation of flowering		-	0.913**	0.790**	0.779**	0.746**	-0.145	0.577**	-0.254**	0.421**	0.581**	-0.151	-0.016
Days to 50 per cent flowering			-	0.884**	0.806**	0.814**	-0.104	0.637**	-0.245*	0.352**	0.671**	-0.125	0.028
Days to maturity				-	0.731**	0.767**	-0.187	0.581**	-0.264**	0.213*	0.578**	-0.088	0.041
No. of primary branches					-	0.864**	-0.077	0.670**	-0.316**	0.430**	0.596**	-0.211*	-0.087
No. of pods per plant						-	-0.031	0.722**	-0.207*	0.330**	0.675**	0.044	0.197*
Pod length(cm)							-	0.256**	0.500**	-0.088	0.095	0.331**	0.344**
Pod breadth (mm)								-	-0.004	0.203*	0.554**	0.161	0.272**
No. of seeds per pod									-	-0.151	0.027	0.230*	0.220*
Hundred seed weight (g)										-	0.106	-0.244*	-0.227*
Straw yield per plant (g)											-	-0.200*	0.043
Harvest index												-	0.963**

*Significant at 5% level **Significant at 1% level

Table 20. Estimates of genotypic correlation coefficient between different characters in pigeon pea

	Plant height (cm)	Days to initiation of flowering	Days to 50 per cent flowering	Days to maturity	No. of primary branches per plant	No. of pods per plant	Pod length (cm)	Pod breadth (mm)	No. of seeds per pod	Hundred seed weight (g)	Straw yield per plant (g)	Harvest index	Grain yield per plant (g)
Plant height (cm)	-	0.821**	0.852**	0.742**	0.685**	0.829**	0.138	0.759	-0.103	0.288**	0.605**	0.275**	0.397**
Days to initiation of flowering		-	0.985**	0.843**	0.870**	0.823**	-0.127	0.653**	-0.343**	0.470**	0.709**	-0.138	0.016
Days to 50 per cent flowering			-	0.931**	0.871**	0.871**	-0.110	0.700**	-0.327**	0.357**	0.793**	-0.113	0.062
Days to maturity				-	0.805**	0.847**	-0.169	0.633**	-0.325**	0.221*	0.736**	-0.081	0.076**
No. of primary branches					-	0.872**	-0.099	0.686**	-0.445**	0.471**	0.650**	-0.228*	-0.094
No. of pods per plant						-	-0.047	0.738**	-0.290**	0.356**	0.740**	0.044	0.204*
Pod length(cm)							-	0.413**	0.530**	-0.116	0.156	0.403**	0.433**
Pod breadth (mm)								-	-0.012	0.224*	0.640**	0.164	0.285**
No. of seeds per pod									-	-0.212*	-0.031	0.341**	0.333**
Hundred seed weight (g)										-	0.118	-0.273**	-0.250*
Straw yield per plant (g)											-	-0.127	0.085
Harvest index												-	0.976**

*Significant at 5% level **Significant at 1% level

Table 21. Path analysis for different characters at phenotypic level in Pigeon pea

	Plant height (cm)	Days to initiation of flowering	Days to 50 per cent flowering	Days to maturity	No. of primary branches per plant	No. of pods per plant	Pod length (cm)	Pod breadth (mm)	No. of seeds per pod	Hundred seed weight (g)	Straw yield per plant (g)	Harvest index	Grain yield per plant (g)
Plant height (cm)	**0.042**	0.01590	-0.02530	0.00044	-0.02064	-0.00146	-0.00002	-0.02920	0.00132	0.00089	0.14646	0.21688	0.347**
Days to initiation of flowering	0.02994	**0.022**	-0.03131	0.00054	-0.02473	-0.00141	0.00036	-0.02417	0.00325	0.00145	0.16052	-0.15261	-0.016
Days to 50 per cent flowering	0.03089	0.02030	**-0.034**	0.00061	-0.02557	-0.00154	0.00026	-0.02668	0.00312	0.00122	0.18538	-0.12617	0.028
Days to maturity	0.02684	0.01756	-0.03031	**0.001**	-0.02320	-0.00145	0.00047	-0.02433	0.00337	0.00074	0.15958	-0.08869	0.041
No. of primary branches	0.02723	0.01732	-0.02762	0.0005	**-0.032**	-0.00163	0.00019	-0.02805	0.00403	0.00148	0.16459	-0.21378	-0.087
No. of pods per plant	0.03226	0.01660	-0.02790	0.00053	-0.02741	**-0.002**	0.00008	-0.03025	0.00264	0.00114	0.18635	0.04451	0.197*
Pod length(cm)	0.00039	-0.00322	0.00357	-0.00013	0.00244	0.00006	**-0.002**	-0.01070	-0.00639	-0.000030	0.02611	0.33498	0.344**
Pod breadth (mm)	0.02919	0.01283	-0.02185	0.00040	-0.02126	-0.00137	-0.00064	**-0.042**	0.00005	0.00070	0.15288	0.16331	0.272**
No. of seeds per pod	-0.0043	-0.00565	0.00839	-0.00018	0.01002	0.00039	-0.00125	0.00015	**-0.013**	-0.00052	-0.00744	0.23325	0.220*
Hundred seed weight (g)	0.01077	0.00937	-0.01208	0.00015	-0.01366	-0.00062	0.00022	-0.00851	0.00193	**0.003**	0.02940	-0.24764	-0.227*
Straw yield per plant (g)	0.02220	0.01292	-0.02302	0.00040	-0.01892	-0.00128	-0.00024	-0.02318	0.00034	0.00037	**0.276**	-0.20252	0.043
Harvest index	0.00896	-0.00335	0.00427	-0.00006	0.00670	-0.00008	-0.00083	-0.00675	-0.00294	-0.00084	-0.05520	**1.013**	0.963**

*Significant at 5% level Note : Bold figures indicate direct effects

**Significant at 1% level

Residual effect = 0.01237

Table 22. Path analysis for different characters at genotypic level in Pigeon pea

	Plant height (cm)	Days to initiation of flowering	Days to 50 per cent flowering	Days to maturity	No. of primary branches per plant	No. of pods per plant	Pod length (cm)	Pod breadth (mm)	No. of seeds per pod	Hundred seed weight (g)	Straw yield per plant (g)	Harvest index	Grain yield per plant (g)
Plant height (cm)	**-0.017**	0.32697	-0.32234	0.07083	-0.08274	0.12495	0.00743	-0.03132	0.00079	-0.01164	0.11503	0.26987	0.397**
Days to initiation of flowering	-0.05796	**0.398**	-0.37279	0.08055	-0.10509	0.12397	-0.00681	-0.02694	0.00263	-0.01898	0.13466	-0.13584	0.016
Days to 50 per cent flowering	-0.06014	0.39284	**-0.379**	0.08889	-0.10524	0.13123	-0.00594	-0.02889	0.00251	-0.01442	0.15081	-0.11106	0.062
Days to maturity	-0.05237	0.33595	-0.35228	**0.096**	-0.09727	0.12758	-0.00910	-0.02609	0.00250	-0.00892	0.13996	-0.07931	0.076**
No. of primary branches	-0.04836	0.34654	-0.32972	0.07691	**-0.121**	0.13141	-0.00534	-0.02830	0.00342	-0.01899	0.12348	-0.22440	-0.094
No. of pods per plant	-0.05855	0.32770	-0.32962	0.08086	-0.10534	**0.151**	-0.00252	-0.03046	0.00223	-0.01435	0.14060	0.04299	0.204*
Pod length(cm)	-0.00974	-0.05040	0.04180	-0.01615	0.01200	-0.00707	**0.054**	-0.01704	-0.00407	0.00469	0.02959	0.39573	0.433**
Pod breadth (mm)	-0.05361	0.26015	-0.26511	0.06042	-0.08290	0.11129	0.02223	**-0.041**	0.00009	-0.00906	0.12158	0.16145	0.285**
No. of seeds per pod	0.00728	-0.13654	0.12361	-0.03102	0.05371	-0.04377	0.02853	0.00049	**-0.008**	0.00855	-0.00590	0.33539	0.333**
Hundred seed weight (g)	-0.02036	0.18740	-0.13522	0.02112	-0.05685	0.05360	-0.00626	-0.00926	0.00163	**-0.040**	0.02248	-0.26785	0.250*
Straw yield per plant (g)	-0.04274	0.28223	0.30033	0.07033	-0.07848	0.11148	0.00838	-0.02639	0.00024	-0.00477	**0.190**	-0.12476	0.085
Harvest index	-0.01940	-0.05509	0.04280	-0.00771	0.02760	0.00660	0.02168	-0.00678	-0.00262	0.01101	-0.02414	**0.982**	0.976**

*Significant at 5% level
**Significant at 1% level

Note : Bold figures indicate direct effects
Residual effect = 0.00175

Table 3. Mean performance of Pigeon pea for different quantitative characters

Genotypes	Plant height (cm)	Days to initiation of flowering	Days to 50 per cent flowering	Days to maturity	No. of primary branches per plant	No. of pods per plant	Pod length (cm)	Pod breadth (mm)	No. of seeds per pod	Hundred seed weight (g)	Straw yield per plant (g)	Harvest index	Grain yield per plant (g)
ICPL 11249	63.30	57.00	66.67	107.33	4.70	39.03	4.13	5.20	3.93	9.67	32.80	13.39	5.07
ICPL 11263	63.43	57.00	66.00	108.00	4.37	34.80	4.90	5.23	4.13	7.67	36.40	12.76	5.33
ICPL 20341	63.10	59.00	67.33	109.00	5.77	51.60	4.30	5.27	3.93	9.33	32.13	14.95	5.63
ICPL 11252	63.80	58.33	66.67	108.33	4.67	34.30	4.13	5.50	3.48	10.00	34.70	15.20	6.20
ICPL 11255	62.47	58.00	65.33	107.67	4.70	42.93	4.57	5.63	3.67	9.67	29.53	15.13	5.20
ICPL 20338	62.90	58.33	65.33	107.33	5.70	53.07	4.67	5.00	4.10	9.33	34.17	13.59	5.37
ICPL 20340	61.47	59.00	65.67	108.00	5.20	47.20	3.93	6.17	3.33	7.33	31.83	12.81	4.67
ICPL 20336	62.97	59.33	67.67	110.00	4.17	33.77	4.16	5.40	3.39	9.47	333.50	16.77	6.73
ICPL 11256	62.90	60.33	68.33	111.00	4.10	32.60	5.37	5.53	4.00	7.67	31.97	14.00	5.20
ICPL 11259	63.83	60.33	68.33	109.67	4.83	41.10	5.17	6.03	3.80	8.33	35.33	14.46	5.97
ICPL 11298	64.73	59.00	69.33	112.67	5.63	54.37	5.01	6.37	3.87	7.67	33.43	21.53	9.13
ICPL 11318	62.30	59.00	71.00	112.67	5.553	58.10	5.10	6.07	4.00	8.83	35.70	24.85	11.80
ICPL 11300	66.33	60.00	71.00	111.00	5.00	54.97	5.07	6.83	5.47	8.50	37.47	17.68	8.10
ICPL 11285	63.57	62.00	73.33	114.00	3.93	34.93	5.17	6.50	5.80	7.50	39.60	18.21	8.77
ICPL 11242	65.77	61.33	71.67	113.67	4.80	54.63	5.53	6.13	3.87	7.33	37.60	23.65	11.50
ICPL 11244	66.10	61.00	71.67	112.00	5.67	65.90	5.01	6.37	3.93	7.83	36.67	21.15	9.80
ICPL 11245	67.23	60.67	72.67	115.67	6.10	66.27	5.00	7.17	3.87	8.00	34.23	20.16	8.67
ICPL 20333	67.43	67.00	75.33	117.67	5.87	69.40	4.93	7.37	3.87	7.17	34.17	24.40	10.93
ICPL 20335	65.60	64.00	72.33	118.33	4.90	52.50	4.57	7.00	3.53	7.33	36.50	19.14	8.57
ICPL 20329	68.57	68.33	79.00	120.00	5.60	71.37	5.37	6.90	4.00	7.17	37.13	31.85	17.17

Contd…..

Genotypes	Plant height (cm)	Days to initiation of flowering	Days to 50 per cent flowering	Days to maturity	No. of primary branches per plant	No. of pods per plant	Pod length (cm)	Pod breadth (mm)	No. of seeds per pod	Hundred seed weight (g)	Straw yield per plant (g)	Harvest index	Grain yield per plant (g)
ICPL 20325	66.97	65.33	74.00	117.67	5.67	73.07	5.72	6.73	5.07	7.17	37.00	24.45	11.67
ICPL 20328	69.40	71.33	79.33	119.67	5.43	88.80	4.37	6.57	4.00	8.33	38.03	25.05	12.43
ICPL 20326	68.33	64.67	76.00	116.67	4.83	98.03	5.67	6.20	4.00	7.50	37.20	27.28	13.87
ICPL 12335	64.20	68.00	85.00	134.67	6.60	85.57	4.32	6.27	3.13	7.33	41.97	11.74	5.57
ICPL 12336	66.33	83.33	86.00	126.00	6.80	85.47	4.14	5.97	3.72	9.83	41.93	13.63	6.6
ICPL 12337	68.80	69.00	85.33	125.67	6.47	90.70	5.01	7.23	3.67	9.50	41.13	13.26	6.30
ICPL 12338	67.53	74.00	85.33	126.00	6.87	98.73	4.43	6.70	3.80	10.00	41.40	12.39	5.87
ICPL 12339	68.77	74.33	84.67	120.33	7.43	100.13	4.78	7.53	3.42	7.33	44.30	12.02	6.07
ICPL 88039	65.00	71.67	82.00	125.33	7.67	105.03	5.13	7.87	3.87	8.50	43.13	13.80	6.90
ICP 8863	69.30	89.00	97.00	129.33	7.70	89.70	3.83	6.73	2.87	9.73	40.17	15.22	7.20
ICPL 87119	69.37	89.00	94.67	122.33	7.30	85.17	5.30	7.40	3.77	9.33	41.27	13.31	6.37
ICP 7035	69.50	82.67	87.67	122.00	7.80	111.67	5.43	8.13	3.80	17.00	39.57	17.73	8.47
ICPH 2671	70.43	83.33	89.00	129.67	7.90	98.57	4.60	7.37	3.64	11.33	38.70	16.68	7.73
ICPH 2740	69.90	84.33	94.67	140.67	7.50	101.73	3.89	6.90	3.67	10.00	36.17	15.78	6.77
Genaral mean	65.93	67.03	76.33	117.35	5.80	67.77	4.79	6.45	3.89	8.79	36.97	17.59	7.99
Min.	61.47	57	65.33	107.33	3.93	32.60	3.93	5	2.87	7.17	29.53	11.74	4.67
Max.	70.43	89	97	140.67	7.90	111.67	5.72	8.13	5.80	17	44.30	31.85	17.17
SE	0.5453	2.56905	1.99787	2.017	0.0938	1.4517	0.2887	0.0773	0.2944	0.3461	0.9373	1.2632	0.5725
CD @ 5%	1.5387	7.248	5.6367	5.692	0.2648	4.0960	0.8146	0.2183	0.8306	0.9765	2.6446	3.5639	1.6154