# STUDY OF GENETIC DIVERGENCE IN PIGEON PEA (*Cajanus cajan* (L.) Millsp.)

A Thesis submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH**

**(AGRICULTURAL UNIVERSITY)**

**RAHURI, District : Ahmednagar, ( Maharashtra )**

in partial fulfilment of the requirements for the degree of

Master of Science ( Agriculture )

in

Botany : Cytogenetics & Plant Breeding

By


Uddhav Raghunath Wagh

*B. Sc. ( Agri. )*


**DEPARTMENT OF BOTANY**

**Post-Graduate School, Rahuri**

**May, 1976**

AFFECTIONATELY DEDICATED

TO

MY PARENTS

# STUDY OF GENETIC DIVERGENCE IN PIGEON PEA

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By

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in partial fulfilment of the requirements for the degree of
MASTER OF SCIENCE ( AGRICULTURE )
in
BOTANY : CYTOGENETICS AND PLANT BREEDING

May, 1976.

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## : C E R T I F I C A T E :

This is to certify that the thesis entitled "Study of genetic divergence in pigeon pea ( *Cajanus cajan* (L.), Millsp. )", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirement for the degree of MASTER OF SCIENCE ( AGRICULTURE ) in CYTOGENETICS and PLANT BREEDING, embodies the results of a piece of bonafide research work carried out by Shri. Uddhav Raghunath Wagh under my guidance and supervision and that no part of the thesis has been submitted for any other degree or publication.

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# CHAPTER I

# I N T R O D U C T I O N

# CHAPTER I

# I N T R O D U C T I O N

Pigeon pea ( Cajanus cajan, (L.) Millsp.) locally known as tur, is an important pulse crop grown in India. Amongst the different pulses, it constitutes main source of proteins in Indian diet. Most of the pulses including 'tur' contain 20 to 30 per cent proteins on an oven dry basis, which is nearly three times the value found in cereals. Pulses also contain, Vitamin A, B, C and fat ( Chavan and Bhat, 1949 ).

Pulses constitute a group of crops of the leguminosae family which, with the help of the bacteria in their root nodules, fix atmospheric nitrogen and improve the soil fertility. They are generally included in rotation in most of the areas and have helped to keep soil alive and productive. Tur ( Cajanus cajan ) benefits the soil by opening up the sub-soil layer by means of its extensive and deep root system and also utilizes the limited available soil moisture more efficiently than many other crops. It also adds considerable amounts of organic matter in the form of the large root system left behind in the soil after harvest and enormous quantities of shed leaves. It was estimated in some experiments conducted at Pusa that a crop of arhar adds organic matter equivalent of 6 tonnes of cowdung manure per acre. It was also estimated that every year in India, pulse crops use about 1.2 lakh tonnes of atmospheric nitrogen.

Tur 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 its seed together with the part of the 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.

In India pulses are grown over an area of 22 million hectares producing about 9.8 million tonnes of grains. Total area of 2.576 million hectares was under cultivation of 'tur' with the production of 1.364 million tonnes, during the year 1973-74 in India. In Maharashtra State tur occupies an area of 627.9 thousand hectares producing 363.5 thousand tonnes of grain during 1973-74 (Anonymous, 1976 ).

Numerous types of pigeon pea are known, differing in height, time of maturity, colour, size and shape of pods and seeds. Shaw *et al.* ( 1933 ) have distinguished 86 different types from the collections made all over India. Mehta and Dave ( 1931 ) recognized 36 types from Madhya Pradesh alone. These types can be grouped broadly under two varieties, arhar ( *Cajanus cajan* var. bicolor D.C. ) and tur (*C. cajan* var. Flavus D.C. ). The arhar variety includes most of the perennial types and comprises generally of the late maturing, large, bushy plants, bearing purple streaked, yellow flowers and dark coloured pods, each having 4-5 seeds. The Tur variety comprises of the early maturing, smaller plants, bearing yellow flowers and plain pods, each containing 2-3 seeds. Tur varieties are commonly cultivated in the peninsular region and the late maturing arhar types are cultivated in U.P., Bihar, Bengal and Assam while both the types are cultivated in M.P.

In India, tur breeding work was initiated at the Pusa Institute in 1909 ( Howard et al., 1919 ). Work was also taken up latter bythe State Department of Agriculture mainly in Bombay, M.P., Madras, U.P., Hydrabad and Bihar. In Maharashtra tur research work commenced in the year 1930 at Nagpur as reported by Mehata and Dave in 1931 and in the year 1934 at Niphad ( Anonymous, 1959 ). The object of undertaking research on tur in India and in the State of Maharashtra was to develop bold grained high yielding varieties resistant to major diseases. As a result of systematic research in Maharashtra State few improved varieties like T-84, No.148, Tur-Hydrabad, P.T. 301, C-11, No. 290-21 (D'Cruz and Patil, 1966 ) have been released.

A comprehensive collection of cr p varieties is the base for any crop improvement programme. Phenotypically expressed diversity in respect of quantitative characters in such collections is due to the combined effect of genetic components and environmental influence. For the selection of economic varieties, it will be advantageous for the breeder to have a knowledge about the degree of influence, which the environment and the genetic components have on phenotypic variation. An estimate of the extent of variability available in populations would be of immense value to the breeder in efficiently designing his testing procedures to identify superior genotypes in a population.

Many of the present day good varieties have been obtained by selection from the local sorts, and as such the potentialities of the existing material must be assessed at the very out set. With the progress of the science of genetics it has been made clear that it is the genetic diversity in a crop that offers promise for its further improvement.

While a considerable amount of attention has been given to the study of mainly botanical characters for the purpose of classification of varieties in this crop, variation in respect of the important yield contributing characters does not seem to have been quantitatively assessed. The importance of such study to plant breeder is too obvious to need any emphasis. Economic breeding is concenred with genetic variability brought about by a group of genes, each having a small individual effect, and the fundamental nature of this variability involves the study of quantitative characters.

In tur the major economic characters are maturity, yield, resistance to diseases and pests, high quality protein content and good cooking quality.

Improvement by selection would depend upon two factors viz., the initial mean value of the material, and the amount of genetic variability present.

The extent of improvement that can be expected by carrying out a given degree of selection could be anticipated from the initial mean values in respect of the different economic characters in the varietal collection under study and from the amount of genetic variability present in it. A variety of tur having all, or most of the above desirable characters, and qualities, could be produced by means of sound breeding programme only when the varieties have been evaluated for their variability in respect of all these characters, which are essentially quantitative in nature. With careful study of a large number of varieties, much information could be gathered in regard to the functions and importance of the different attributes contributing to yield. Such varietal evaluation would also bring out the relative merits to the different varieties under study with respect to different characters, so that necessary crosses may be planned to combine the best among them.

It is often observed that few or more characters, qualitative or quantitative, may be correlated. A study of correlation in crop plants is, therefore, very profitable for understanding the extent to which it is feasible or otherwise to achieve, in single strain, the desirable combinations of economic characters. Hence the study of genetic divergence present in the crop is the first and the foremost item for a breeder to focus his attention on it.

In pigeon pea ( Cajanus cajan, L. ) a great amount of variability exists and the present study is undertaken to ascertain the actual and relative variability present in some yield contributing characters. It deals with a preliminary study of 79 tur varieties which would form the basis for subsequent work on genetic variability in respect of the yield contributing characters.

# CHAPTER II

# REVIEW OF LITERATURE

# CHAPTER II

## REVIEW OF LITERATURE

1. Cytological studies :

Basudeo Roy ( 1933 ) was the first to report the somatic chromosome number 2n = 22 of pigeon pea. Krishnaswamy *et al.*( 1935 ) observed the haploid chromosome number, n = eleven in pigeon pea. Kajjari ( 1956 ) also reported the chromosome number 2n = 22. Joglekar and Deshmukh ( 1958 ) and Deshmukh and Phirke ( 1962 ) reported the haploid chromosome number, n = 11, in different mutants. Recently Akinola *et al.* ( 1972 ), D'Cruz and Jadhav ( 1972 ) and Shrivastava and Joshi ( 1972 ) also reported that in pigeon pea 2n number is 22.

2. Polyploidy :

Kumar *et al.* ( 1945 ) induced auto-tetraploidy by the application of colchicine in arhar. Joshi ( 1966 ) reported that the tetraploids were late maturing and low yielding and produced highly sterile pollen compared with the diploids, and also stated, after cytological observations, that there was irregular meiosis with quadrivalent, trivalent and univalent formation. D'Cruz and Jadhav ( 1972 ) reported aneuploidy (2n + 1 ) with 23 chromosome, appeared to result in extra vigour of plant and seed. Shrivastava *et al.* (1972) induced tetraploids by the application of colchicine in pigeon pea variety T.21, and stated that tetraploids had reduced petiole length, increased stomata and pollen size, delayed maturity and considerable pollen sterility. All tetraploids had poor seed set and yield per plant as compared to diploid.

3. Anthesis and pollination :

The duration of the opening of flowers varies according to climate and environment which varies from place to place. The flowers which open in the evening usually remain open throughout the night and close before noon on the following day. Howard *et al.* ( 1919 ) observed that under pusa conditions, the flowers opened at any time during the day from 9 a.m. to 5 p.m. and remained open for about a day and half. The anthers burst a day before opening of flowers. Though cleistogamy is a rule in this crop, natural cross-pollination brought about by bees and other insects was found to be common. Howard et al ( 1919 ) found 2.25 to 12 per cent cross-pollination in this crop. Similar were the observations of Mehata and Dave ( 1931 ).

Kadam *et al.* ( 1945 ) observed the cross pollination to the extent of 15 per cent in tur crop under Niphad conditions and hence the crop is classified under often cross-pollinated group. Subramanyam ( 1950 ) observed the anthesis between 9 a.m. to 10 p.m., the maximum rate being between 10 a.m. to 12 noon.

Durga Prasad and Narasimha Murthy ( 1963 ) reported that the dehiscence of anthers took place at 36$^{o}$ to 40$^{o}$C temperature.

Sen and Sur ( 1964 ) observed that there was 3.2 per cent natural cross-pollination between two varieties located four feet apart. As the distance was increased from 16 to 32 feet, the cross-pollination was below one per cent, while there was no cross-pollination between two varieties for the distance of 36 to 40 feet.

Abrams ( 1967 ) observed the range of cross-pollination from 5.47 to 6.33 per cent with an average of 5.80 per cent. Sidheswar Prasad *et al.* ( 1972 ) showed that natural cross-pollination has ranged from 3.79 to 26.66 per cent which was depending on variety and site.

Datta and Arati Deb ( 1970 ) observed that the high percentage of cleistogamous flowers were found early in the flowering period. Fertilization occurs five hours after pollination and this long period may explain the large proportion of flowers failing to form fruits. Khan ( 1973 ) suggested that the high potential for cross-pollination be utilized in the formation of random mating composites. Veeraswamy and Mohamed Sherif ( 1973 ) found that the maximum anthesis occured between 10 to 10.30 a.m. and gave maximum setting of pods.

4. <u>Inheritance of morphological characters</u> :

Krauss ( 1927 ) was the first to study the inheritance of different characters in pigeon pea. Dave ( 1934 ) also studied the mode of inheritance of morphological characters.

4.1 <u>Plant habit</u> :

Krauss ( 1927 ) reported that plant stature in this crop showed the tendency towards blended inheritance. The crossing of very dwarf varieties with very tall varieties tended to produce an intermediate type but crossing between two tall types almost invariably produced a form taller than either parent.

Rekhi ( 1966 ) studied the inheritance of intervarietal crosses of tur and found that the erect branching type was dominant to spreading one.

Sen *et al.* ( 1966 ) studied inheritance of dwarfness in pigeon pea and found a dwarf bushy type with brittle stalks, late maturity, low yield and various other features and supposed that a single recessive gene designated 'd' appears to be involved.

4.2 Flower characters :

Krauss ( 1927 ) observed the red flower standard was dominant over yellow. Dave ( 1934 ) stated that the flower colour in tur was generally either plain yellow or with yellowish red veins. In addition to these, three other forms viz., orange, purple and yellow with purple veins and diffused purple base were also found. Rekhi ( 1966 )reported that the yellow flower with red streaks on standard petal was dominant to plain yellow. Ganguly and Shrivastava ( 1967 ), observed purple coloured standard dominant over yellow one and orange coloured wing over the yellow one. Patil *et al.* ( 1972 ) reported the segregation for the yellow and creamy white flower colour in the $F_2$ ratio of 3:1.

Krauss ( 1927 ) reported that, a axillary flower and pods were dominant over those located in the terminal inflorescence. Ganguli and Shrivastava ( 1967 ) found that the lateness in flowering was completely dominant over earliness in one of the cross, while incompletely dominant over the later in the other cross.

Pankaja Reddy and Gangaprasad Rao ( 1974 ) studied the inheritance of indeterminate and determinate flowering habit and reported that the determinate type is recessive with single factor difference.

4.3 Leaflet characters :

Sivakaran and Ramabhadran ( 1958 ) detected a marker gene in red gram ( *C. cajan* (L.) Millsp. ) which produced oblong leaflets with obovate apex. Patil and D'Cruz (1965) reported the dominance of lanceolate leaflet shape over obovate type in a cross between creeping 3-2-8 and obovate and obtained 3 lanceolate : 1 obovate in $F_2$. Sekhi ( 1966 ) studied the inheritance of leaf characters in tur and observed that the trifoliate condition and pointed apex of leaf were dominant over the unifoliate and roundish apex respectively. Patil *et al.* ( 1972 ) reported genetic ratio of 183 : 73 for trifoliate and multifoliate leaf shape. Chaudhari ( 1973 ) observed a ratio of 39 lanceolate; 25 round in the cross round leaf x N.P. 51. Gundewadi ( 1975 ) recorded five types of leaflet shapes viz., Lanceolate, Linear, obovate/obcordate, ovate and oval. The leaves may be classified as green colour, dark green and a medium shade.

4.4 Stem colour :

In tur there were two stem colours i.e. purple and green. However, purple colour could be differentiated into light purple and dark purple.

Ganguli and Shrivastava ( 1967 ) stated the incomplete dominance of purplish pigmented stem over the green one.

D'Cruz and Deokar ( 1970 ), Patil ( 1971 ) and D'Cruz *et al.* ( 1971 ) indicated a monogenic dominance of purple colour over green colour. Mujawar ( 1973 ) observed the ratio of 3 purple : 1 green in the cross obcordifolia (N.B. 1 ) x arhar, and designated the gene as '*Pst*' for stem colour.

4.5 Pod characters :

The immature pods ranged from light green to deep maroon in colour, with varying degrees of blotching. The mature pods ranged from straw yellow to dark purple, with intermediate types which also include blotched and striped markings.

Krauss ( 1927 ) observed that the blotched pods were dominant over self-coloured light tinted. Dave ( 1934 ) reported that the green was recessive to both dark and maroon blotched pods. He has also reported that maroon blotched pods were dominant to green but recessive to dark, and dark pods were dominant over both green and maroon blotched.

Rekhi ( 1966 ) observed the dominance of maroon blotched pods over green pod. Ganjuli and Shrivastava(1967) reported the dominance of purple streak markings over complete green pods.

Krauss ( 1927 ) found that the, pubescent, large flat pods and 4-5 seeded pods were dominant over glabrous, small and 3-4 seeded pods respectively. Rekhi ( 1966 ) also reported that the 4 seeded pods were dominant over 3 seeded pods.

Teerandaj ( 1973 ) observed the ratio of 9 green with purple patches : 3 green with streaks : 4 green with diffused purple colour for raw pod colour in the cross creeping 3-2-8 x N.P. 82.

4.6 <u>Seed coat colour</u> :

Krauss ( 1927 ) noted that the blotched or speckled seeds was dominant over self coloured and maroon. Dave ( 1934 ) noted the following findings - (i) White coloured seeds was recessive to brown and purplish black; (ii) Brown seeds was dominant to white but recessive to purplish; (iii) Purplish black seeds was dominant over white and brown and (iv) White with purple spot dominant over white but recessive to purplish black and epistatic to brown.

Rekhi ( 1966 ) observed that the brown seed coat was partial or incomplete dominant over white seed. Ganguli and Shrivastava ( 1967 ) reported that the deep dark purple seed coat with splaches was incompletely dominant over chocolate seed coat and light brown seed coat. Patil *et al*. ( 1972 ) were first to report that, the reddish brown and white seed coat colours in red gram segregated in a ratio of 63 : 1.

4.7 <u>Inflorescence</u> :

Krauss ( 1927 ) observed that the axillary inflorescence was dominant over terminal.

5. <u>Genetic variability and heritability concept</u> :

Johnson *et al*. ( 1955 ) in their studies with soybean concluded that the heritability estimates along with their genetic advance is more useful than the heritability estimates alone in predicting the resultant effect for selecting the best individuals.

Ganguli and Shrivastava ( 1969 ) studied variability in arhar and noted a wide range of phenotypic variation for the important quantitative characters on the basis of the genetic parameter, like genetic coefficient of variation, heritability and genetic advance. It was concluded that the phenotypic selection for the number of branches per plant, number of fruiting branches per plant, number of pods per plant and number of leaves per plant may be useful in selection improvement of tur.

Hiremath and Jalawar ( 1971 ) studied the genetic variability in pigeon pea, and observed that there were high heritability and low genetic advance for the characters viz., number of primary branches, number of seeds per pod, pod length and 100 seed weight. While the high heritability and high genetic advance was recorded for the plant height, number of pods per plant and yield per plant.

Munoz and Abrams ( 1971 ) reported high heritability for the characters like flowering date, plant height and seed weight and also observed greater variation in above characters than in number of seeds per pod.

Sharma et al. ( 1972 ) reported that the seed size had a high heritability value of 0.82. Singh et al. ( 1972 ) reported maximum heritability for pod length and the minimum one for the plant height, while genetic advance was maximum for yield. Joshi ( 1973 ) reported that the plant height was highly heritable followed by seed yield.

Kumar and Haque ( 1973 ) obtained high heritability values in the broad sense and high genetic advance for the number of leaves and number of seeds per plant, and also obtained moderate genetic advance for the number of days to maturity. They have also recorded moderate heritability and genetic advance for plant height and pod number and moderate heritability and high genetic advance for seed yield per plant. Nathnaswamy <u>et al.</u> ( 1973 ) observed high genetic coefficient of variation for the characters like clusters per plant, seed per plant, pods per plant, weight of pods, branches per plant, plant height and days to flower. They have also recorded high heritability and similar genetic gain in plant height, braches per plant, clusters per plant, pods per plant and days to flower. They have stated that these characters may be considered as reliable for exercising selection in red gram.

Shrivastava <u>et al.</u> ( 1973 ) observed substantial genetic variability for Zn, P, Cu, Fe and Mu content in seeds and heritability in broad sense varied from 0.69 to 0.97 for yield and days to maturity.

Laxman Singh and Pandey ( 1974 ) reported that the heritability range from 54.9 for plant width to 96.8 for seed yield (broad sense ) and 28.7 for plant width to 95.2 for days to flowering (narrow sense).

6. <u>Yield and yield components</u> :

Mollano ( 1964 ) found that, under controlled 8 hour photoperiod, two generations can be produced each year and it has been suggested that this technique could be used to accelerate breeding.

Abrams *et al.* ( 1969 ) reported that yield, date of flowering, plant height and seed weight were more influenced by the interaction of variety x year than that of variety x location x year.

Dasappa and Mahadevappa ( 1970 ) reported that plant spread and number of pods per plant were significantly correlated with yield of seed per plant. Sharma *et al.* ( 1971 ) stated that yield was positively correlated with spread of plant, number of secondary branches, effective pod bearing length and pod number.

Munoz and Abrams ( 1971 ) observed that seed yield was highly positively correlated with number of pods per plant, to a lesser extent positively correlated with plant height and 100 seed weight and was negatively correlated with days to flowering. Beohar and Nigam ( 1972 ) reported positive correlation between seed yield and the number of branches or pods per plant and between number of branches and number of pods per plant. They also reported a negative correlation between number of pods per plant and pod length. Khan and Machie ( 1972 ) reported that seed yield was positively correlated with plant width, length of main branch, number of pods per main branch and per plant, threshing factor and grain : straw ratio. Singh *et al.* ( 1972 ) reported that yield has significant and positive phenotypic and genetic association with plant height, secondary branches and pod length. They also reported high degree of associations between primary branches and three characters viz., days to flower, secondary branches and plant height. The negative association was found between yield and days to flower.

Joshi ( 1973 ) reported that seed yield was positively correlated with number of pods and number of branches per plant. Veeraswamy et al. ( 1973 b ) reported that the number of branches, clusters of pods and pods per plant were main characters which contributed to yield of red gram. However, plant height and number of days to flower were also useful as phenotypic indices for selection.

Kumar and Haque ( 1973 ) reported that seed yield was significantly and positively correlated with the number of leaves, branches, pods and seeds per plant and with plant height. The yield was significantly and negatively correlated with the number of days to first flowering and to maturity. Singh and Malhotra ( 1973 ) observed significant and positive association between yield and three characters viz., clusters per plant, pods per plant and secondary branches. They also stated that the clusters per plant was the main yield component in pigeon pea.

Pankaja Reddy and Ganga Prasad Rao ( 1974 ) reported by preliminary association analysis between plant type and yield that the indeterminate flowering habit was favoured over determinate forms.

Pankaja Reddy et al. ( 1975 ) observed that, as the duration increased, pod number, yield and seed size also increased. The pod number and seed size were the most important components contributing to yield.

Soloman *et al.* ( 1957 ) obtained 24.5 per cent hybrid vigour for grain yield in tur. Veeraswamy *et al.* ( 1973 a ) studied intervarietal hybrids and observed heterosis for plant height, plant spread, number of branches, number of clusters, number of pods and days to 50 per cent flowering.

Sharma *et al.* ( 1973 ) studied general and specific combining ability in a diallel set. They observed higher heterotic effect for plant height and seed yield. The general combining ability variances, were higher than the specific combining ability variances, indicating the predominance of additive gene action.

# CHAPTER III

# MATERIALS AND METHODS

# CHAPTER III

## MATERIALS AND METHODS

For the present study seventy nine varieties of pigeon pea ( Cajanus cajan, (L.) Millsp. ) were taken. The varieties showing variability were selected from the germ plasm being maintained by the Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri.

The names of the varieties are listed in Table 1.

Table 1 : Names of the varieties.

| Sr. No. | Name of variety | Sr. No. | Name of variety |
|---|---|---|---|
| 1 | Ahmedpur-442 | 17 | IP-80 |
| 2 | Ahmedpur-539 | 18 | Kalamb-8 |
| 3 | B-35 | 19 | Kanpur-14 |
| 4 | Batil-4 | 20 | MI-130-7 |
| 5 | C-11 | 21 | M-57-2-B |
| 6 | D.T.154 | 22 | Mahallad-U |
| 7 | D-1-13 | 23 | N-290-21 |
| 8 | D-1 | 24 | N-84 |
| 9 | Dwarf | 25 | N-18-A |
| 10 | DT-73 | 26 | NPC-16 |
| 11 | Datal-12-10 | 27 | No.148 |
| 12 | G.P.M.-4 | 28 | Obcordifolia |
| 13 | G.P.M.-134 | 29 | Osmanabad-420 |
| 14 | G.D.M-2 | 30 | Poly-8 |
| 15 | HD-2 | 31 | Prabhat |
| 16 | HY-5 | 32 | Patur-7 |

Contd.

Table 1 (Contd.)

| Sr. No. | Name of variety | Sr. No. | Name of variety |
|---|---|---|---|
| 33 | Udgir-503 | 57 | 2866 |
| 34 | Ugawa-12 | 58 | 252-11 |
| 35 | Upas-120 | 59 | 28-17-1-a |
| 36 | Sarguja | 60 | 2869 |
| 37 | S-5 | 61 | 2615 |
| 38 | Sangola Bold | 62 | 237-14 |
| 39 | Sailu-1-1 | 63 | 2369 |
| 40 | Sharda | 64 | 3703 |
| 41 | S-18-4 | 65 | 3-1-3-1-9 |
| 42 | Tuljapur-1-2 | 66 | 3-1 |
| 43 | T-21 | 67 | 4145 |
| 44 | T-9-B | 68 | 4839-3 |
| 45 | Tiny leaf | 69 | 4804 |
| 46 | Round leaf | 70 | 4628 |
| 47 | Wanga-2 | 71 | 4790-2 |
| 48 | 116-2-5-34 | 72 | 4693 |
| 49 | 1-3-2-16 | 73 | 4442 |
| 50 | 1867 | 74 | 4878-3-a |
| 51 | 165-11 | 75 | 4-1-1 |
| 52 | 196-6 | 76 | 54-1-2 |
| 53 | 1-4-2-7 | 77 | 78-16 |
| 54 | 124-16-19-1 | 78 | 7-18-14 |
| 55 | 126-1 | 79 | 74 |
| 56 | 126-Ws. | | |

Methods :

The experimental material was sown in the kharif season of 1974-75 in medium black soil, fertilised with 15 cartloads of F.Y.M., 20 kg N in the form of urea and 50 kg $P_2O_5$ in the form of single superphosphate per hectare.

These varieties were grown in randomised block design with two replicates at pulses improvement scheme of Mahatma Phule Krishi Vidyapeeth, Rahuri. Two rows of 5 meter length for each variety were planted at the spacing of 60 cm between rows and 30 cm within rows. Five plants per treatment in each replication were selected for recording the observations, and the observations were recorded on the following characters

A) Quantitative characters :

i) Days to 50 per cent flowering.

ii) Plant height at maturity in meter.

iii) Number of primary branches at maturity.

iv) Number of secondary branches at maturity.

v) Leaf area in sq.cms.

vi) number of effective pods per plant.

vii) Number of grains per pod.

viii) Weight of 1000 grains in each variety.

ix) Grain yield per plant.

B) Qualitative characters :

x) Flower colour.

xi) Flowering habit.

xii) Colour of leaves.

xiii) Leaf shape.

xiv) Colour of green pods

xv) Seed coat colour.

The means of five plants selected at random per entry were used for further statistical analysis.

Observation in respect of the above characters were recorded as follows :-

A) Quantitative Characters :

1) Days to 50 per cent flowering : The date on which 50 per cent of plants in the plot had flowered was taken as date of 50 per cent flowering, and the number of days for flowering was calculated.

2) Plant height : Height was recorded at maturity and was measured in meters from the soil surface to the tip of the main stem.

3) Number of primary branches : Primary branches on main stem were counted at maturity.

4) Number of secondary branches : The total number of secondary branches growing on the primary shoots were recorded for the 5 plants selected in each variety and average value was determined.

5) Leaf area : On each of the selected five plants five fully developed branches were selected and from each of the selected branches, fully developed five leaves were taken to calculate leaf area and averages were taken for further calculation.

6) Number of effective pods per plant : Five plants of each variety were selected in each replication and on each

of the selected plants all the pods containing seeds were counted.

7) Number of grains per pod : On each of the selected five plants five fully developed pods were taken and number of seeds per pod were recorded.

8) Weight of 1000 grain : For this 1000 grain of each variety were counted and weight was recorded.

9) Grain yield per plant : Single plant yield was recorded in grams for each of the five selected plants of a culture and average values were obtained.

B) Qualitative characters :

1) Flower colour : The colour of flower was noted when most plants flowered and when flowers were fully opened. The following was the type of variation observed :-(i) Yellow; (ii) Yellow flowers with red veins on the dorsal surface of standard petal; and (iii) Creamy white.

2) Flowering habit : Habit of flowering was noted when most plants flowered and when flowers were fully opened. Varieties were grouped broadly in to following classes :- (i) Indeterminate; (ii) Semi-determinate; and (iii)Determinate.

3) Colour of leaves : Observations on leaf colour were recorded before maturity on fully developed, representative leaf and cultures were grouped into following classes :- (i) Light green colour, and (ii) Dark green colour.

4) Leaf shape : This was recorded before maturity on fully developed, representative leaf and cultures were grouped into the following classes:- (i) Linear, (ii Lanceolate, (iii) Obcordate, (iv) Round/Ovate.

5) Colour of green pods :

Observations were taken when the pods were just mature and the following classes were observed :- (i) Green with purplish black streaks ( Green blotched with moroon), (ii) Green, and (iii) Dark (diffused purplish black colour all over the pod).

6) Seed coat colour :

Observations were recorded after threshing and the following different categories were observed :- (i) Dirty white, (ii) Light brown, (iii) Dark brown, (iv) Black and (v) Mottled brown.

Statistical methods :

The mean values of five plants selected at random in each replication for each character were used for statistical analysis.

a) Analysis of variance :

The method of 'Analysis of variance' commonly used in case of randomised block design was adopted. The gross variation was split up in its components such as variation due to blocks, due to treatments and due to error. The standard error of mean and significance of mean sum of squares by 'F' test at varietal level were worked out. Observational data on all characters were subjected to analysis of above nature. The procedure adopted as as follow :-

1) $C.F. = \frac{(G.T)^2}{r \times n}$

2) Total S.S. = Total sum of squares of all plot observations - C.F.

3) $S.S. \text{ for block} = \frac{S.S. \text{ for all blocks total}}{n} - C.F.$

4) $S.S. \text{ for treatments} = \frac{S.S. \text{ for all treatments total}}{r} - C.F.$

5) S.S. for Error = Total S.S. - (Block S.S. + Treatment S.S.)

Where :

r = number of replications or blocks.

n = number of varieties.

G.T. = grand total.

S.S. = Sum of square.

C.F. = Correction factor.

The analysis of variance table was constructed as under.

Table 2 : Analysis of variance .

| Sr. No. | Variation due to | D.F. | S.S. | M.S.S. | 'F' value Calculated | Table |
|---|---|---|---|---|---|---|
| 1 | Block | r-1 | B.S.S. | $\frac{B.S.S.}{r-1}$ | | |
| 2 | Treatments | n-1 | T.S.S. | $\frac{T.S.S.}{n-1}$ | $\frac{T.M.S.S.}{E.M.S.S.}$ | |
| 3 | Error | (r.n-1) - (n-1)+(r-1) | E.S.S. | $\frac{E.S.S.}{E.d.f.}$ | | |
| | Total | r.n-1 | | | | |

b) Analysis of co-variance :

Co-variance analysis between all pairs of the characters, under study, was carried out on the same line as that of analysis of variance. The estimates of co-variance between two traits (Cov.1.2) were derived in the same manner as for corresponding variances for the two characters under reference.

C) Partitioning of variance and Co-variance into genotypic, Phenotypic and environmental variance and co-variance :

Environment has a great bearing upon many of the economically important characters, most of which are quantitatively inherited. Thus, it becomes difficult to judge whether observed variability is heritable or due to environment. It is, therefore, necessary to break up the observed variability into its heritable (genetic) and non-heritable (non-genetic) components.

In the present investigation, the following procedure suggested by Weber and Moorthy ( 1952 ), Serra ( 1966 ) and Kempthorne ( 1957 ) for partitioning of total variance and co-variance into heritable and non-heritable components was adopted.

If the two characters viz., X and Y are under study, then the relationship among the different variance would be :

$$\sigma^2 X = \sigma^2 X_G + \sigma^2 X_I$$

$$\sigma^2 Y = \sigma^2 Y_G + \sigma^2 Y_I$$

$$\text{Cov. } XY = \text{Cov } XY_G + \text{Cov } XY_I$$



Where :

$\sigma^2 X$ and $\sigma^2 Y$ = Represent total phenotypic variance observed in characters X and Y respectively.

| | | |
|---|---|---|
| $6^2 X_G$ and $6^2 X_E$ | = | Represent genotypic and environmental portions respectively of variance in the expression of character X. |
| $6^2 Y_G$ and $6^2 Y_E$ | = | Represent genotypic and environmental portions respectively of variance in the expression of character Y. |
| Cov. $XY_G$ and Cov. $XY_E$ | = | Represent genotypic and environmental portions respectively of co-variance between characters X and Y. |

The estimates of genotypic variance of X and Y and their co-variance could be made by substracting environmental variances and co-variances from the observed phenotypic variance and co-variance of X and Y.

In the present investigation, variances and co-variances at variety level were taken as phenotypic and at error level as environmental. The genotypic variances and co-variances were then obtained by substracting the variances and co-variances at error level from those at variety level respectively.

For comparing the heritable variability in different traits, three genetic parameters were computed viz., genetic co-efficient of variation, heritability percentage and genetic advance expressed in percentage of mean.

d) Genotypic co-efficient of variation :

Genotypic co-efficient of variation (G.C.V.) was estimated by the formula suggested by Burton (1952) viz.,

$$G.C.V. = \frac{\sqrt{\text{Genotypic variance}}}{\bar{X}} \times \frac{100}{1}$$

Where :

$\bar{X}$ is the mean of the character.

e) Heritability percentage :

Heritability percentage in broad sense was calculated by using the following formula, suggested by Burton and Devane ( 1953 ) :

$$H = \frac{G}{G + E} \times \frac{100}{1}$$

Where,

G = Genotypic variance,

E = Error variance.

In turn G and were obtained from the analysis of variance table Where E = M.S.S. due to error.

$$G = \frac{\text{Treatment Mean S.S. - Error mean S.S.}}{\text{Number of replications.}}$$

f) Expected Genetic Advance Over Mean ( E.G.A.) :

xpected genetic advance at 5 per cent selection intensity was calculated by the following formula :

$$E.G.A. = \frac{V_g}{\sqrt{V_p}} \times K.$$

Where :

$V_g$ = Genotypic variance.

$V_p$ = Phenotypic variance.

K = Selection differential as defined by Lush(1949) (at 5 per cent the value of 'K' = 2.06 ).

c) Correlation :

In order to study the various types of inter-relationship between different characters, phenotypic and genotypic correlations at varietal level were worked out. For this, the method of analysis of co-variance was adopted.

For estimation of phenotypic and genotypic correlation co-efficients, the following formulae were used :

$$\text{Phenotypic } r = \frac{\text{Co-variance of XY}}{\sqrt{\text{Variance X x Variance Y}}}$$

Where :

Co-variance XY = Phenotypic co-variance means of the two characters.

Variance X, Variance Y } Phenotypic variances of mean for two characters

$$\text{Genotypic } r = \frac{\text{Cov. XY(G)}}{\sqrt{\text{Variance } X_G \text{ x Variance } Y_G}}$$

Where :

Cov. $XY_{(G)}$ = Genotypic co-variance between two characters. (M.S.P.XY-E.M.S.P.)

Variance $X_G$, Variance $Y_G$ } Genetic variance of first (M.S.S.X-E.M.S.S.) and second character respectively (M.S.S.Y - E.M.S.S.).

Co-variances at treatment level were used to compute the phenotypic correlation co-efficients. For obtaining genotypic variances and co-variances, sum of squares and sum of products at error level were deducted from their respective values at treatment level. These derived values were used for working out the genotypic correlation co-efficients.

h) Significance of simple correlation co-efficients :

Significance of simple correlation co-efficients was determined from "table of correlation co-efficients at 5 per cent level and 1 per cent level of significance" (Snedecor, 1959), for simple correlation coefficients 'n' is two less than the number of pairs in the trait.

i) Calculation of partial correlation co-efficient, partial regression co-efficients and multiple correlation co-efficients :

Since a change in one plant character is often, accompanied by change in several other characters, it is obvious that conclusions of practical application cannot be made from calculation of simple correlation co-efficients only.

The question of working out partial correlation co-efficients, therefore, assumes special significance. For this purpose, six important characters were selected based on the study of simple correlation co-efficients and relationship of each with plant yield was calculated by the method of partial correlation co-efficients.

A) The partial correlation co-efficients :

The partial correlation co-efficients, regression co-efficients and multiple correlation co-efficients were calculated by employing "Abbreviated Doolittle Method" which is based on the use of calculation of inverse matrix and guass multipliers ( Gaulden, 1959 ) as detailed below :-

First Matrix of multipliers, which is inverse of 'r' Matrix were calculated. Calculation of 'r' matrix on the left below, gives 'C' matrix, as shown on the right.

$$\begin{array}{cccccc|cccccc}
r_{11} & r_{12} & r_{13} & r_{14} & r_{15} & r_{16} & c'_{11} & c'_{12} & c'_{13} & c'_{14} & c'_{15} & c'_{16} \\
r_{12} & r_{22} & r_{23} & r_{24} & r_{25} & r_{26} & c'_{12} & c'_{22} & c'_{23} & c'_{24} & c'_{25} & c'_{26} \\
r_{13} & r_{23} & r_{33} & r_{34} & r_{35} & r_{36} & c'_{13} & c'_{23} & c'_{33} & c'_{34} & c'_{35} & c'_{36} \\
r_{14} & r_{24} & r_{34} & r_{44} & r_{45} & r_{46} & c'_{14} & c'_{24} & c'_{34} & c'_{44} & c'_{45} & c'_{46} \\
r_{15} & r_{25} & r_{35} & r_{45} & r_{55} & r_{56} & c'_{15} & c'_{25} & c'_{35} & c'_{45} & c'_{55} & c'_{56} \\
r_{16} & r_{26} & r_{36} & r_{46} & r_{56} & r_{66} & c'_{16} & c'_{26} & c'_{36} & c'_{46} & c'_{56} & c'_{66}
\end{array}$$

From c' matrix standard partial regression co-efficients are calculated as below :-

$$b'_{12.3456} = \frac{-c'_{12}}{c'_{11}} ; \quad b'_{16.2345} = \frac{-c'_{16}}{c'_{11}} \text{ etc.}$$

Where b' value is the standard partial regression co-efficient.

Partial correlation co-efficients are calculated as under :-

$$r_{12.3456} = \frac{-c'_{12}}{\sqrt{c'_{11} \; c'_{22}}} ; \quad r_{23.1456} = \frac{-c'_{23}}{\sqrt{c'_{22} \; c'_{33}}} \text{ etc.}$$

The detailed procedure is described by Goulden (1959).

B) Multiple correlation coefficients :

Besides simple and partial correlation co-efficients, multiple correlation co-efficients of plant yield and five other characters taken in different combinations were worked out with a view to find out the values of 'R' and also the contribution which different characters made towards yield. The multiple correlation co-efficients were calculated by the formula :-

$$R^2_{1.23456} = a_{12}\, b'_{12} + a_{13}\, b'_{13} + a_{14}\, b'_{14} + a_{15}\, b'_{15} + a'_{16}\, b'_{16}$$

Where a value represent simple correlation co-efficients and b' value represent partial regression co-efficients.

$$R = \sqrt{R^2} \qquad \text{(Gouldon, 1959 ).}$$

The values of $R^2$ calculated in percentage give the contribution of different characters towards yield when they occur in various combinations ( Sikka and Gupta, 1949 ). From the percentage contribution of characters towards yield when occurring in different combinations, percentage contribution towards yield of each characters was worked out.

Significance of multiple correlation was tested by comparing the observed values of 'R' with values presented in table for significance of 'r' and 'R' ( Hayes, Immer and Smith, 1955 ). For multiple correlation co-efficients the column corresponding to the number of variables was referred to for degrees of freedom equivalent to the number of pairs minus the number of variables involved.

# CHAPTER IV

# EXPERIMENTAL RESULTS

# CHAPTER IV

## EXPERIMENTAL RESULTS

The present investigations "Studies in genetic divergence in Pigeon pea ( *Cajanus cajan* (L.) Millsp. )", were mainly aimed at to estimate the variability present in different economically important quantitative characters in 'Tur' Varieties and to identify the promising genotypes. Such an identification has to be made, however, from the studies of phenotyp-es. In such studies critical observation on various quantitative characters which are directly or indirectly associated with the grain yield are very important. In these studies the observations were also recorded on the variability present in the qualitative characters. While conducting these studies, observations on 15 different qualitative and quantitative plant characters viz., flower colour, flowering habit, leaf shape, leaf colour, seed coat colour, colour of green pods, days to 50 per cent flowering, plant height at maturity, number of primary branches, number of secondary branches, leaf area, number of effective pods per plant, number of grains per pod, weight of 1000grains and grain yield per plant were recorded.

The results obtained in these investigations are presented below. The characteristic features and mean values of each of the 79 varieties are presented in the Appendices I and II. The ranges of variability for quantitative characters are given in Table 3.

1) Flower colour :

There were three types of flower colour. The distribution of the varieties according to flower colour was : 57 yellow flower, 20 yellow flower with red veins on the dorsal surface of standard petal, and 2 creamy white.

2) Flowering habit :

Varieties were grouped into three classes according to flowering habit was : 47 Indeterminate, 5 determinate and 27 semi-determinate.

3) Leaf shape :

Four types of leaf shapes were observed and the distribution of the varieties was : 46 lanceolate, 31 Linear, 1 Round, and 1 obcordate.

4) Leaf colour :

In the types understudy two types of leaf colour were recorded. There were 30 varieties with light green leaf and 49 with dark green colour.

5) Seed coat colour :

Seed coat colour was recorded after harvesting and threshing of pods. Five different types of seed coat colour were recorded. Grouping of varieties according to seed coat colour was : 16 dirty white, 38 light brown, 20 dark brown, 1 mottled brown and 4 black.

6) Colour of green pods :

According to colour of green pods, varieties were grouped into three classes. There were 74 varieties with green with purplish black streaks pods, 3 with green colour pods and 2 with dark colour pods.

I) Mean values, Range of variability, General means and their significance :

The analysis of variance worked out for each character indicated significant differences from the values at general means, among the entities in all the nine characters. These results thus indicate that there exists considerable amount of diversity in the seventy-nine Gur varieties selected for present study.

The observations recorded in Appendix II and Table 3 can be summarised as below :

1) Days to 50 per cent flowering :

The general mean for this character was 103.22 days. This character has shown the range from 78 to 141.50 days in varieties, Prabhat and Dwarf, respectively. In all 15 varieties viz., Dwarf, 2866, 1867, 4693, 28-17-1-a, Sangola Bold, 1-3-2-16, 2369, 4145, 4-1-1, Kailu-1, I.P. 80, Ny-5, Ahmedpur-539 and Obcordifolia were found to be significantly late in this respect when compared with the general mean. Similarly 18 varieties viz., Prabhat, Upas-120, Sharda, Ujjain-12, M-84, M-21, S-5, 124-16-19-1, 237-14, 3704, Patur-7, Sangli-2, Latil-4, 4628, 4442, 252-11, 126-1 and 74 were significantly earlier than the general mean.

2) Plant height at maturity :

The character was significant at 5 per cent level. The general mean for this character was 1.30 meter. The range of variability observed for this character was from 0.32 mt. in S-5 to 1.98 meter in the variety 2866. In all 11 varieties

Table 3 : Range of phenotypic variation, Means, S.E. and M.S.S. for different quantitative characters in seventy-nine varieties of pigeon pea (C.cajan,(L.) Millsp.).

| Sr. No. | Characters | Range | General mean | S.E. | M.S.S. varieties | Calculated 'F' |
|---|---|---|---|---|---|---|
| 1. | Days to 50 per cent flowering ( days ) | 78.00-141.50 | 103.22 | 3.39 | 314.99 | 13.69 |
| 2. | Plant height at maturity ( meter ) | 0.32-1.98 | 1.30 | 0.10 | 0.15 | 8.04 |
| 3. | Number of primary branches at maturity ( Number | 3.30-13.90 | 6.54 | 1.29 | 8.65 | 2.60 |
| 4. | Number of secondary branches at maturity ( Number ) | 2.80-56.20 | 10.61 | 2.63 | 92.42 | 6.68 |
| 5. | Leaf area(sq.cm.) | 8.56-45.09 | 20.76 | 2.59 | 62.68 | 4.64 |
| 6. | Number of effective pods per plant (Number) | 56.80-318.00 | 186.97 | 32.24 | 6753.31 | 3.25 |
| 7. | Number of grains per pod(Number) | 2.92-4.37 | 3.48 | 0.15 | 0.12 | 2.88 |
| 8. | Weight of 1000 grain in each variety (gm.) | 62.10-169.90 | 98.32 | 4.82 | 487.62 | 10.50 |
| 9. | Grain yield per plant (gm.) | 6.52-80.82 | 43.93 | 8.69 | 410.87 | 2.72 |

viz., S-5, Prabhat, Dwarf, G.P.M.-134, Upas-120, Kharda, Tiny leaf, T-21, G.P.M.-4, 4442 and 74 were shorter than the general mean and only 10 varieties were taller than the general mean. From data it may be seen that variety Prabhat and Dwarf did not differ in their height, and so also varieties 4442 and 74.

3) <u>Number of primary branches at maturity</u> .

General mean for this character was observed to be 6.54. This character has shown the range from 3.30 to 13.90 in the varieties I.T. 154 and S-5 respectively. Only five varieties viz., S-5, 2615, C-11, Dwarf and Ahmedpur-442 have significantly more primary branches than the general mean, while none of variety showed significantly less primary branches than the general mean.

4) <u>Number of secondary branches at maturity</u> :

General mean for this character was 10.61. Minimum and maximum number of secondary branches recorded were 2.80 and 56.20 in the varieties 2869 and Dwarf respectively. Only five varieties viz., Dwarf, 1867, Tuljapur-1-2, Ahmedpur-442 and C-11 showed significantly more secondary branches than the general mean. Only one variety 2069 showed significantly less secondary branches than the general mean.

5) <u>Leaf area</u> :

General mean for this character was 23.76 sq.cms. This character has shown the range from 8.56 to 45.09 sq.cm. in the varieties G.P.M.-4 and 28-17-1-a respectively. It has been observed that four varieties viz., 28-17-1-a, Kangola-Bold, 2369 and 2866 showed significantly more leaf area than the general mean, while the three varieties viz., C.P.M.-4, Tiny leaf and Upas-120 were found to have significantly less leaf area as compared to general mean.

6) Number of effective pods per plant :

General mean for this character was 186.97. The range was observed from 56.80 to 318.00 in the varieties Upas-120 and 3-1 respectively. This character has a very close association with yield. Observation on this character gives an idea about the yielding capacity of variety.

In all seven varieties viz., 3-1, Ahmedpur-442, 2866, 4-1-1, 2369, C-11 and 126-Ws produced significantly more number of effective pods per plant than the general mean. There were only two varieties viz., Upas-120 and Prabhat which have produced significantly lower number of pods per plant than general mean.

7) Number of grains per pod :

General mean for this character was recorded as 3.48. The range of variability observed for this character was from 2.92 to 4.37 in the varieties obcordifolia and 28-17-1-a respectively. Six different varieties were recorded to have higher grains per pod when compared with the mean. Varieties showing higher grains per pod were 28-17-1-a, 3704, Jangola-Bold, 2866, 54-1-2 and 4628. Only the variety Obcordifolia showed significantly lower grains per pod than the general mean.

8) Weight of 1000 grains :

General mean for this character was 98.32 gm. The weight of 1000 grains ranged from 62.10 gm. in Prabhat to 169.90 gm. in variety Sangola-Bold.

In all eleven varieties have weight of 1000 grains significantly higher than the value indicated by the general mean. Similarly there were eleven varieties which show significantly lower 1000 grain weight. This indicates the wide range of variability for this character present in these 79 varieties. The varieties with higher weight of 1000 grains were Sangola-Bold, 28-17-1-a, 3704, Mahallad-W, L-1-13, 4878-3-a, 252-11, 4628, 4839-3, S-18-4 and 3-1-3-1-9.

9) Grain yield per plant :

General mean for this character was 43.93. This character has the range of variability from 6.52 gm to 80.82 gm in the varieties Prabhat and Ahmedpur-442 respectively.

In all five varieties have grain yield per plant higher than the general mean. These varieties are Ahmedpur-442, 2866, 3-1, Bailu-1-1 and 1-3-2-16. Similarly some of the varieties which yielded significantly low grains per plant are, Prabhat, Upas-120, G.P.M.-4, Obcordifolia, 2-21 and S-5.

'F' values at 5 and 1 per cent levels have been found to be significant in the cases of all nine characters.

II) Genetic co-efficient of variation, heritability percentage and expected genetic advance :

The success of selection as a breeding method would much depend on the determination of specific genetic parameters like genetic co-efficient of variation, heritability percentage, expected genetic advance and correlation in important yield contributing characters. These parameters certainly help in making the selection of superior genotypes from a diverse genetic population.

The estimates of genetic parameters are presented for nine characters in Table 4.

Table 4 : Genetic coefficient of variation, heritability percentage and expected genetic advance in pigeon pea varieties ( C. cajan (L.), Millsp.).

| Sr. No. | Name of character | Genetic co-efficient of variation | Heritability percentage | Expected genetic advance | General mean for the character |
|---|---|---|---|---|---|
| 1. | Days to 50 per cent flowering | 11.70 | 86.38 | 16.9455 | 103.22 |
| 2. | Plant height at maturity | 19.68 | 77.88 | 0.3487 | 1.30 |
| 3. | Number of primary branches at maturity | 24.94 | 44.45 | 1.8638 | 6.54 |
| 4. | Number of secondary branches at maturity | 59.07 | 73.95 | 8.4194 | 10.61 |
| 5. | Leaf area | 23.86 | 64.57 | 6.3938 | 20.76 |
| 6. | Number of effective pods per plant | 25.85 | 52.91 | 58.5833 | 186.97 |
| 7. | Number of grains per pod | 5.77 | 48.44 | 0.2364 | 3.48 |
| 8. | Weight of 1000 grain | 15.10 | 82.61 | 20.5796 | 98.32 |
| 9. | Grain yield per plant | 25.95 | 46.26 | 13.2085 | 43.93 |

1) The genetic co-efficient of variation :

The phenotypic or gross variation is the resultant of genotypic and environmental variation the extent of genotypic variation is expressed as genotypic co-efficient of variation.

From Table-4, it will be seen that the characters grain yield per plant and number of effective pods per plant exhibit maximum genetic variability . For these characters, the values of genetic co-efficient of variation are 25.95 and 25.85 respectively, while the characters number of secondary branches at maturity, number of primary branches at maturity and leaf area have given maximum values i.e. 59.07, 24.94 and 23.86 respectively. The other characters like plant height at maturity, weight of 1000 grain and days to 50 per cent flowering were also found to have moderate value for genotypic co-efficient of variation, while it was lowest for character number of grains per pod (5.77).

ii) Heritability percentage :

The heritability percentage in broad sense is the proportion of heritable variation to the phenotypic variation. From the breeders point of view, characters with high heritability percentages are of more importance than those which are influenced readily by the environmental changes. The estimates of heritability percentage are also presented in Table 4. Heritability estimates which help the breeder in selection on the basis of phenotypic performance was highest for character - days to 50 per cent flowering, followed by weight of 1000 grain, plant height at maturity, number of secondary branches and leaf area. While lowest was observed for number of primary branches i.e. 44.45. Heritability estimates were fairly high for the rest of the characters like number of effective pods per plant, number of grains per pod and grain yield per plant. The heritability percentages for these characters was 52.91, 48.44 and 46.26 respectively.

Heritability is the transmission of character from the parent to offspring.

iii) Expected genetic advance ( E.G.A. ) :

The expected genetic advance has been calculated and expressed as percentage of mean for nine characters, and presented in Table 4. A very high E.G.A. was obtained for the number of effective pods per plant, while fairly high E.G.A. was obtained for weight of 1000 grain, days to 50 per cent flowering, grain yield per plant, number of secondary branches and leaf area. The characters like number of primary branches at maturity, plant height at maturity and number of grains per pod exhibited a low genetic gain.

iv) Estimates of phenotypic, genotypic and error variances :

The data regarding the phenotypic, genotypic and error variances obtained in respect of the nine characters for seventy-nine varieties under study are presented in Table 5.

III) Correlation studies :

i) Phenotypic and genotypic correlation co-efficients :

Grain yield in crops is influenced by different components like number of primary and secondary branches, number of effective pods per plant, days to 50 per cent flowering etc. Knowledge about the relationship between grain yield and its components is useful to research workers while making

Table 5 : Estimates of phenotypic, genotypic and error variances for different characters in pigeon pea varieties ( *C. cajan* (L.), Millsp. ).
([illegible] two characters under study)

| Sr. No. | Characters | Variances | | |
|---|---|---|---|---|
| | | Phenotypic | Genotypic | Error |
| 1. | Days to 50 per cent flowering | 314.99 | 291.99 | 23.00 |
| 2. | Plant height at maturity | 0.15 | 0.13 | 0.02 |
| 3. | Number of primary branches at maturity | 8.65 | 5.33 | 3.32 |
| 4. | Number of secondary branches at maturity | 92.42 | 78.58 | 13.84 |
| 5. | Leaf area | 62.58 | 49.11 | 13.47 |
| 6. | Number of effective pods per plant | 6753.31 | 4674.07 | 2079.24 |
| 7. | Number of grains per pod | 0.12 | 0.08 | 0.04 |
| 8. | Weight of 1000 grain | 487.62 | 441.20 | 46.42 |
| 9. | Grain yield per plant | 410.87 | 259.94 | 150.93 |

selections in their breeding programme, with similar objectives of finding of relationship of various yield contributing characters in tur ( C.cajan ) varieties, phenotypic and genotype correlation co-efficients were worked out in following nine characters.

1) Days to 50 per cent flowering.
2) Plant height at maturity in meter.
3) Number of primary branches.
4) Number of secondary branches.
5) Leaf area in sq.cm.
6) Number of effective pods per plant.
7) Number of grains per pod.
8) Weight of 1000 grain in gm.
9) Grain yield per plant in gm.

The values of phenotypic and genotypic correlation coefficients in all possible combinations between characters are presented in Table 6 and 7 respectively.

The phenotypic and genotypic correlation co-efficients reveal that the grain yield per plant was positively and significantly related to number of effective pods per plant, plant height, days to 50 per cent flowering, leaf area, weight of 1000 grain, number of secondary branches and number of grains per pod ( Table 6 and 7 ). Whereas correlation coefficients between pod yield with number of primary branches was non-significant at both the phenotypic (r=0.0925) and genotypic ( r = 0.1072 ) levels.

Table 6 : Phenotypic correlation co-efficients in nine characters of pigeon pea(*C. cajan* (L.)Millsp.) varieties.

| Sr. No. | Characters | Grain yield per plant | Days to 50% flowering | Plant height at maturity | Number of primary branches | Number of secondary branches | Leaf area | Number of effective pods per plant | Number of grains per pod | Weight of 1000 grain |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Grain yield per plant | 1.0000 | 0.5624** | 0.7111** | 0.0925 | 0.2884* | 0.4285** | 0.8453** | 0.2398* | 0.2999** |
| 2. | Days to 50% flowering | - | 1.0000 | 0.4739** | 0.2376* | 0.5518** | 0.4993** | 0.6021** | 0.1411 | 0.0126 |
| 3. | Plant height at maturity | - | - | 1.0000 | 0.0510 | -0.0061 | 0.5293** | 0.5090** | 0.3514** | 0.3357** |
| 4. | Number of primary branches | - | - | - | 1.0000 | 0.2288* | 0.2182 | 0.0948 | 0.1521 | 0.2166 |
| 5. | Number of secondary branches | - | - | - | - | 1.0000 | 0.0488 | 0.4924** | -0.1041 | -0.0702 |
| 6. | Leaf area | - | - | - | - | - | 1.0000 | 0.2397* | 0.6001** | 0.4735** |
| 7. | Number of effective pods per plant | - | - | - | - | - | - | 1.0000 | -0.0416 | -0.1181 |
| 8. | Number of grains per pod | - | - | - | - | - | - | - | 1.0000 | 0.4461** |
| 9. | Weight of 1000 grain | - | - | - | - | - | - | - | - | 1.0000 |

Level of significance at 5% = 0.2215*.          Level of significance at 1 % = 0.2887.**

Table 7 : Genotypic correlation co-efficients in nine characters of pigeon pea (*C.cajan* (L.) Millsp.) varieties.

| Sr. No. | Characters | Grain yield per plant | Days to 50 % flowering | Plant height at maturity | Number of primary branches | Number of secondary branches | Leaf area | Number of effective pods per plant | Number of grains per pod | Weight of 1000 grain |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Grain yield per plant | 1.0000 | 0.7237** | 0.8803** | 0.1072 | 0.3240** | 0.5904** | 0.8256** | 0.4129** | 0.3613** |
| 2. | Days to 5% flowering | - | 1.0000 | 0.5427** | 0.3543** | 0.6176** | 0.5939** | 0.7646** | 0.1842 | -0.1383 |
| 3. | Plant height at maturity | - | - | 1.0000 | 0.0558 | -0.0320 | 0.5668** | 0.5974** | 0.6455** | 0.4113** |
| 4. | Number of primary branches | - | - | - | 1.0000 | 0.3412** | 0.3112** | 0.1066 | 0.2001 | 0.4644** |
| 5. | Number of secondary branches | - | - | - | - | 1.0000 | 0.0381 | 0.6443** | -0.1977 | -0.1066 |
| 6. | Leaf area | - | - | - | - | - | 1.0000 | 0.3307** | 0.7883** | 0.5195** |
| 7. | Number of effective pods/plant | - | - | - | - | - | - | 1.0000 | -0.0298 | -0.1727 |
| 8. | Number of grains per pod | - | - | - | - | - | - | - | 1.0000 | 0.5316** |
| 9. | Weight of 1000 grain | - | - | - | - | - | - | - | - | 1.0000 |

Level of significance at 5 % = 0.2215 *          Level of significance at 1 % = 0.2887 **

The inter-componental relationship has thus indicated that days to 50 per cent flowering was significantly and positively correlated to number of effective pods per plant, number of secondary branches, leaf area, plant height and primary branches at both the genotypic and phenotypic levels. While its correlation with the number of grains per pod and weight of 1000 grain was non-significant. Similarly the plant height was highly positively correlated with leaf area, number of effective pods per plant, number of grains per pod and weight of 1000 grain at both the genotypic and phenotypic levels. While it was negatively correlated with number of secondary branches at both the phenotypic ( r = - 0.0061 ) and genotypic ( r = - 0.0320 ) levels.

Number of primary branches was significantly correlated with number of secondary branches ( r = 0.2288 ), while its correlation with the remaining characters was positive but non-significant only at phenotypic level. Genotypic correlation coefficient between number of primary branches with secondary branches, leaf area and weight of 1000 grain were positive and significant.

Number of secondary branches was highly positively correlated with number of effective pods per plant (r = 0.4924 and r = 0.6443 ), while its correlation with number of grains per pod and weight of 1000 grain was negative and non-significant at both the phenotypic and genotypic levels. It showed positive and non-significant correlation with leaf area.

The association between leaf area and number of grains per pod, weight of 1000 grain, number of effective pods per plant was highly significant at both the phenotypic and genotypic levels. Number of effective pods per plant was negatively correlated with number of grains per pod and weight of 1000 grain at both the levels. Negative correlation between number of effective pods per plant and number of grains per pod was more on phenotypic basis ( r = -0.0416 ) than at the genotypic level ( r = -0.0298 ).

A close association was found to exist between number of grains per pod and weight of 1000 grain on both the phenotypic ( r = 0.4461 ) and genotypic ( r = 0.5316 ) basis.

Phenotypic and genotypic correlation coefficients were high and positive in many instances. A general feature noticed in this respects was that the genotypic correlation coefficients were higher than the phenotypic correlation coefficients indicating a strong inherent relationship between the characters studied and their expression was impeded to a limited extent by environmental factors.

The primary yield components viz., plant height, days to 50 per cent flowering, number of secondary branches, leaf area, number of effective pods per plant and weight of 1000 grain showed a highly significant association with yield both at phenotypic as well as genotypic levels. This results thus indicate that selections based on these traits will lead to more productive types 'tur'.

ii) <u>Partial correlation coefficients</u>

The estimates of partial correlation coefficients are useful in determining the relationship between two characters independent of the other variables under study.

In the present studies partial correlation coefficients were calculated for six characters which showed high simple correlation coefficients with yield.

The results of the phenotypic partial correlation coefficients are presented in Table 8.

It is seen from the table that the partial correlation coefficient between grain yield and plant height was highly significant ( r 12.3456 = 0.448 ) when the effect of days to 50 per cent flowering, number of effective pods per plant, weight of 1000 grain and leaf area were kept constant.

The grain yield has no relationship with days to 50 per cent flowering when all other variables were kept constant.

The partial correlation coefficient between grain yield and number of effective pods per plant (r = 14.2356 = 0.872 ), was highly significant when all other variables were kept constnat. The partial correlation between grain yield and weight of 1000 grain, was highly significant when other variables held constant.

The partial correlation coefficient between grain yield and leaf area was negative and non-significant when all other variables were held constant.

The partial correlation coefficient between plant height and leaf area was significant, when all other variables were kept constant. It has no relationship with other variables.

The values of partial correlation coefficient between days to 50 per cent flowering with leaf area and weight of 1000

Table 8 : Phenotypic partial correlation coefficient in six selected characters of pigeon pea (*C. cajan* (L.)Millsp.) varieties.

1) Grain yield per plant
2) Plant height at maturity
3) Days to 50 per cent flowering.
4) Number of effective pods/plant.
5) Weight of 1000 grain
6) Leaf area.

| Sr. No. | Partial correlations | Character concerned | Partial correlation co-efficients |
|---|---|---|---|
| 1. | $r_{12.3456}$ | Grain yield per plant with height at maturity. | 0.448** |
| 2. | $r_{13.2456}$ | Grain yield per plant with days to 50 per cent flowering. | 0.002 |
| 3. | $r_{14.2356}$ | Grain yield per plant with number of effective pods per plant. | 0.872** |
| 4. | $r_{15.2346}$ | Grain yield per plant with weight of 1000 grain | 0.650** |
| 5. | $r_{16.2345}$ | Grain yield per plant with leaf area. | -0.074 |
| 6. | $r_{23.1456}$ | Plant height at maturity with days to 50 per cent flowering. | 0.070 |
| 7. | $r_{24.1356}$ | Plant height at maturity with number of effective pods per plant. | -0.206 |
| 8. | $r_{25.1346}$ | Plant height at maturity with weight of 1000 grain | -0.094 |
| 9. | $r_{26.1345}$ | Plant height at maturity with leaf area. | 0.263* |
| 10. | $r_{34.1256}$ | Days to 50 per cent flowering with number of effective pods per plant. | 0.218 |

Contd.

Table 8 (Contd.)

| Sr. No. | Partial correlations | Character concerned | Partial correlation co-efficients |
|---|---|---|---|
| 11. | $r_{35.1246}$ | Days to 50 per cent flowering with weight of 100 grain. | -0.146 |
| 12. | $r_{36.1245}$ | Days to 50 per cent flowering with leaf area. | 0.436** |
| 13. | $r_{45.1236}$ | Number of effective pods per plant with weight of 1000 grain. | -0.655** |
| 14. | $r_{46.1235}$ | Number of effective pods per plant with leaf area. | 0.010 |
| 15. | $r_{56.1234}$ | Weight of 1000 grain with leaf area. | 0.366** |

Level of significance at 5 % = 0.227*

Level of significance at 1 % = 0.296**

grain with leaf area was highly significant.

The partial correlation coefficient between number of effective pods per plant and weight of 1000 grain, was negative and highly significant ( r 45.1236 = -0.655 ), when grain yield, plant height, days to 50 per cent flowering and leaf area were held constant.

Genotypic partial correlation coefficients between grain yield and other related components after eliminating the effect of two remaining variables are presented in Table 9.

The value ( 0.8264 ) of genotypic partial correlation coefficients between grain yield and days to 50 per cent flowering, increased and become highly significant when the effect of weight of 1000 grain and leaf area were kept constant.

The partial correlation coefficient between grain yield and number of effective pods per plant was highly significant ( 0.9558 ), even after the effect of weight of 1000 grain and leaf area or days to 50 per cent flowering and plant height were eliminated. This indicates that strong relationship between grain yield and number of effective pods per plant. These results thus suggest that in 'tur' crop the selection made on the basis of number of effective pods per plant would prove effective.

The partial correlation coefficients between grain yield and plant height was also highly significant, when the effect of days to 50 per cent flowering and number of

Table 9 : Genotypic partial correlation coefficients in six characters of pigeon pea (*C.cajan* (L.) Millsp.) varieties, taken four at a time.

| Sr. No. | Partial correlations | Character concerned | Genotypic partial correlation coefficients |
|---|---|---|---|
| I | | A = Grain yield per plant; B = Days to 50 per cent flowering; C = No.of effective pods per plant; D = Plant height | |

| | | | |
|---|---|---|---|
| 1 | $r^{AB.CD}$ | Grain yield with days to 50 per cent flowering. | 0.2197 |
| 2 | $r^{AC.BD}$ | Grain yield with number of effective pods per plant. | 0.6454** |
| 3 | $r^{AD.BC}$ | Grain yield with plant height. | 0.8527** |
| II | | A = Grain yield per plant; B = Days to 50 per cent flowering; I = Weight of 1000 grain and F = Leaf area. | |

| | | | |
|---|---|---|---|
| 1 | $r^{AB.IF}$ | Grain yield with days to 50 per cent flowering. | 0.8264** |
| 2 | $r^{AI.BF}$ | Grain yield with weight of 1000 grain. | 0.7281** |
| 3 | $r^{AI.BI}$ | Grain yield with leaf area | 0.4571 |

Contd.

Table 9 ( Contd. )

| Sr. No. | Partial correlations | Character concerned | Genotypic partial correlation coefficients |
|---|---|---|---|
| III | A = Grain yield per plant; C = No.of effective pods/plant; E = Weight of 1000 grain and F = Leaf area. | | |
| 1 | $r_{AC.EF}$ | Grain yield with number of effective pods per plant. | 0.9558** |
| 2 | $r_{AE.CF}$ | Grain yield with weight of 1000 grain. | 0.8525** |
| 3 | $r_{AF.CE}$ | Grain yield with leaf area. | 0.1016 |
| IV | A = Grain yield per plant; D = Plant height; E = Weight of 1000 grain and F = Leaf area. | | |
| 1 | $r_{AD.EF}$ | Grain yield with plant height. | 0.8216** |
| 2 | $r_{AE.DF}$ | Grain yield with weight of 1000 grain. | 0.1014 |
| 3 | $r_{AF.DE}$ | Grain yield with leaf area. | 0.2538* |

Level of significance at 5 % = 0.2245*

Level of significance at 1 % = 0.2925**.

effective pods per plant or weight of 1000 grain and leaf area were kept constant.

The partial correlation coefficient between grain yield and weight of 1000 grain, was highly significant when the effect of days to 50 per cent flowering and leaf area or number of effective pods per plant and leaf area were held constant. But the real association between grain yield and weight of 1000 grain tended to decrease, when the effect of plant height and leaf area were eliminated.

Genotypic value ( 0.1016 ) of partial correlation coefficient indicate that, between grain yield and leaf area had no relationship when the effect of number of effective pods per plant and weight of 1000 grain were kept constant, but it became significant ( 0.2538 ) when the effect of plant height and weight of 1000 grain and highly significant ( 0.4571 ) when days to 50 per cent flowering and weight of 1000 grain were kept constant.

iii) Multiple correlation coefficients :

The multiple correlation coefficient measures the degree to which the dependent variable is influenced by a series of other variables. In the present studies, multiple correlation coefficients of grain yield per plant with five other variables viz., plant height, days to 50 per cent flowering, number of effective pods per plant, weight of 1000 grain, and leaf area taken together or in groups of two, three or four at a time were estimated at both the phenotypic and genotypic levels.

The estimates of phenotypic multiple correlation coefficients and their significance are presented in Table 10. Data from Table 10 reveals that, in most of the combination, the values of multiple correlation coefficients was highly significant. Only a few combinations are non-significant.

The five independent variables, viz., plant height, days to 50 per cent flowering, number of effective pods per plant, weight of 1000 grain and leaf area accounted for 89.99 per cent contribution towards the grain yield per plant. Only 10.01 per cent contribution was left unaccounted for.

The genotypic multiple correlation coefficients showing the combined effects of three different independent variable towards grain yield were estimated ( Table 11 ) and were found to be highly significant in all the cases.

Number of effective pods per plant weight of 1000 grain, and leaf area jointly accounted for 94.40 per cent contribution towards grain yield. Days to 50 per cent flowering, number of effective pods per plant and plant height jointly accounted for 91.87 per cent contribution towards grain yield.

79.48 and 78.95 per cent of the variability in grain yield accounted for by its association with days to 50 per cent flowering, weight of 1000 grain and leaf area, and plant height, weight of 1000 grain and leaf area respectively.

Table 10 : Phenotypic multiple correlation coefficients in six characters of pigeon pea (*C. cajan* (L.) Millsp.) varieties.

1. Grain yield per plant.
2. Plant height at maturity.
3. Days to 50 per cent flowering.
4. Number of effective pods per plant.
5. Weight of 1000 grain.
6. Leaf area.

| Sr. No. | Character combinations | $R^2$ | R | Percentage contribution towards yield |
|---|---|---|---|---|
| 1. R 1.23 | Yield per plant : plant height at maturity, days to 50 per cent flowering. | 0.1557 | 0.3946* | 15.57 |
| 2. R 1.24 | Yield per plant : plant height at maturity, No.of effective pods per plant | 0.8154 | 0.9030** | 81.54 |
| 3. R 1.25 | Yield per plant : plant height at maturity, weight of 1000 grain . | 0.2532 | 0.5032** | 25.32 |
| 4. R 1.26 | Yield per plant : plant height at maturity, leaf area. | 0.1409 | 0.3754** | 14.09 |
| 5. R 1.34 | Yield per plant : days to 50 % flowering, No.of effective pods per plant. | 0.6609 | 0.8129* | 66.09 |
| 6. R 1.35 | Yield per plant : days to 50% flowering, weight of 1000 grain. | 0.0987 | 0.3142* | 9.87 |
| 7. R 1.36 | Yield per plant : days to 50% flowering, leaf area. | 0.0136 | 0.1166 | 1.36 |
| 8. R 1.45 | Yield per plant : No.of effective pods/plant, weight of 1000 grain. | 0.7584 | 0.8709** | 75.84 |
| 9. R 1.46 | Yield per plant : No.of effective pods/plant, leaf area. | 0.6461 | 0.8038** | 64.61 |
| 10. R 1.56 | Yield per plant : weight of 1000 grain, leaf area. | 0.0839 | 0.2896* | 8.39 |

Contd.

Table 10 (Contd.)

| Sr. No. | Character combinations | $R^2$ | R | Percentage contribution towards yield |
|---|---|---|---|---|
| 11. R 1.234 | Yield per plant : plant height, days to 50% flowering, No.of effective pods/plant. | 0.8160 | 0.9033** | 81.60 |
| 12. R 1.235 | Yield per plant : plant height, days to 50% flowering, weight of 1000 grain. | 0.2538 | 0.5038** | 25.38 |
| 13. R 1.236 | Yield per plant : plant height, days to 50 flowering, leaf area. | 0.1415 | 0.3762** | 14.15 |
| 14. R 1.245 | Yield per plant : plant height, No.of effective pods/plant, weight of 1000 grain. | 0.9135 | 0.9558** | 91.35 |
| 15. R 1.246 | Yield per plant : plant height, No.of effective pods/plant, leaf area. | 0.8012 | 0.8951** | 80.12 |
| 16. R 1.256 | Yield per plant : plant height, weight 1000 grain, leaf area. | 0.2390 | 0.4889** | 23.90 |
| 17. R 1.345 | Yield per plant : days 50% flowering, No.of effective pods/plant, weight of 1000 grain. | 0.7590 | 0.8712** | 75.90 |
| 18. R 1.346 | Yield per plant : days to 50% flowering, No.of effective pods/plant, leaf area. | 0.6467 | 0.8042** | 64.67 |
| 19. R 1.356 | Yield per plant : days to 50% flowering, weight of 1000 grain, leaf area. | 0.0845 | 0.2907 | 8.45 |
| 20. R 1.456 | Yield per plant : No.of effective pods/plant, weight of 1000 grain, leaf area. | 0.7442 | 0.8627** | 74.42 |

contd.

Table 10 (Contd.)

| Sr. No. | Character combinations | $R^2$ | R | Percentage contribution towards yield |
|---|---|---|---|---|
| 21. R 1.2345 | Yield per plant : plant height, days to 50% flowering, No.of effective pods/plant, weight of 1000 grain. | 0.9141 | 0.9561** | 91.41 |
| 22. R 1.2346 | Yield per plant : plant height, days to 50% flowering, No.of effective pods/plant, leaf area. | 0.8018 | 0.8954** | 80.18 |
| 23. R 1.2356 | Yield per plant : plant height, days to 50% flowering, weight of 1000 grain, leaf area. | 0.2396 | 0.4895** | 23.96 |
| 24. R 1.2456 | Yield per plant : plant height, No.of effective pods/plant, weight of 1000 grain, leaf area. | 0.8993 | 0.9483** | 89.93 |
| 25. R 1.3456 | Yield per plant : days to 50% flowering, No. of effective pods/plant, weight of 1000 grain, leaf area. | 0.7448 | 0.8630** | 74.48 |
| 26. R 1.23456 | Yield per plant : plant height, days to 50% flowering, No.of effective pods/plant, weight of 1000 grain, leaf area. | 0.8999 | 0.9486** | 89.99 |

Level of significance for phenotypic =

| | | |
|---|---|---|
| for 6 variable | at 5% level | = 0.372. |
| | at 1% level | = 0.428. |
| for 5 variable | at 5% level | = 0.345. |
| | at 1% level | = 0.403. |
| for 4 variable | at 5% level | = 0.314. |
| | at 1% level | = 0.374. |
| for 3 variable | at 5% level | = 0.276. |
| | at 1% level | = 0.338. |

Table 11 : Genotypic multiple correlation coefficients in six characters of pigeon pea ( *C. cajan* (L.) Millsp.) varieties, taken four at a time.

A = Grain yield per plant,

B = Days to 50 per cent flowering,

C = Number of effective pods per plant,

D = Plant height,

E = Weight of 1000 grain and

F = Leaf area.

| Sr. No. | Character combinations | $R^2$ | R | Percentage contribution towards yield |
|---|---|---|---|---|
| 1. $R_{A.BCD}$ | Grain yield/plant : days to 50% flowering, No. of effective pods/plant, plant height | 0.9137 | 0.9535** | 91.87 |
| 2. $R_{A.BEF}$ | Grain yield/plant : days to 50% flowering, weight of 1000 grain, leaf area. | 0.7948 | 0.8915** | 79.48 |
| 3. $R_{A.CEF}$ | Grain yield/plant : No. of effective pods/plant, weight of 1000 grain, leaf area. | 0.9440 | 0.9716** | 94.40 |
| 4. $R_{A.DEF}$ | Grain yield/plant : Plant height, weight of 1000 grain, leaf area. | 0.7895 | 0.8885** | 78.95 |

Level of significance for 4 variables at 5% level = 0.324*

at 1% level = 0.374**.

Table 12 : Standard partial regression coefficients in six selected characters of pigeon pea (*C.cajan* (L.) Millsp.) varieties.

1. Grain yield per plant. 3. Days to 50 per cent flowering.
2. Plant height at maturity. 4. Number of effective pods per plant.
5. Weight of 1000 grain. 6. leaf area.

| Sr. No. | Partial regression co-efficients | Characters concerned | Phenotypic partial regression coefficients | Relative magnitude of potencies (Phenotypic) | |
|---|---|---|---|---|---|
| 1. | $b'_{12.3456}$ | Grain yield per plant on plant height at maturity. | 0.2101 | $\frac{b14}{b12}$ | 3.5814 |
| 2. | $b'_{13.2456}$ | Grain yield per plant on days to 50 % flowering. | 0.0012 | $\frac{b13}{b12}$ | 0.0055 |
| 3. | $b'_{14.2356}$ | Grain yield per plant on number of effective pods per plant. | 0.7011 | $\frac{b14}{b15}$ | 2.3872 |
| 4. | $b'_{15.2346}$ | Grain yield per plant on weight of 1000 grain. | 0.3272 | $\frac{b14}{b16}$ | 23.5981 |
| 5. | $b'_{16.2345}$ | Grain yield per plant on leaf area. | -0.0031 | $\frac{b16}{b12}$ | -0.1517 |
| 6. | $b'_{21.3456}$ | Plant height at maturity on grain yield per plant. | 0.9204 | | |
| 7. | $b'_{23.1456}$ | Plant height at maturity on days to 50% flowering. | 0.0646 | | |
| 8. | $b'_{24.1356}$ | Plant height at maturity on number of effective pods per plant. | -0.3771 | | |
| 9. | $b'_{25.1346}$ | Plant height at maturity on weight of 1000 grain. | -0.0994 | | |

Contd.

Table 12 (Contd.)

| Sr. No. | Partial regression coefficients | Characters concerned | Phenotypic partial regression coefficients |
|---|---|---|---|
| 10. | b'26.1345 | Plant height at maturity on leaf area. | 0.2401 |
| 11. | b'31.2456 | Days to 50 % flowering on grain yield per plant. | 0.0052 |
| 12. | b'32.1456 | Days to 50 % flowering on plant height at maturity. | 0.0759 |
| 13. | b'34.1256 | Days to 50 % Flowering on number of effective pods per plant. | 0.4359 |
| 14. | b'35.1246 | Days to 50% flowering on weight of 1000 grain. | -0.1671 |
| 15. | b'36.1245 | Days to 50% flowering on leaf area. | 0.4316 |
| 16. | b'41.2356 | Number of effective pods per plant on grain yield per plant. | 0.9736 |
| 17. | b'42.1356 | Number of effective pods per plant on plant height at maturity. | -0.1113 |
| 18. | b'43.1256 | Number of effective pods per plant on days to 50% flowering. | 0.1096 |
| 19. | b'45.1236 | Number of effective pods per plant on weight of 1000 grain. | -0.3765 |
| 20. | b'46.1235 | Number of effective pods per plant on leaf area. | 0.005 |
| 21. | b'51.2346 | Weight of 1000 grain on grain yield per plant. | 1.2611 |

Contd.

Table 12(Contd.)

| Sr. No. | Partial regression coefficients | Characters concerned | Phenotypic partial regression coefficients |
|---|---|---|---|
| 22. | $b'_{52.1346}$ | Weight of 1000 grain on plant height at maturity. | -0.0887 |
| 23. | $b'_{53.1246}$ | Weight of 1000 grain on days to 50 per cent flowering. | -0.1270 |
| 24. | $b'_{54.1236}$ | Weight of 1000 grain on number of effective pods per plant. | -1.1384 |
| 25. | $b'_{56.1234}$ | Weight of 1000 grain on leaf area. | 0.3163 |
| 26. | $b'_{61.2345}$ | Leaf area on grain yield per plant. | -0.1672 |
| 27. | $b'_{62.1345}$ | Leaf area on plant height at maturity. | 0.2874 |
| 28. | $b'_{63.1245}$ | Leaf area on days to 50 per cent flowering. | 0.4397 |
| 29. | $b'_{64.1235}$ | Leaf area on number of effective pods per plant. | 0.0203 |
| 30. | $b'_{65.1234}$ | Leaf area on weight of 1000 grain. | 0.4240 |

iv) Standard partial regression co-efficients :

The standard phenotypic partial regression coefficients of yield on remaining characters were estimated. Similarly regression coefficients of the other five characters on each of the remaining character combinations have also been estimated. These values are presented in Table 12.

It will be seen that partial regression coefficients of grain yield on number of effective pods per plant ( 0.7811 ), and on the weight of 1000 grain ( 0.3272 ) are high. It is further seen that addition of a single pod per plant would add 0.78 gm. in grain yield per plant, and increase of one gram in 1000grain weight would increase grain yield per plant by 0.33 gram.

From the study of relative magnitude of potencies presented in Table 12, it can be seen that number of effective pods per plant is 3.5 times as effective as the character plant height, and number of effective pods per plant is 2.38 times as effective as the weight of 1000 grain in grams.

CHAPTER V

# D I S C U S S I O N

# CHAPTER V

## D I S C U S S I O N

The present studies were undertaken with a view to study the nature of variability in 'tur' ( C.cajan (L.) Millsp. ) germplasm collection of the Pulses Improvement Scheme, Mahatma Phule Krishi Vidyapeeth, Rahuri in respect of certain qualitative and quantitative characters. Seventy-nine varieties of 'tur' collected from various locations in India were studied for qualitative characters like flower colour, flowering habit, leaf shape, leaf colour, seed coat colour, and colour of green pods and for quantitative characters viz., days to 50 per cent flowering, plant height at maturity, number of primary and secondary branches, leaf area, number of effective pods per plant, number of grains per pod, weight of 1000 grain and grain yield per plant.

The following aspects were included in the present investigations :-

i. Variation for qualitative characters viz., flower colour, flowering habit, leaf shape, leaf colour, seed coat colour and colour of green pods.

ii. Range of variability present in nine different characters was worked out for quantitative characters. The significant differences from the general means were calculated by the analysis of variance method.

iii. The parameters genetic coefficient of variation, heritability percentage and expected genetic advance were worked out for nine different characters.

iv. Phenotypic and genotypic correlation coefficients were calculated for nine characters. Phenotypic partial and multiple correlation coefficients were worked out for six characters. Phenotypic partial regression coefficient was also worked out for these six characters.

1) Variation for qualitative characters :

Flower colour : Three types of flower colours were observed in the seventy-nine varieties studied. Out of these 57 had yellow flower colour, 20 had yellow flower with red veins on the dorsal surface of the standard petal and 2 had creamy white flower colour.

Thus the majority of variety under study were with plain yellow flower colour. Dave ( 1934 ) also reported majority of the types with plain yellow colour. Various combinations of purple and yellow flower colour reported by Dave ( 1934 ) and Ganguli and Shrivastava ( 1967 ) were not met within these studies.

Flowering habit : There were three types of flowering habits. Out of the seventy-nine varieties, 47 had indeterminate habit and the remaining 32 varieties were distributed into two groups, viz., determinate and semi-determinate. Majority of the varieties thus had indeterminate habit, according to Pankaja Reddy and Ganga Prasad Rao (1974 ) the indeterminate habit is single gene dominant over determinate habit. Indeterminate habit indicates long duration, the presence of majority of indeterminate varieties in this collection indicates that the selection pressure on indeterminate habit by the early workers in this crop. The presence of semi-determinate types suggest the possibility of some other gene relationship for this character than suggested by Pankaja Reddy and Gangaprasad Rao ( 1974 ).

<u>Leaf shape</u> : Four leaf shapes viz., lanceolate, linear, round and obovate or obcordate were observed. Out of total varieties studied,46 varieties had lanceolate leaf shape and remaining 33 varieties were distributed as 31 linear, 1 round and1 1 obcordate. Majority of the varieties thus had lanceolate or linear leaf shape while only two being with round or obcordate, leaf shape. These observations agreed with the early reports of Patil and D'Cruz ( 1965 ) and Chaudhari ( 1973 ) according to which lanceolate or linear leaf shape is determined by dominant alleles and their various interactions. Further it appeared that the linear and lanceolate leaf shape might be associated with the various economic characters in tur.

<u>Leaf colour</u> : Two types of leaf colour viz., light green and dark green were observed. Out of seventy-nine varieties 49 had dark green leaves and the remaining 30 had light green leaves. Three types of leaf colour viz., green, dark green and a medium shade have been reported ( Anonymous, 1970 ). The absence of medium green shade might be due to the method of recording the leaf colour rather than the absence of variability for this colour.

<u>Seed coat colour</u> : There were five different types of seed coat colour. Out of the 79 varieties 38 had light brown seed coat colour and remaining 41 varieties were distributed

into four groups. As indicated in the review for this character, a number of seed coat colours are present in this crop. The inheritance being dependent on a number of interacting factors. However, the five colours reported were the ones, observed in commonly cultivated types indicating the presence of sufficient variability in the collection under study.

Colour of green pods : In respect of this character there was less variation because most of the varieties had green with purplish black streaked pods, and very few were with green colour pods or dark colour pods. Practically all the previous workers Krauss ( 1927 ), Dave ( 1934 ), Bokhi (1966) and Ganguli and Shrivastava ( 1967 ) have reported the dominance of dark colour, blotched or green with purplish black streaks over the plain green coloured pods. The results obtained in this respects confirmed the previous observations.

2) Range of variability :

Grain yield is the character of prime importance to the plant breeder. It is generally governed by a number of pollygenes which are complex in their behaviour and its expression is modified to a great extent by environmental factors. This is generally true of all other quantitative characters which are often directly associated with yield. Thus the information regarding the variation present in respect of such characters is important from the plant breeding point of view which helps the breeder to assess superior types.

It has been pointed out ( Appendix II and Table 3 ) that the varietal differences were significant for all the characters. A wide range of variation was observed in days to 50 per cent flowering, plant height, number of secondary branches, leaf area, number of effective pods per plant, weight of 1000 grain and grain yield per plant. Anthnaswamy et al.,( 1973 ) have studied these characters and obtained the same results. Variation between the important yield contributing characters, thus indicates the scope for the plant breeder to make selection for desirable types.

3) Genetic co-efficient of variation, heritability percentage and expected genetic advance :

The variation found in different varieties under study is the total of environmental and genetic components of variation. It is necessary to know the amount of genetic variability existing, since that will be constant inheritable portion of the total variation. However, genetic co-efficient of variability alone would not indicate proportion of total heritable variation. Thus, the heritability estimates are better indications of heritable portion of variation. The heritability percentage includes additive gene effect, allelic interaction due to dominance and non-allelic due to epistasis. Number of secondary branches, leaf area, number of effective pods per plant, plant height, weight of 1000 grain, grain yield per plant and days to 50 per cent flowering have shown high g.c.v. The g.c.v. indicates the genetic variability present in different characters but does not indicate how much of variability is heritable. Most of the characters have shown high values of heritability with the exception of grain yield per plant, number of grain per pod, and number of primary branches. A low heritability for grain yield per plant was recorded by Rathnaswamy *et al.* ( 1973 ) in 'tur' and Singh and Malhotra ( 1970 ) in 'mung' ( *Phaseolus aureus* Roxb. ).

In tur, the high heritability noted for the characters for, days to 50 per cent flowering, plant height, number of secondary branches, leaf area, number of effective pods per plant and weight of 1000 grain will enable the plant breeder to select superior genotypes based on phenotypic variation and these characters will also serve as indices in selection work. A high genetic advance is recorded for days to 50 per cent flowering, number of secondary branches, number of effective pods per plant, leaf area, weight of 1000 grain and grain yield per plant. A high heritability accompanied by similar genetic gain will help in predicting the effect of selecting types with such characters. Further, it is a good indication of variation being due to a high degree of additive effects ( Johnson *et al.*, 1955 ). The characters of days to 50 per cent flowering, number of secondary branches, leaf area, number of effective pods per plant, and weight of 1000 grain have high heritability and similar genetic gain was mainly due to additive gene action, and as such selection of these characters would prove effective. Number of primary branches and number of grains per pod were found to have low values of heritability as well as genetic gain and therefore, are not likely to respond favourably to selection. Grain yield per plant had shown fairly high g.c.v. and genetic advance but lowest heritability estimate, though moderate advance can be made in this character itself by keeping the selection intensity at 5 per cent. Plant height had expressed high g.c.v. and heritability estimate but low genetic advance therefore, little advance can be made in this character through direct selection.

The results obtained by Ganguli and Shrivastava (1969), Hiremath and Jalawar ( 1971 ), Munoz and Abrams ( 1971 ), Singh **et al.** (1972 ), Joshi ( 1973 ), and Lathnaswamy **et al.**, ( 1973 ) in 'tur' are in confirmity with those presented in this work.

From the estimates of phenotypic, genotypic and error variances it can be seen that, the genotypic variances were smaller in magnitude for all characters except for plant height which indicated that though the variation was large it was due to environmental factors rather than genotypic differences. Similar results were recorded by Joshi ( 1973 ).

4) Correlation studies :

a) Phenotypic and genotypic correlation coefficients :

In the present studies, the phenotypic and genotypic correlation have been worked out in nine characters, viz., grain yield per plant, days to 50 per cent flowering, plant height, number of primary and secondary branches, leaf area, number of effective pods per plant, number of grains per pod and weight of 1000 grains. Of the genotypic and phenotypic correlations, the former are less reliable as these are subject to the change due to environmental conditions. The genotypic correlations being estimated after eliminating the effects of environmental variations, are however, more dependable.

In the present studies it is seen that grain yield per plant is positively and significantly correlated to days to 50 per cent flowering, plant height, number of secondary branches, leaf area, number of effective pods per plant, number of grains per pod, and weight of 1000 grain at both the phenotypic and genotypic levels. Similar findings have also been reported by Dasappa and Mahadevappa ( 1970 ), Munoz and Abrams ( 1971 ), Singh et al.,( 1972 ), Veeraswamy et al.,( 1973 b ) and Singh and Malhotra ( 1973 ) in 'tur'.

All the attributes show positive and significant correlation with the yield. However, the number of effective pods per plant, plant height, days to 50 per cent flowering, and leaf area is found to be the most reliable and useful index for selection for yield because of their high genotypic and phenotypic correlation with yield. The number of secondary branches is also an important character in selection due to its positive and high degree of genetic association with the number of effective pods per plant. Joshi ( 1973 ) also reported that seed yield in 'tur' was positively correlated with number of pods and number of branches per plant. Kumar and Haque ( 1973 ) reported that seed yield was significantly and positively correlated with number of leaves, branches, pods and seeds per plant and with plant height. The results obtained by the previous workers are confirmed in the present study. From the study of phenotypic and genotypic correlation, different genetic parameters and range of variability, it appears that the characters days to 50 per cent flowering, plant height, number of secondary branches, leaf area, weight of 1000 grain and number of effective pods per plant may be useful in selection for improvement of 'tur' crop.

b) Partial correlation coefficients :

Partial correlation coefficients help to understand the relationship between an important characters like yield and any one character eliminating the effects of remaining characters at a time. Phenotypic and genotypic partial correlation coefficients were worked out for six characters viz., grain yield per plant, plant height, days to 50 per cent flowering, number of effective pods per plant, weight of 1000 grain and leaf area.

From the study of simple correlation coefficients, it has been observed that the yield were positively and highly significantly associated with remaining characters. But this did not hold good when partial correlation coefficients were estimated. After allowing the effect of other variables collectively it is found that grain yield per plant has highly significant and positive correlation with plant height, number of effective pods per plant and weight of 1000 grain at phenotypic level and grain yield with days to 50 per cent flowering at genotypic level. It become non-significant with days to 50 per cent flowering, at phenotypic level.

Similarly, the character number of effective pods per plant with weight of 1000 grain show significant negative values, indicating that the varieties with more number of effective pods give lowweight of 1000 grain. The character days to 50 per cent flowering have shown non-significant partial correlation coefficients with yield indicating that this character have high heritability percentage and high genetic advance. At genotypic level it can be seen that the character grain yield per plant has highly significant partial correlation coefficient with number of effective pods, plant height, days to 50 per cent flowering and weight of 1000 grain.

The values of partial correlation coefficient thus confirm the significance of values of simple correlation coefficients worked out earlier and indicate that selections made onthe basis of number of effective pods per plant, plant height and weight of 1000 grain and followed by days to 50 per cent flowering would be effective.

c) Multiple correlation coefficients :

The multiple correlation coefficients have been worked out to estimate association of group of characters with yield eliminating effects of two or more characters. It has been observed that whenever the characters like number of effective pods per plant, plant height and weight of 1000 grain have been included the 'R' values are of very high order. It thus appears from these studies that the number of pods per plant, plant height and weight of 1000 grain followed by days to 50 per cent flowering and leaf area are the most important characters on which more selection pressure may be exerted to make improvement in grain yield per plant.

d) Partial regression coefficients :

The plant breeder is primarily interested in the yield of crop with which he is working. However, in the selection procedure, yield is determined only after the harvest of the crop. If the contribution and relationship of other related characters towards yield are known, the information would be highly useful for early selection of the material under study. The partial regression coefficients for yield with remaining five characters were worked out. The results obtained have shown that the maximum contribution towards yield is made by the character, number of effective pods per plant, followed by character weight of 1000 grain and plant height. The contribution by character leaf area is negative. The data on relative mangitude of potencies indicate that the combinations of grain yield with number of effective pods per plant and grain yield with weight of 1000 grain followed by grain yield with plant height are highly effective in contribution to yield.

The consideration of the trend of results obtained in respect of parameters like genetic coefficient of variation, heritability percentage and expected genetic advance and those obtained from simple, partial and multiple correlations and partial regression coefficients, thus reveal the results obtained in both the studies are in confirmity with each other. The values obtained by heritability percentage, coefficient of variation and expected genetic advance give broad idea regarding the scope of selection based on individual characters, however, from correlation and regression studies role of various character combinations have been elaborated.

The heredity nature of those important paramters being mostly of additive type (Johnson *et al.*, 1955 ) improvement programme is likely to be rewarded if proper selection pressure is applied in respect of individual characters and characters combination discussed here.

# CHAPTER VI

# SUMMARY AND CONCLUSIONS

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## SUMMARY AND CONCLUSIONS

The present investigations were undertaken in seventy-nine varieties selected from the germplasm of the Pulses Improvement Scheme, Mahatma Phule Krishi Vidyapeeth, Rahuri to study the nature of variation in 'tur' (C. cajan, (L.) Millsp. ) in respect of qualitative and quantitative characters during the year 1974-75.

1. The observations for qualitative characters like flower colour, flowering habit, leaf shape, leaf colour, seed coat colour and colour of green pods were recorded in 79 different varieties under study. The varieties appeared to be more or less homogenous for the qualitative characters.

2. Nine different characters were selected viz., days to 50 per cent flowering, plant height, number of primary and secondary branches, leaf area, number of effective pods per plant, number of grains per pod, weight of 1000 grain and grain yield per plant, for the study of range of variability significance of general mean values, genetic coefficient of variation, heritability percentage, expected genetic advance and simple genotypic and phenotypic correlation coefficients. Partial and multiple correlation coefficients and partial regression coefficients were worked out for six different characters including grain yield per plant which showed significant correlation with yield.

3. The data on range of variability and significance of the means indicated that sufficient variability was present in the varieties under study.

The observations on genetic coefficient of variation, heritability percentage and the expected genetic advance showed that heritable variation was present for the characters days to 50 per cent flowering, number of secondary branches, leaf area, number of effective pods per plant, and weight of 1000 grains. These characters showed high heritability as well as high genetic advance which was mainly due to additive gene action, indicating that if these traits be selected would be maintained in following generations. The non-additive type of gene action was indicated for the traits with little importance.

4. Values of simple phenotypic and genotypic correlation coefficients in respect of grain yield per plant are highly significantly correlated to days to 50 per cent flowering, plant height, number of secondary branches, number of effective pods per plant, leaf area, number of grains per pod and weight of 1000 grain.

5. Partial correlation coefficients values were worked out at both phenotypic and genotypic levels. Highly significant values of partial correlation were obtained between grain yield per plant and plant height, number of effective pods per plant and weight of 1000 grains at phenotypic level. Partial correlation between grain yield per plant and days to 50 per cent flowering was highly significant at genotypic level but non-significant at phenotypic level.

6. Multiple correlation coefficints were calculated to find out the contribution of various combinations of two

to five characters. It was observed that the combination of three characters, viz., number of pods per plant, plant height and weight of 1000 grain have maximum contribution towards yield followed by the combinations of days to 50 per cent flowering and leaf area. The relative magnitude of potencies also confirmed these observations.

7. Partial regression coefficients of yield on the five yield contributing characters were estimated. From the results obtained it can be seen that the maximum contribution towards yield is made by the number of effective pods per plant followed by characters weight of 1000 grain and plant height.

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# A P P E N D I C E S

# APPENDIX - I

## Data on qualitative characters (Abbreviations).

| | | |
|---|---|---|
| 1) Flower colour : | Y = | Yellow flowers. |
| | Y.V. = | Yellow flower with red veins on the [dorsal surface] back of standard petal. |
| | C.W. = | Creamy white. |
| 2) Flowering habit : | I.D. = | Indeterminate. |
| | Det. = | Determinate. |
| | S.D. = | Semi-determinate. |
| 3) Leaf shape : | Lant.= | Lanceolate. |
| | Lin. = | Linear. |
| | R = | Round |
| | Ob. = | Obcordate/Obovate |
| 4) Leaf colour : | L.G. = | Light green. |
| : | D.G. = | Dark green. |
| 5) Seed coat colour : | D.W. = | Dirty White. |
| : | L.B. = | Light brown. |
| | D.B. = | Dark brown. |
| | B. = | Black. |
| | M.B. = | Mottled brown. |

6) Colour of green pods :

G.P. = Green with purplish black streaks.

G = Green.

D = Dark.

## Data on qualitative characters

| Sr. No. | Name of variety | Flower colour | Flowering habit | Leaf shape | Leaf colour | Seed coat colour | Colour of green pods |
|---|---|---|---|---|---|---|---|
| 1. | Ahmedpur-442 | Y | I.D. | Lant. | L.G. | L.B. | G.P. |
| 2. | Ahmedpur-539 | Y | I.D. | Lant. | L.G. | D.W. | G.P. |
| 3. | B-35 | Y.V. | I.D. | Lant. | D.G. | L.B. | G.P. |
| 4. | Batil-4 | Y | S.D. | -do- | -do- | D.B. | -do- |
| 5. | C-11 | Y | I.D. | -do- | L.G. | L.B. | -do- |
| 6. | D.T. -154 | Y | -do- | -do- | D.G. | -do- | -do- |
| 7. | D.1-13 | C.W. | -do- | -do- | L.G. | D.W. | -do- |
| 8. | D-1 | Y | -do- | -do- | D.G. | D.B. | -do- |
| 9. | Dwarf | -do- | Det. | -do- | L.G. | D.W. | -do- |
| 10. | D.P-73 | Y.V. | I.D. | -do- | -do- | L.B. | -do- |
| 11. | Datal-12-10 | Y | -do- | Lin. | D.G. | -do- | -do- |
| 12. | G.P.M-4 | Y.V. | -do- | -do- | L.G. | D.B. | G. |
| 13. | G.P.L-134 | Y | S.D. | -do- | D.G. | -do- | G.P. |
| 14. | G.D.M-2 | Y.V. | I.D. | Lant. | L.G. | L.B. | -do- |
| 15. | H.B.-2 | Y | -do- | -do- | -do- | L.B. | -do- |
| 16. | Hy-5 | -do- | -do- | -do- | -do- | L.B. | -do- |
| 17. | I.P80 | -do- | -do- | -do- | D.G. | D.B. | -do- |
| 18. | Kalamb-8 | -do- | -do- | -do- | L.B." | L.B. | -do- |
| 19. | Kanpur-14 | -do- | -do- | -do- | -do- | D.B. | -do- |
| 20. | MI-130-7 | Y.V. | S.D. | Lin. | -do- | B. | -do- |
| 21. | M-57-2-B | Y | I.D. | -do- | -do- | D.W. | -do- |
| 22. | Mahalld-W | -do- | S.D. | -do- | -do- | -do- | -do- |
| 23. | N-290-21 | -do- | I.D. | Lant. | -do- | D.B. | -do- |
| 24. | N-84 | C.W. | S.D. | Lin. | -do- | L.B. | -do- |
| 25. | N-18-A | Y.V. | -do- | Lant. | -do- | B. | -do- |
| 26. | N.P.C-16 | -do- | I.D. | -do- | -do- | B. | -do- |
| 27. | No.-148 | Y | -do- | Lin | -do- | L.B. | -do- |
| 28. | Obcordifolia | -do- | S.D. | Ob. | -do- | D.W. | G. |
| 29. | Osmanabad-420 | -do- | -do- | Lant. | -do- | L.B. | G.P. |
| 30. | Poly-8 | Y.V. | I.D. | Lin. | -do- | -do- | -do- |
| 31. | Prabhat | Y.V. | Det. | Lant. | -do- | L.B. | -do- |
| 32. | Patur-7 | Y | S.D. | Lin. | -do- | -do- | -do- |
| 33. | Udgir-503 | -do- | -do- | Lant. | L.G. | D.W. | -do- |

Contd.

(Contd.)

| Sr. No. | Name of variety | Flower colour | Flowering habit | Leaf shape | Leaf colour | Seed coat colour | Colour of green pods |
|---|---|---|---|---|---|---|---|
| 34. | Ugawa-12 | Y. | S.D. | Lin. | D.G. | D.B. | G.P. |
| 35. | Upas-120 | Y.V. | Det. | -do- | L.C. | -do- | -do- |
| 36. | Sarguja | Y | S.D. | -do- | D.G. | L.B. | -do- |
| 37. | S-5 | Y.V. | Det. | Lant. | -do- | -do- | -do- |
| 38. | Gangola-Bold | -do- | I.D. | -do- | L.G. | D.M. | -do- |
| 39. | Sailu-1-1 | Y | -do- | -do- | D.G. | -do- | -do- |
| 40. | Sharda | Y.V. | Det. | -do- | L.G. | L.D. | -do- |
| 41. | S-18-4 | Y | S.D. | Lin. | D.G. | -do- | -do- |
| 42. | Tuljapur-1-12 | -do- | I.D. | -do- | -do- | M.B. | -do- |
| 43. | T-21 | Y.V. | S.D. | -do- | L.G. | L.B. | -do- |
| 44. | T-9-B | -do- | I.D. | Lant. | D.G. | B. | D. |
| 45. | Tiny-leaf | Y | S.D. | Lin. | -do- | L.B. | G.P. |
| 46. | Round leaf | -do- | I.D. | R. | -do- | D.M. | -do- |
| 47. | Wanga-2 | -do- | -do- | Lin. | -do- | L.B. | -do- |
| 48. | 116-2-5-34 | Y.V. | -do- | Lant. | -do- | -do- | G. |
| 49. | 1-3-2-16 | Y | -do- | -do- | L.G. | D.B. | G.P. |
| 50. | 1867 | -do- | -do- | -do- | D.G. | L.B. | -do- |
| 51. | 165-11 | -do- | -do- | -do- | -do- | D.B. | -do- |
| 52. | 196-6 | -do- | -do- | -do- | L.G. | -do- | -do- |
| 53. | 1-4-2-7 | -do- | S.D. | -do- | -do- | L.B. | -do- |
| 54. | 124-16-191 | -do- | -do- | Lin. | D.G. | D.M. | -do- |
| 55. | 126-1 | -do- | -do- | Lant. | -do- | D.B. | -do- |
| 56. | 126-ws | -do- | I.D. | -do- | L.G. | -do- | -do- |
| 57. | 2866 | Y.V. | -do- | -do- | -do- | L.L. | D. |
| 58. | 252-11 | Y | S.D. | Lin. | D.G. | D.B. | G.P. |
| 59. | 28-17-1-a | -do- | I.D. | Lant. | -do- | D.M. | -do- |
| 60. | 2869 | -do- | -do- | -do- | L.G. | L.B. | -do- |
| 61. | 2615 | Y | I.D. | Lin. | L.G. | L.B. | G.P. |
| 62. | 237-14 | -do- | .D. | -do- | D.G. | -do- | -do- |
| 63. | 2369 | Y.V. | I.D. | Lant. | -do- | -do- | -do- |

Contd.

| Sr. No. | Name of variety | Flower Clour | Flowering habit | Leaf shape | Leaf colour | Seed coat colour | Colour of green pods |
|---|---|---|---|---|---|---|---|
| 64. | 3704 | Y.V. | S.D. | Lin. | L.G. | D.W. | G.P. |
| 65. | 31-3-1-9 | Y | I.D. | Lant. | -do- | D.B. | -do- |
| 66. | 3-1 | -do- | -do- | -do- | L.G. | L.B. | -do- |
| 67. | 4145 | -do- | -do- | -do- | D.G. | -do- | -do- |
| 68. | 4839-3 | -do- | S.D. | Lin. | -do- | -do- | -do- |
| 69. | 4804 | -do- | -do- | -do- | L.G. | -do- | -do- |
| 70. | 4628 | -do- | -do- | -do- | D.G. | D.W. | -do- |
| 71. | 4790-2 | -do- | I.D. | Lant. | L.G. | L.B. | -do- |
| 72. | 4693 | -do- | -do- | Lin. | -do- | -do- | -do- |
| 73. | 4442 | -do- | S.D. | Lant. | D.G. | D.W. | -do- |
| 74. | 4878-3-a | -do- | I.D. | -do- | L.G. | -do- | -do- |
| 75. | 4-1-1 | -do- | -do- | Lin. | -do- | D.B. | -do- |
| 76. | 54-1-2 | -do- | S.D. | -do- | -do- | -do- | -do- |
| 77. | 78-16 | -do- | I.D. | Lant. | -do- | L.B. | -do- |
| 78. | 7-18-14 | -do- | -do- | Lin. | D.G. | -do- | -do- |
| 79. | 74 | Y.V. | S.D. | -do- | -do- | -do- | -do- |

# APPENDIX- II

| Sr. No. | Name of variety | Days to 50% flowering | Plant height at maturity (mt.) | No. of primary branches at maturity | No. of second. branches at maturity | Leaf area (sq. cm) | No. of effective pods/plant | No. of grains per pod | Weight of 1000 grains | Grain yield/plant |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 |
| 1. | Ahmedpur-442 | 109.5 | 1.84 | 10.3 | 21.4 | 19.33 | 311.6 | 3.34 | 105.1 | 80.82 |
| 2. | Ahmedpur-539 | 113.0 | 1.27 | 6.2 | 9.2 | 21.06 | 144.7 | 3.46 | 98.3 | 32.92 |
| 3. | B-35 | 100.0 | 1.44 | 4.3 | 9.4 | 18.38 | 231.0 | 3.42 | 95.4 | 59.57 |
| 4. | Batil-4 | 91.0 | 1.09 | 5.3 | 10.3 | 18.83 | 188.8 | 3.65 | 89.3 | 41.93 |
| 5. | C-11 | 111.0 | 1.48 | 11.9 | 20.6 | 21.27 | 279.0 | 3.36 | 100.1 | 57.68 |
| 6. | DT-154 | 101.5 | 1.36 | 3.3 | 10.7 | 20.72 | 249.9 | 3.19 | 83.0 | 45.30 |
| 7. | D-1-13 | 96.5 | 1.42 | 8.7 | 8.5 | 21.32 | 146.9 | 3.12 | 119.7 | 42.64 |
| 8. | D-1 | 106.5 | 1.17 | 6.7 | 14.0 | 23.71 | 198.4 | 3.33 | 88.2 | 44.46 |
| 9. | Dwarf | 141.5 | 0.70 | 10.6 | 56.2 | 22.22 | 234.0 | 3.27 | 98.1 | 38.33 |
| 10. | D.T.-79 | 108 | 1.73 | 7.6 | 13.3 | 24.06 | 183.2 | 3.50 | 98.5 | 48.21 |
| 11. | Datal-12-10 | 101 | 1.28 | 5.4 | 7.1 | 22.38 | 165.6 | 3.25 | 95.3 | 36.31 |
| 12. | G.P.M.-4 | 103.5 | 0.98 | 8.0 | 5.6 | 8.56 | 99.30 | 3.10 | 76.0 | 15.44 |
| 13. | G.P.M.-134 | 98 | 0.87 | 5.8 | 6.0 | 19.52 | 115.5 | 3.36 | 97.5 | 25.75 |
| 14. | G.D.M.-2 | 109.5 | 1.48 | 5.3 | 8.8 | 27.44 | 221.2 | 3.82 | 88.3 | 50.73 |
| 15. | H.B.-2 | 111.0 | 1.38 | 6.7 | 6.6 | 25.97 | 162.4 | 3.46 | 106.5 | 42.43 |
| 16. | Hy-5 | 113.5 | 1.45 | 4.3 | 13.9 | 22.59 | 206.3 | 3.20 | 96.7 | 47.29 |
| 17. | I.P.80 | 115 | 1.31 | 5.3 | 8.5 | 21.31 | 227.8 | 3.45 | 72.3 | 48.67 |
| 18. | Kalamb-8 | 102 | 1.51 | 6.5 | 8.5 | 20.13 | 217.4 | 3.37 | 95.9 | 54.51 |
| 19. | Kanpur-14 | 102 | 1.30 | 5.9 | 10.6 | 21.84 | 199.1 | 3.37 | 86.9 | 39.76 |
| 20. | MI-130-7 | 112 | 1.25 | 8.0 | 6.8 | 18.79 | 158.8 | 3.50 | 99.55 | 44.52 |
| 21. | M-57-2-B | 105.5 | 1.15 | 6.6 | 9.8 | 18.29 | 175.1 | 3.57 | 92.9 | 42.00 |
| 22. | Mahallad-W | 100.0 | 1.45 | 4.7 | 7.7 | 21.94 | 102.8 | 3.75 | 132.3 | 35.26 |
| 23. | N-290-21 | 96.5 | 1.38 | 4.9 | 10.8 | 17.49 | 160.9 | 3.38 | 97.7 | 39.31 |
| 24. | N-84 | 86.0 | 1.13 | 5.9 | 10.3 | 16.19 | 158.6 | 3.42 | 100.9 | 36.12 |
| 25. | N-18-A | N-8-A 101. | 1.40 | 6.7 | 7.1 | 21.57 | 207.0 | 3.51 | 95.0 | 51.38 |
| 26. | NPC-16 | 96.5 | 1.37 | 4.4 | 6.1 | 21.81 | 202.6 | 3.22 | 98.9 | 54.39 |
| 27. | No-148 | 95.5 | 1.45 | 5.0 | 6.7 | 18.70 | 133.6 | 3.56 | 105.7 | 40.38 |
| 28. | Obcordifolia | 113 | 1.11 | 8.5 | 6.9 | 14.51 | 135.5 | 2.92 | 81.2 | 16.00 |
| 29. | Osmanabad-420 | 100.5 | 1.23 | 7.5 | 5.4 | 22.09 | 171.9 | 3.42 | 105.9 | 45.57 |

Contd.

| Sr. No. Name of variety | Days to 50% flowering | Plant height at maturity | No. of primary branches at maturity | No. of secondary branches at maturity | Leaf area (sq.cm.) | No. of effective pods/plant | No. of grains per pod | Wt. of 1000 grains | Grain yield per plant |
|---|---|---|---|---|---|---|---|---|---|
| 30.Poly-8 | 112.5 | 1.41 | 4.1 | 9.3 | 21.09 | 225.7 | 3.42 | 104.1 | 54.24 |
| 31.Prabhat | 73 | 0.70 | 4.1 | 5.1 | 19.44 | 72.4 | 3.80 | 62.10 | 6.52 |
| 32.Latur-7 | 90 | 1.18 | 5.7 | 17.4 | 16.26 | 136.9 | 3.55 | 93.60 | 29.55 |
| 33.Udgir-503 | 95 | 1.28 | 6.4 | 7.5 | 19.04 | 177.9 | 3.34 | 105.20 | 46.49 |
| 34.Ugawa-12 | 94.5 | 1.20 | 4.7 | 16.7 | 15.43 | 191.6 | 3.55 | 95.30 | 41.52 |
| 35.Upas-120 | 32.5 | 0.89 | 5.8 | 3.4 | 10.42 | 56.8 | 3.65 | 79.20 | 8.50 |
| 36.Surguja | 96 | 1.40 | 7.1 | 10.8 | 16.97 | 148.6 | 3.45 | 98.10 | 35.29 |
| 37.S-5 | 87 | 0.32 | 13.9 | 10.0 | 21.92 | 99.4 | 3.43 | 89.50 | 17.72 |
| 38. Mangola-Bold | 123.5 | 1.96 | 6.9 | 10.5 | 45.08 | 151.4 | 4.23 | 169.90 | 58.10 |
| 39.[illegible]illu-1-1 | 115 | 1.55 | 7.3 | 7.8 | 22.93 | 276.1 | 3.50 | 102.50 | 72.72 |
| 40.[illegible]harda | 83.5 | 0.91 | 8.7 | 4.1 | 21.04 | 16[illegible].7 | 3.34 | 97.90 | 36.25 |
| 41.[illegible]-18-4 | 98 | 1.18 | 8.0 | 11.8 | 18.80 | 10[illegible].3 | 3.33 | 113.60 | 43.37 |
| 42.Tuljapur-1-2 | 112 | 1.43 | 4.8 | 22.4 | 18.88 | 275.9 | 3.30 | 79.60 | 54.11 |
| 43.T-21 | 86.5 | 0.96 | 5.0 | 7.4 | 16.55 | 103.0 | 3.26 | 70.0 | 16.19 |
| 44.T-9-B | 109.5 | 1.29 | 5.7 | 9.9 | 21.30 | 194.6 | 3.70 | 110.80 | 44.78 |
| 45.Tiny leaf | 96.5 | 0.92 | 5.0 | 8.9 | 9.28 | 110.3 | 3.32 | 92.60 | 27.88 |
| 46.Round leaf | 109.5 | 1.60 | 6.9 | 10.2 | 21.39 | 199.3 | 3.44 | 97.20 | 57.72 |
| 47.Ganga-2 | 90 | 1.06 | 5.6 | 5.9 | 13.70 | 119.6 | 3.30 | 97.90 | 30.72 |
| 48.116-2-5-34 | 103 | 1.19 | 8.4 | 5.4 | 21.60 | 136.1 | 3.45 | 80.50 | 28.13 |
| 49.1-3-2-16 | 121.5 | 1.59 | 8.9 | 16.8 | 25.77 | 259.4 | 3.67 | 102.40 | 70.71 |
| 50.1867 | 130.5 | 1.30 | 4.6 | 22.8 | 22.68 | 259.2 | 3.36 | 89.50 | 52.11 |
| 51.165-11 | 105.0 | 1.45 | 5.9 | 7.9 | 19.58 | 196.0 | 3.37 | 96.90 | 42.45 |
| 52.~~165-11~~ 196-6 | 98 | 1.48 | 6.5 | 11.3 | 19.33 | 239.2 | 3.35 | 86.40 | 54.43 |
| 53.1-4-2-7 | 111.0 | 1.16 | 6.9 | 15.2 | 18.95 | 229.4 | 3.37 | 93.70 | 41.36 |
| 54.124-16-19-1 | 89.5 | 1.15 | 5.0 | 8.2 | 16.55 | 151.5 | 3.42 | 103.75 | 29.52 |
| 55.126-1 | 93 | 1.13 | 7.8 | 8.4 | 16.99 | 271.4 | 3.33 | 103.80 | 39.98 |
| 56.126-Ws. | 109.5 | 1.44 | 4.8 | 9.3 | 21.75 | 278.2 | 3.37 | 95.0 | 58.65 |
| 57.2866 | 132 | 1.98 | 8.6 | 17.3 | 30.68 | 303.4 | 4.00 | 98.4 | 74.36 |
| 58.252-11 | 92 | 1.20 | 4.8 | 6.3 | 16.29 | 136.2 | 3.38 | 117.2 | 43.44 |
| 59.28-17-1-a | 128 | 1.61 | 8.6 | 5.6 | 45.09 | 144.8 | 4.37 | 136.3 | 58.21 |
| 60.2869 | 109.5 | 1.85 | 8.6 | 2.8 | 27.43 | 175.0 | 3.7 | 87.4 | 41.39 |

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| Sr. No. Name of variety | Days to 50% flowering | Plant height at maturity | No. of primary branches at maturity | No. of second. branches at maturity | Leaf area (sq.cm.) | No. of effective pods/plant | No. of grains per pod | Wt. of 1000 grains | Grain yield/plant |
|---|---|---|---|---|---|---|---|---|---|
| 61.2615 | 111.5 | 1.62 | 12.2 | 10.8 | 21.69 | 222.5 | 3.67 | 73.10 | 40.41 |
| 62.237-14 | 89.5 | 1.35 | 4.6 | 6.8 | 16.74 | 162.3 | 3.26 | 105.40 | 35.63 |
| 63.2369 | 119.0 | 1.77 | 9.7 | 12.5 | 32.59 | 288 | 3.73 | 90.80 | 61.81 |
| 64.3704 | 89.5 | 1.39 | 9.3 | 4.6 | 19.07 | 109.1 | 4.25 | 132.50 | 38.61 |
| 65.3-1-31-9 | 95.5 | 1.37 | 7.9 | 9.6 | 19.89 | 196.2 | 3.60 | 113.40 | 47.98 |
| 66.3-1 | 111.5 | 1.28 | 4.9 | 11.5 | 21.68 | 318.0 | 3.48 | 92.40 | 73.74 |
| 67. 4145 | 117 | 1.50 | 4.1 | 15.0 | 20.47 | 231.3 | 3.45 | 91.90 | 47.61 |
| 68. 4039-3 | 94 | 1.31 | 6.5 | 4.5 | 20.52 | 138.4 | 3.50 | 115.30 | 39.47 |
| 69. 4804 | 97 | 1.20 | 4.6 | 8.9 | 20.72 | 147.3 | 3.22 | 80.5 | 31.86 |
| 70.4628 | 91 | 1.31 | 5.8 | 7.9 | 23.88 | 144.6 | 3.92 | 116.10 | 45.20 |
| 71.4790-2 | 101 | 1.19 | 4.9 | 10.1 | 23.47 | 177.1 | 3.65 | 103.70 | 41.00 |
| 72.4693 | 130 | 1.29 | 4.6 | 18.3 | 16.66 | 276.4 | 3.45 | 91.70 | 59.03 |
| 73.4482 | 91.5 | 1.00 | 6.3 | 7.0 | 20.31 | 183.5 | 3.42 | 96.70 | 42.77 |
| 74.4878-3-a | 97 | 1.28 | 6.2 | 10.2 | 22.81 | 182.0 | 3.56 | 118.90 | 53.61 |
| 75.4-1-1 | 117 | 1.31 | 9.2 | 16.8 | 17.93 | 294.5 | 3.45 | 92.90 | 57.35 |
| 76.54-1-2 | 104 | 1.29 | 7.6 | 13.2 | 20.30 | 204.0 | 3.98 | 90.60 | 52.14 |
| 77.78-16 | 96.5 | 1.30 | 4.2 | 7.0 | 25.71 | 176.1 | 3.50 | 105.3 | 36.07 |
| 78.7-18-14 | 96 | 1.31 | 5.4 | 12.3 | 17.53 | 269.1 | 3.65 | 99.1 | 58.42 |
| 79.74 | 93.5 | 1.00 | 3.7 | 7.9 | 14.40 | 140.2 | 3.30 | 105.6 | 33.83 |
| Total | 8154.5 | 102.82 | 517.1 | 838.1 | 1640.48 | 14770.8 | 275.36 | 7767.00 | 3470.63 |
| G.Mean | 103.22 | 1.30 | 6.54 | 10.61 | 20.76 | 186.97 | 3.48 | 98.32 | 43.93 |
| F test | 13.6943 | 8.0430 | 2.6006 | 6.6789 | 4.6449 | 3.2479 | 2.8013 | 10.5053 | 2.7222 |
| S.E. | 3.39 | 0.10 | 1.29 | 2.63 | 2.59 | 32.24 | 0.15 | 4.82 | 8.69 |
| C.D. | 9.54 | 0.28 | 3.63 | 7.40 | 7.30 | 90.73 | 0.41 | 13.55 | 24.44 |