CORRELATION STUDIES IN SOYBEAN

(*Glycine max* L. Merrill)

THESIS

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CERTIFICATE - I

This is to certify that the thesis entitled CORRELATION STUDIES IN SOYBEAN (*Glycine max* L. Merrill) submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE IN AGRICULTURE of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, is a record of the bonafide research work carried out by Shri CHANDRIKA PRASAD TIWARI under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

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<u>CERTIFICATE - II</u>

This is to certify that the thesis entitled CORRELATION STUDIES IN SOYBEAN (*Glycine max* L. Merrill) submitted by Shri CHANDRIKA PRASAD TIWARI to the J.N. Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of M.Sc. (Agri.) in the Department of Plant Breeding & Genetics, has been approved by the Student's Advisory Committee and External Examiner(s) after an oral examination of the same.

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CHAPTER I

INTRODUCTION

The area under soybean cultivation in India was about 66,600 hectares in 1974-75 which has now increased steadily. There was sharp increase in the area under soybean cultivation in the country during 1974-75 to 1978-79 due to exotic introduction and development of improved varieties. The area under soybean in Madhya Pradesh alone was 209,067 hectares in 1978-79 (Rathore and Motiramani, 1978).

The maximum genetic potential of improved varieties can be exploited only under better environmental conditions because environment itself determines the closeness of actual yield to the genetic potential.

Spectacular improvement in economic yield of certain crop varieties has been achieved by exploiting major genes whose presence could be identified easily.

Even after optimum set of conditions there are several intrinsic or extrinsic factors which effect the productivity to a considerable extent. Number of varieties have been produced by the breeders to suit different environmental conditions. Under this situation the yield potential of the plant is influenced by yield component in order to adjust itself under varying environments.

Identification of physiological components of yield and their genetic control should make it possible to plan crosses to maximize production of genotype combining physiological complications and balances for high yield, thereby leading to more rapid and predictable yield improvements.

Yield components can be measured with much less degree of error than yield *per se* and those which are highly correlated with yield are obviously very much useful as an aid to yield improvement. The yield components are influenced by genetic and environmental variation and the interaction between these two while selecting for yield, breeder places more emphasis on some components than others with degree of importance varying among breeders. Sometimes yield can bear correlations with number of characters. It would be of an advantage to use those characters for yield improvement which do not require any sophisticated, time consuming or elaborate technique of measurement.

Thus for the breeding for improvement of yield has to simplify this complex situation and resort to component approach by handling number of correlated characters which can be easily assayed and are highly heritable. Hence the present investigation was undertaken with the following objectives:

1. To find out the pattern of genetic variability

2. To determine the heritability for yield and its components

3. To predict genetic advance for yield and its components

4. To estimate inter-relationships of yield and yield components at genotypic, phenotypic and environmental levels

5. To find out the genotype x environmental interaction.

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CHAPTER II

REVIEW OF LITERATURE

The available literature related to various aspects of the present study is being presented under the following heads.

1. Genetic Variability
2. Heritability
3. Genetic Advance
4. Genotypic, phenotypic and environmental correlations among various characters.

I. GENETIC VARIABILITY

For successful crop improvement programmes breeders should be well aware of the nature and the amount of genetic variability within species for the characters of agronomic importance. The genetic variation can be partitioned into components attributable to different causes. The degree of resemblance between relatives is determined by the genetic properties of the population.

Fisher (1918) attempted to study the genetic variability in relation to environmental variability. Next to Fisher a number of workers discovered several techniques for the estimation of components of variance (Wright, 1921; Lush, 1940, 1943; Robinson *et al*., 1951 and Warner, 1952).

Bulah and Aristarhova (1970) reported maximum variability for number of pods, seeds per plant and 100 seed weight. Singh and Mittal (1970) reported a wide range of variation regarding the pattern of branching in soybean. Lal and Fazlul Haque (1972) reported higher estimates of genotypic coefficient of variation for number of pods, plant height and hundred seed weight. Verma *et al*. (1972) studied variation pattern of 82 soybean varieties including exotic as well as indigenous at three locations in India. These workers found significant genetic variation for maturity, flowering, number of pods per plant, 100 seed weight and grain yield.

Shwe *et al*. (1972) observed considerable variation for developmental traits related to the productivity of soybean. Similar results have also been obtained on genetic variability estimates of various characters in soybean by other workers (Weber and Moorthy, 1952; Yoshino *et al*. 1955; Johonson *et al*. 1955a).

Low estimates of genotypic coefficient of variation for 100 seed weight and primary branches, moderate estimates for yield and the highest values for number of pods per plant were observed by Malhotra (1973). Khangura and Sandhu (1973) reported high estimates of phenotypic and genotypic coefficients of variation for various developmental traits viz. pod yield and number of matured pods per plant in groundnut. Nandpuri *et al*. (1973) observed high estimates of genotypic coefficients of variation for yield per plant and pod number per plant in pea. Lal *et al*. (1973) studied 11 characters in 25 varieties of soybean. The highest genotypic coefficient of variation was obtained for plant height. Yassin (1973) studied phenotypic and genotypic variances for yield and yield components. He observed substantial genotypic variances for yield per plant, 1000 seed weight and number of pods per plant. Variability in seed number per pod and much of the yield per plant resulted from environmental effect and interaction with varieties. Rao (1974) studied eight characters in seven varieties and seven F_2 derivatives in soybean. He found high genetic variability for plant height, number of pods per plant and seeds per plant.

Varied results have been reported on genotypic and phenotypic variability for various characters in pea, pigeon pea, gram, black gram and groundnut (Pandey and Gritton, 1975; Chandra *et al*. 1975; Singh *et al*., 1975; Chand *et al*. 1975; Soundrapandian *et al*. 1975 and Sangha and Sandhu, 1974).

II. HERITABILITY

Although genetic variation is important, it can be used for effective crop improvement programme only when it is considered in relation to non-genetic variation. Fisher (1918, 1954) proposed the idea of the partitioning of genetic variance. Numerous experiments were conducted by plant breeders to determine relative importance of environmental and genetic variances. Lush (1940) defined the broad sense heritability as the ratio of genotypic variance to total variance. Johnson et al. (1955a) stated that the broad sense heritability estimates may vary greatly depending upon the unit for which the variance are considered. Different methods of estimation of heritability have been reviewed (Kaul, 1967; Reddy and Heyne, 1968 and Hill and Nicholus, 1974).

Panse (1940) used coefficient of regression of F_3 progenies on F_2 plants for estimation of heritability. Mather (1949) developed the method of partitioning of phenotypic variability into additive and non-additive components. Johnson et al. (1955a) emphasized the importance of additive component of variation in predicting the effects of selection. If heritability is only due to non-additive gene effects the expected genetic gain would be low (Panse, 1957).

The value of heritability depends on all the components of variance, a change in any one of these components will effect the estimates. It is important to realise that the heritability estimates differ from character to character, population under study and the environmental circumstances to which the individuals are subjected.

1. Days to 50 per cent flowering:

Nandpuri et al. (1973) observed low estimates of heritability for days to first flowering in pea. Bak and I (1974) reported high estimates of heritability for first flowering in soybean. Chandra et al. (1975) also reported high estimates of heritability in pigeon pea.

2. Plant height:

In general, high estimates of heritability have been reported for this character. Mahmud and Kramer (1951) observed heritability estimates as low as 35 per cent and as high as 41 per cent. Weber and Moorthy(1952) reported heritability estimates from 50 to 76 per cent. Bartley and Weber (1952) observed 66 to 83 per cent heritability estimates for height in soybean.

Similarly high estimates of heritability have been reported by other workers (61 to 81 per cent, Johnson et al. 1955a; 72 to 93 per cent, Yoshino et al. 1955; 67 to 70 per cent, Kwon and Torrie, 1964 and 29 to 88 per cent, Luedders et al. 1973). In other crops high heritability estimates for plant height were reported by Bhagmal (1969) in pea, Singh et al. (1973) in table pea, Sounderpandian et al. (1975) in black gram, Chandra et al.

(1975) in pigeon pea, Singh *et al*. (1975) in black gram and Wishwanath *et al*. (1975) in soybean.

3. Number of branches per plant:

Wide range of heritability estimates have been reported for number of branches in soybean by various workers. Long *et al*. (1950) observed low estimates of heritability for number of branches per plant. Low estimates (30%) of heritability were also observed by Malhotra (1973) and Thseng and Hosokawa (1973). However, Lal and Mehta (1973) observed medium estimates of heritability in soybean. On the other hand high estimates of heritability for this character was reported by Naphade *et al*. (1972).

4. Number of nodes per plant:

Wishwanath *et al*. (1975) concluded from their studies that the number of nodes per plant had high heritability estimates.

5. Number of pods per plant:

The low estimates of heritability were observed by Long *et al*. (1950). Aylesworth and Lambert (1969) and Anand and Torrie (1963) in soybean. Ardeleon (1975) observed that number of pods per plant was influenced by environmental conditions in F_2 population of soybean. Johnson *et al*. (1955a) reported heritability estimates from 22 to 50 per cent. Yoshino *et al*. (1955) found heritability estimates for the number of pods per plant ranging from 36 to 83 per cent. On the other hand Lal and Mehta (1973) found medium heritability estimates in soybean. Hanway (1957) reported high estimates of heritability for number of pods per plant in soybean. High estimates of heritability for number of pods per plant were also reported by Bhagmal (1969) and Nandpuri et al. (1973) in pea, Naphade et al. (1972) in soybean, Singh et al. (1973) in bengal gram and Sounderpandian et al. (1975) in black gram.

6. Yield:

Several workers reported the estimates of heritability for yield. Weber and Moorthy (1952) reported that heritability estimates for seed yield were erratic due to large environmental variances. Low to moderate estimates of heritability were reported by various workers as 8 per cent to 17 per cent (Bartley and Weber, 1952), 12 per cent to 53 per cent (Hanson and Weber, 1962), 3 per cent to 10 per cent (Kwon and Torrie, 1964) and 10 per cent to 40 per cent (Luedders et al. 1973).

Anand and Torrie (1963) observed low estimates of heritability for seed yield. Low estimates of heritability was also observed by Mubaihayo and Onim (1978).

Moderate estimates of heritability have been reported by Naphade et al. (1972) in soybean and Chand *et al*. (1975) in gram. Mahmud and Kramer (1951) reported heritability estimates for seed yield in soybean from 43 to 77 per cent. Weber and Moorthy (1952) also observed a wide range (13 to 78 per cent) of heritability estimates for this character. Shannon *et al*. (1972) observed that the heritability estimates varied from 0 to 73 per cent. Thseng (1972) reported 66 to 97 per cent estimates of heritability in F_1 and F_2 populations.

High estimates of heritability were observed by Malhotra (1973) in soybean, Nandpuri *et al*. (1973) and Singh *et al*. (1973) in pea, Singh *et al*. (1973) in bengal gram. Hiremath and Talawar (1971) and Chandra *et al*. (1975) in pigeon pea and Sounderpandian *et al*. (1975) in black gram.

III. GENETIC ADVANCE

The amount of progress expected through selection of best individuals can not be made based on the heritability estimates alone. The genetic progress would increase with an increase in heritability estimates. Hence the heritability estimates could be best utilized in conjuction with the selection differential in predicting genetic gain following selection.

Bhagmal (1969) studied 14 characters in 25 exotic and local varieties in pea. He indicated that number of pods per plant, plant height and 100 seed weight had high genetic advance. He further suggested that these traits might be effectively improved on the basis of phenotypic selection. Jaimini *et al*. (1971) studied 9 characters in lentil. They reported that estimates of heritability and genetic advance indicated that progress could be made through selection for number of days to flowering, yield and number of primary and secondary branches. Thseng (1971) observed high genetic gains for quantitative and growth habit characters in F_2 population of soybean. Hiremath and Talawar studied seven quantitative characters in 15 varieties of soybean. They observed low estimates of genetic advance for number of primary branches, number of seeds per pod and 1000 seed weight and high estimates of genetic advance was obtained for plant height, yield per plant. Naphade *et al*. (1972) reported high genetic advance for number of pods and plant height in soybean.

Nandpuri *et al*. (1973) reported high estimates of genetic advance for yield per plant, pod number per plant, while low estimates for number of days to first flowering in 33 varieties of pea. Singh *et al*. (1973) reported appreciable genetic advance for height and yield per plant in some parents and their F_1 and F_2 of pea cultivars.

Kumar and Haque (1973) studied 10 characters in some varieties of pigeon pea and their F_1 and F_2 progenies. They observed moderate genetic advance and high heritability for number of days to maturity, moderate heritability and moderate genetic advance for plant height and pod number and moderate heritability and high genetic advance for seed yield per plant.

Lal and Mehta (1973) observed high genetic advance for plant height while studying 25 varieties of soybean, Chandra et al. (1975) observed high heritability estimates together with high genetic advance for yield per plant and 100 seed weight.

IV. GENOTYPIC, PHENOTYPIC AND ENVIRONMENTAL CORRELATIONS

The correlations studies are of considerable importance in plant breeding programmes. The theory of correlation was developed by Pearson (1904). Galton (1888) suggest the need of coefficient of correlation to describe the degree of associations between variables.

Searle (1961) described the mathematical implications of correlation at phenotypic, genotypic and environmental level. Genotypic correlation in general are higher than phenotypic correlations. This has been confirmed in correlation studies of plants and animals (Johnson *et al.* 1955b; Johnson and Bernard, 1962; Lernar and Cruden, 1948; Morley, 1951 and Van Vleck, 1960).

The extent to which various characters are correlated has been studied by a number of investigators in soybean. Stewart (1913) found that height of plant was more nearly associated with yield in soybean. Biankouynen (1932) observed low correlation ($r = 0.15$) for yield with height. Yoshino _et al_. (1955) estimated the correlations between yield and various characters on F_2 plants of 11 crosses. The magnitude of correlation varied from cross to cross, the number of branches, number of pods, plant height and flowering time being variously associated with yield. Shih (1948) made field observations on ten varieties of soybean and found positive correlation of yield with plant height, number of branches per plant, seed weight and number of pods per plant.

Weber and Moorthy (1952) used F_2 plants derived from three crosses to estimate genotypic and phenotypic correlations between different pairs of characters. At genotypic level, correlation of yield in two crosses was found to be positive with maturity ($r = 0.4, 0.28$), height ($r = 0.46, 0.23$) and seed weight ($r = 0.61, 0.21$). At phenotypic level, these correlations were positive but of lower magnitudes.

Johnson _et al_. (1955b) estimated all genotypic and phenotypic correlations between pairs of 24 characters in two crosses of soybean to be positive. In general, the genotypic correlations were higher than phenotypic correlations. They outlined positive and high genotypic correlation of yield with maturity (r = 0.75, 0.40), seed weight (r = 0.43, 0.66), number of branches (0.09, 0.62) and number of pods per plant (r = 0.14, 0.28).

Kwon and Torrie (1964) measured genotypic and phenotypic correlations in two crosses of soybean over five environments. High seed yield was genetically correlated with height (r = 0.54, 0.82) and maturity (r = 0.52, 0.95) in both the populations. Similar associations were also reported by Anand and Torrie (1963) and Johnson et al. (1955b) where one hundred seed weight was positively correlated with yield (r = 0.22) in one population at genetical level but negatively correlated (r = -0.59) in other population.

The significant relationship of grain yield with number of branches was reported by Gotoh (1963) and Pan (1967). Positive correlation of seed weight with yield has been reported by Storhm (1966) and Pan (1967). YU (1966) obtained negative correlation between days to flowering and yield. Shkuropat (1970) obtained positive correlation between seed yield and height. Sengupta and Kataria (1971) reported at phenotypic level a fairly strong and significant positive correlation between yield and other components like maturity, number of primary branches, plant height, number of clusters per plant excepting those of one hundred seed weight and days to flowering. The strongest correlation was however, observed between yield and number of pods per plant. At genotypic level more or less same picture was noticed.

Lal and Fazlul Haque (1971) reported very high positive association at genotypic level of yield with plant height (r = 0.48), number of nodes (r = 0.56) and number of pods per plant (r = 0.69). Non significant association of seed yield with days to maturity (r = 0.28), days to first flowering (r = 0.46) and one hundred seed weight (r = 0.14) was observed.

Kaw and Menon (1972) reported that at genotypic level yield was strongly correlated with number of pods (r = 0.858), number of beans (r = 0.884), and plant height (r = 0.532) and moderately correlated with maturity (r = 0.406). Correlation with hundred seed weight was observed to be negative (r = -0.165) and non significant.

Thseng and Hosokawa (1972) observed positive correlation of grain yield with number of nodes per plant and number of pods per plant. Fubaihayo (1973) observed bean yield positively correlated with number of pods per plant. Rohewal and Kappur (1973) found grain yield to be positively correlated at phenotypic, genotypic and environmental levels with number of branches (r = 0.279, 0.270, 0.308), days to maturity (r = 0.395, 0.458, 0.236), seeds per pod (r = 0.13, 0.134, 0.135) and hundred seed weight (r = 0.205, 0.126, 0.454).

Yu *et al*. (1965) observed negative relationship between flowering and maturity and highly positive values for days to flowering and height. Similar results were also reported by Solorio (1967). Kaw and Menon (1972) reported that number of pods per plant was positively correlated with days to 50 per cent flowering (r = 0.655 and 0.823).

Gautam and Singh (1977) reported that hundred seed weight showed a negative correlation coefficients with yield and other characters. Singh *et al*. (1979) studied genotypic,phenotypic and environmental correlations in 28 varieties of soybean. They concluded that the yield was positively correlated with plant height, number of primary branches, number of pod bearing nodes and number of pods per plant.

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CHAPTER III

MATERIAL AND METHODS

The present experiment was carried out at the Livestock Farm, Department of Plant Breeding and Genetics, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during Rabi 1975-76 and Kharif 1976.

The climatic conditions of Jabalpur are semi-humid and subtropical with extreme rainy, winter and summer seasons. In general, monsoon breaks by the end of June and proceeds upto the end of September. Occassional winter showers are received somewhere in between December to February. The meteorological observations regarding the weather conditions prevailed during the crop seasons from the month of November 1975 to December 1976 are given in Appendix-I.

The climatological data showed that environment was favourable for the normal crop growth and development. However, a marked differences were observed with regard to temperature, humidity and rainfall during the Kharif and Rabi seasons.

The soil of the experimental area was rich in available potassium and the other major nutrients (Nitrogen and Phosphorous) were at normal levels. The soil was medium black clay in texture with uniform topography and was free from water logged conditions.

Experimental material

The experimental material comprised of eight promising lines of soybean was obtained from the Soybean Research Project, Department of Plant Breeding and Genetics, J.N.K.V.V. Jabalpur.

These eight genotypes were grown for two seasons i.e. in Rabi 1975-76 and Kharif 1976. The experiments were laid out in a randomized complete block design with four replications in each seasons. Each plot consisted of five rows, 3 m in length and row to row distance was 45 cm. For each variety in each replication, ten competitive plants were taken for recording detail observations as follows:

1. Days to 50 per cent flowering:

The days to 50 per cent flowering were recorded from the date of planting to the date when 50 per cent of the plants in a plot were in bloom

2. Plant height (cm):

The height of the plants upto the tip of the main stem from ground level were recorded at the time of maturity.

3. Number of branches per plant:

The number of branches borne on the main stem was recorded at the time of maturity.

4. Number of nodes per plant:

The number of nodes per plant were counted at the time of harvest.

5. Number of pods per plant:

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

6. Grain yield per plant (gm):

The tagged plant were harvested threshed and seeds weighed separately and mean values of ten competitive plants were used for further analysis.

Statistical Methods

1. Analysis of variance:

The data obtained were subjected to analysis of variance season-wise representing different environments.

The mean values for each character of individual variety in each season were based on ten competitively selected plants from each replications for calculation of season-wise analysis. The data were analysed as for randomised complete block design of the experiment, following the standard procedure given by Panse and Sukhatme (1967). The structure of analysis of vance and covariance used for the experiment is as outlined in Table 1.

Table 1: The structure of analysis of variance and covariance

Source of variation	D.F.	M.S.	Expected M.S.	M.S.P.	Expected M.S.P.
Replication	(r-1)				
Treatment	(t-1)	M_1	$\sigma^2 e + r\sigma^2 g$	M_{12}	$\sigma g_{1.2} + r\sigma e_{1.2}$
Error	(r-1)(t-1)	M_2	$\sigma^2 e$	M_e	$\sigma e_{1.2}$
Total	rt - 1				

where

$\hat{\sigma}^2 g$ = genotypic variance $= \frac{M_1 - M_2}{r}$

$\hat{\sigma}^2 e$ = error variance $= \frac{M_2}{r}$

$\sigma^2 p$ = phenotypic variance $= \hat{\sigma}^2 g + \hat{\sigma}^2 e$

$\hat{\sigma} g_{1.2}$ = genotypic covariance for character 1 and 2 $= \frac{M_{12} - M_e}{r}$

$\hat{\sigma} e_{1.2}$ = error covariance for character 1 and 2 $= \frac{M_e}{r}$

$\hat{\sigma} p_{1.2}$ = phenotypic covariance for character 1 and 2 $= \hat{\sigma} g_{1.2} + \hat{\sigma} e_{1.2}$

Pooled Analysis of Data:

Prior to pooling the data, the test of homogenity for error variances is applied by utilizing the Bartlett's method.

$$\chi'^2 = \left(\sum_i^n Kr\right) \text{Loge } \bar{S}^2 - \sum_i^n Kr \text{ loge } S_r^2$$

where

1. $\bar{S}^2 = \frac{1}{\sum_i^n Kr} \left(\sum_i^n Kr\, S_r^2 \right)$

2. $\log e\ \bar{S}^2 = \log \bar{S}^2 \times 2.3026$

3. $\sum_i^n Kr \log e\ S_r^2 = K_1 (\log e\ S_1^2) + \text{------} + Kr(\log e\ S_r^2)$

$$X^2 = \frac{X'^2}{e} \text{ and}$$

$$C = 1 + \frac{1}{3(n-1)} \left(\sum_i^n \frac{1}{Kr} - \frac{1}{\sum_i^n Kr} \right)$$

where

n = number of environments (i.e. n = 1, 2, ----- n)

S_r^2 = error mean sum of square (i.e. S^2 = 1, 2, ---- n)

K = respective degree of freedom for error variances

X^2 = Chi square value

C = Correction Factor

The quantity $\frac{X'^2}{C}$ was tested against the table value of Chisquare (X^2) with (n-1) degree of freedom at 5 per cent level of significance. The means of individual varieties overall replications for each environment were calculated and data thus obtained was analysed by dividing the total variability into (i) due to environment, (ii) due to varietal and (iii) due to varieties x environments. The structure of analysis of variance is presented in Table 2.

Table 2: The structure of analysis of variance for pooled data

Source of variation	d.f.	M.S.S.	Expected M.S.S.
Environments	n-1	-	
Varieties	t-1	M'_1	$\sigma'^2_e + \sigma^2_I + n\sigma^2_g$
Varieties x environments	(t-1)(n-1)	M'_2	$\sigma'^2_e + \sigma^2_I$
Pooled error	n(r-1)(t-1)	M'_e	σ'^2_e

where

n = total number of environments

t = total number of varieties

σ'^2_e = estimates of pooled error ($\bar{S}^2/r$)

$\bar{S}^2$ = pooled E M S

r = number of replications

The mean sum of squares due to varieties and environments were tested against mean sum of squares due to varieties x environments. The mean sum of squares due to pooled error was required to test the mean sum of squares due to varieties x environments.

2. Mean, Range, Components of Variance, Genotypic Coefficients of variation, Heritability and Genetic Advance:

The mean range components of variance coefficients of variation and genetic advance were calculated from individual analysis (Table 1). The means were calculated by conventional method for different characters under study as:

$$\bar{X} = \sum_{i=1}^{R} Xi/R$$

where,

R = total number of observations

Xi = value of i^{th} observation

$\bar{X}$ = character mean

The range for each character was determined by the lowest and the highest values in the particular character.

Heritability in broad sense was estimated according to the formulae given by Allard (1960) and Hanson et al. (1956) as follows:

$$\text{Heritability } (h)^2 = (\hat{\sigma}^2 g / \hat{\sigma}^2 ph) \times 100$$

Genotypic and phenotypic coefficients of variation were computed as per formulae given by Burton (1952).

$$G\ C\ V = (\hat{\sigma}\, g/\bar{X}) \times 100$$

Similarly phenotypic coefficient of variation was computed by replacing $\hat{\sigma}^2 g$ by $\sigma^2 ph$ in above formulae.

The estimated phenotypic standard deviation and heritability were used to determine the genetic advance from one cycle of selection of 5 per cent lines as suggested by Lush (1949) and Johnson *et al.* (1955a), i.e.

$$GA = K.\hat{\sigma}_{ph} \; h^2$$

where

K = constant, 2.06 at 5 per cent selection intensity

$\hat{\sigma}_{ph}$ = phenotypic standard deviation

h^2 = heritability in broad sense, and

GA = genetic advance

Genetic advance in percentage of mean was calculated as $\frac{\text{Genetic advance}}{\text{Character mean}} \times 100$

3. Correlation Coefficients:

Correlations at genotypic, phenotypic and environmental levels were calculated on the basis of individual environments separately using the following formula.

$$r_{1.2} = \frac{Cov_{1.2}}{\sqrt{(var.\ 1) \times (var.\ 2)}}$$

where

$r_{1.2}$ = coefficient of correlation between trait 1 and 2

$Cov_{1.2}$ = Covariance between trait 1 and 2

Var. 1 = variance of 1st trait

Var. 2 = variance of 2nd trait

Genotypic, phenotypic and environmental correlations were computed by substituting corresponding variances and covariances in the above formula. The estimates of covariances between two traits were derived in the same way as for corresponding variance components.

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CHAPTER IV

EXPERIMENTAL RESULTS

I. Genetic Variability

The analysis of variance was carried out for six characters viz. days to 50 per cent flowering, plant height (cm), number of branches per plant, number of nodes per plant, number of pods per plant and yield per plant (gm) for each environment separately which are presented in Table 3.

The mean sum of squares due to genotypes were highly significant for all the characters except for number of branches in the environment 1 (Rabi 1975-76). The mean sum of squares for all the characters was found to be highly significant except number of primary branches which was significant at 5 per cent level. This indicated that there was a considerable genetic variability in the material under study. The variation in the number of branches per plant was found to be considerably low in the present experimental material.

The test of homogeneity for error variances of two environment was carried out for each character separately. The estimated Chi square value at 5 per cent probability level for all the six characters indicated the homogeneity of error variances. After applying the test of homogeneity for each character, the pooled analysis of

Table 3: Analysis of variance for six characters in soybean for each environment

Environment	Source of variation	D.F.	Days to 50 per cent flowering	Plant height (cm)	Number of branches/plant	Number of nodes per plant	Number of pods per plant	Yield per plant (gm)
Rabi 1975-76	Replications	3	12.08	157.37	10.78	3.62	11.81	0.592
	Varieties	7	47.71**	1019.20**	1.05	46.09**	93.74**	5.563**
	Error	21	9.77	31.73	0.70	3.41	21.22	0.243
Kharif 1976	Replications	3	0.28	9.08	0.86	8.01	6.82	0.795
	Varieties	7	80.57**	1598.62**	1.33*	57.53**	136.37**	3.714**
	Error	21	3.50	22.39	0.51	6.50	22.35	0.451

* Significant at 5 per cent level

** Significant at 1 per cent level

variance was carried out. The combined analysis of variance reveal (Table 4) that the varieties and environmental interaction was found to be significant for all the characters. The variance due to environments was found to be highly significant for days to 50 per cent flowering, plant height, number of branches and yield per plant. The varietal differences were also significant for all characters.

II. Parameters of Variation

Range, mean, genotypic, phenotypic variances, genotypic phenotypic coefficient of variation, heritability in broad sense, expected genetic advance, genetic advance as percentage of mean are presented in Table 5, for environment-1 (Rabi 1975-76) and environment-2 (Kharif 1976).

The mean values for various characters under two environments are given in appendix-II.

The days to 50 per cent flowering ranged from 78 to 89 and 35 to 48 in rabi (1975-76) and kharif (1976) respectively.

Similarly ranges for other characters for these environments were as follows. Plant height ranged from 47 to 97 cm and 42 to 104 cm. Number of branches per plant

Table 4: Pooled analysis of variance for six characters in soybean

Source of variation	D.F.	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Number of nodes per plant	Number of pods per plant	Yield per plant (gm)
Environments	1	7921.00**	105.88**	8.36**	0.03	70.52	0.32**
Varieties	7	26.82**	641.02**	0.42*	22.69**	56.31**	0.11**
Varieties x environments	7	6.99**	14.88**	0.36**	3.20**	13.34**	0.025**
Pooled error	42	1.66	6.76	0.15	1.26	5.45	0.007

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 5: Estimates of parameters of variation for six characters in soybean

Characters	Environments	Range		Mean	Variance		Coefficient of variation		Heritability	Expected genetic advance	Genetic advance as % of mean
		Minimum	Maximum		Genotypic	Phenotypic	Genotypic	Phenotypic			
Days to 50% flowering	Rabi 75-76	78	89	83	37.94	47.71	7.39	8.28	79.52	11.31	13.57
	Kharif 1976	35	48	39	77.07	80.57	22.42	22.92	95.66	17.69	45.17
Plant height (cm)	Rabi 75-76	47	97	74	986.75	1018.85	42.34	43.02	96.85	63.68	85.82
	Kharif 1976	42	104	79	1576.23	1598.62	50.03	50.38	98.60	81.20	102.32
Number of branches per plant	Rabi 75-76	3.9	6.1	3.88	0.33	1.05	14.87	26.39	31.77	0.67	17.26
	Kharif 1976	2.85	4.58	3.72	0.82	1.33	24.39	31.09	61.76	1.47	37.47
Number of nodes per plant	Rabi 75-76	11.25	21.00	16.06	42.69	46.09	40.69	42.28	92.61	12.95	80.67
	Kharif 1976	12.13	23.75	15.97	51.03	57.54	44.74	47.51	88.70	13.85	115.20
Number of pods per plant	Rabi 75-76	20.48	37.25	28.61	72.52	93.74	29.76	33.34	77.36	7.49	26.17
	Kharif 1976	24.20	42.00	32.79	164.02	186.37	39.05	41.63	88.00	24.75	75.46
Yield per plant (gm)	Rabi 75-76	0.50	3.89	1.95	1.38	1.39	66.13	60.46	98.00	2.38	122.05
	Kharif 1976	1.82	4.75	3.69	0.90	0.93	25.71	26.12	96.88	1.92	52.03

varied from 3.9 to 6.1 and 2.85 to 4.58. Number of nodes per plant ranged from 11.25 to 21 and 12.24 to 23.75. Number of pods per plant ranged from 20.48 to 37.25 and 24.22 to 42. Yield per plant also varied from 0.50 to 3.89 and 1.82 to 4.75 (gm).

A wide range of genetic variation were observed for all the characters under study except for number of branches per plant. The genotypic variances are widely differing from environment-1 (Rabi 1975-76) and environment-2 (Kharif 1976). However, the magnitude of phenotypic and genotypic variances was not much varied for any character. Phenotypic components of variance was found to be slightly higher in magnitude in comparison to genotypic components of variance. The another interesting feature which was observed in the present study that environment-2 (Kharif 1976) was found to be better for the expression of the yield components in comparison to environment-1 (Rabi 1975-76). The number of branches per plant showed very narrow range of variation under both environments.

Since the magnitude of absolute variation at both genotypic and phenotypic levels are dependent upon the unit in which a particular character has been measured, coefficients of variability were worked out in order to compare the extent of variation encountered for each character. The genotypic coefficient of variation was highest for yield per plant followed by plant height. This indicated that the maximum variability was accounted for yield and plant height. The phenotypic coefficient of variation was slightly higher than genotypic coefficient of variation. The genotypic and phenotypic coefficients of variation were found to be higher in case of Kharif (1976) and in some characters such as yield per plant and days to 50 per cent flowering the values are doubled. The days to 50 per cent flowering and number of branches per plant exhibited low genotypic coefficient of variation as compared to others. Moderate genetic variability were observed for number of nodes and number of pods per plant. In all the characters genotypic coefficient of variation was smaller than phenotypic coefficient of variation. Comparison of genotypic variability under two environments revealed that genotypic variability for all the characters was maximum in Kharif (1976) than Rabi (1975-76). Similar results were obtained for phenotypic variability for all the characters under study.

III. Heritability and Genetic Advance

In order to measure relative magnitude of genotypic and phenotypic variability for estimating masking influence of environment, heritability in broad sense for each trait was worked out. Heritability estimates not only differed from character to character but also environment to environment. In general, heritability estimates were high for all the characters under both environments with the exception of number of branches per plant. The magnitude of heritability was high under both environments for plant height followed by yield per plant and number of nodes per plant, days to 50 per cent flowering and number of pods per plant. The number of branches per plant exhibited medium to low estimates of heritability under the two environments. The heritability estimates for number of branches (31.77%) in Rabi (1975-76) and the same character exhibited just doubled (61.76%) the heritability in Kharif season (1976). In general, higher estimates of heritability was observed with maximum variation in magnitude and vice-versa.

On the basis of heritability estimates, the expected genetic advance was computed from the selection of top 5 per cent individuals and the predicted means for all the six characters are presented in Table 5. Since magnitude of genetic advance is influenced by unit of measurement, genetic advance as percentage of mean was worked out in order to facilitate the comparison of genetic progress in various characters.

Comparatively higher estimates of genetic advance on the basis of both the environments were recorded in case of plant height (72.44%) followed by number of pods per plant, days to 50 per cent flowering and number of nodes per plant. The number of branches per plant and yield per plant gave low genetic advance of 1.07 per cent.

High heritability and high genetic advance as percentage of mean was coupled with yield per plant, number of nodes per plant and plant height. The high heritability estimates and medium genetic advance as percentage of mean was coupled with number of pods per plant and days to 50 per cent flowering. Low genetic advance as percentage of mean was noticed in number of branches per plant (27.36) and days to 50 per cent flowering (29.44), though the days to 50 per cent flowering recorded high heritability estimates.

The relative comparison of the expected genetic advance as per centage of mean under both environments revealed that the Kharif (1976) season was quite favourable for selection for all the components of yield with the exception of yield. On the contrary the Rabi (1975-76) season was found to be the best to get the better selection gain in yield.

IV. <u>Genotypic, Phenotypic and environmental correlations</u>

The genotypic phenotypic and environmental correlations coefficient for different characters were studied separately for each environment and have been presented in table 6 and 7. The results indicated that genotypic

Table 6: Genotypic, phenotypic and environmental correlations for different combination of characters in Rabi season 1975-76

Characters		Plant height (cm)	Number of branches per plant	Number of nodes per plant	Number of pods per plant	Yield per plant (gm)
Days to 50% flowering	G	0.5058	-0.6453	-0.1578	0.6660	-0.5868
	P	0.4545**	-0.3780*	-0.1389	0.5399**	-0.5654**
	E	0.1433	9 .1436	-0.0279	0.0815	0.1324
Plant height (cm)	G		0.5054	-0.1208	0.6190	-0.7728
	P		0.2857	-0.1146	0.5466**	-0.7840**
	E		-0.0370	0.0051	-0.1282	0.7160
Number of branches per plant	G			-0.1157	-0.0266	0.0809
	P			-0.0707	0.0554	0.0650
	E			0.0355	-0.1746	0.1919
Number of nodes per plant	G				0.6696	0.1745
	P				0.5773**	0.1692
	E				0.0813	0.1806
Number of pods per plant	G					0.6939
	P					0.6270**
	E					0.1428

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 7: Genotypic, phenotypic and environmental correlations for different combination of characters in Kharif season 1976

Characters		Plant height (cm)	Number of branches per plant	Number of nodes per plant	Number of pods per plant	Yield per plant (gm)
Days to 50% flowering	G	0.6424	-0.5519	0.6571	0.7382	-0.3701
	P	0.61400**	0.4613**	0.6087**	0.6528**	-0.3595**
	E	-0.3963	-0.2384	0.0492	-0.3404	0.0545
Plant height (cm)	G		-0.2767	0.5413	0.4213	-0.7396
	P		-0.2181	0.5089**	0.3990*	-0.7251**
	E		0.0314	0.0677	0.1614	0.1699
Number of branches per plant	G			0.1976	-0.1318	0.3784
	P			0.2711	-0.0336	0.3385
	E			0.6005	0.2365	0.2924
Number of nodes per plant	G				0.7652	0.7408
	P				0.6819**	0.7142**
	E				0.0501	0.1669
Number of pods per plant	G					0.2302
	P					0.1394
	E					0.0405

* Significant at 5 per cent level

** Significant at 1 per cent level

correlation coefficients are in general higher than the phenotypic which in turn were higher than environmental correlation.

The correlation coefficients of different character combination of the environment-1 (Rabi 1975-76) have been discussed under Table 6.

Days to 50 per cent flowering had significant positive association with plant and number of pods per plant. On the other hand days to 50 per cent flowering had negative association with number of branches per plant and yield per plant. Plant height was positively associated with number of pods per plant and its association was negative with yield, number of pods per plant exhibted positive association with yield. Number of nodes per plant exhibited significant positive association with number of pods per plant, whereas it was not directly associated with yield.

Correlation coefficients for different combination of characters for Kharif season (1976) (Table 7) revealed that the days to 50 per cent flowering was positively associated with plant height, number of branches per plant, number of nodes per plant and number of pods per plant. The plant height had positive association with number of nodes per plant and number of pods per plant.

Number of nodes per plant showed positive association with number of pods per plant and yield per plant.

The relative comparison of correlation coefficients of two different environments did not followed any systematic trend in relation to magnitude of correlation coefficients. The sign of the coefficient of correlations also differed from environment to environment as it was observed in case of plant height to number of nodes per plant, number of pods per plant under the both environments. Yield per plant had a significant positive association with number of nodes per plant in Kharif (1976) and number of pods per plant in Rabi (1975-76). Plant height and days to 50 per cent flowering had significant negative association with yield under two environments.

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CHAPTER V

DISCUSSION

The presence of genetic variability is essential for the genetic improvement of crop. The systematic survey of available genetic variability is necessary for planning and evaluating successful breeding programme. The yield and its components are polygenic and influenced by the environmental conditions and interaction between genotype and environments. Therefore, the observed phenotypic variability could be partitioned into three components viz. genotypic, environment and genotypic and environment interaction.

One of the main objectives of present investigation was to study variability with regard to six agronomical characters. The present study revealed significant differences for all the characters studied in two environments with the exception of number of branches per plant. High magnitude of genotype x environment interaction was observed for all characters. The variability in biological population that we can see measure and study is the ultimate result of the variability in the genetic constitution of the individuals making that population. The genotype should be studied only through phenotype which is the inter-play between genotype and environment. A study in the phenotypic variability in the soybean for yield and its components become imperative. The comparison of relative magnitude of genotypic coefficient of variation for various characters reveal that maximum amount of genetic variability was present in yield followed by plant height. The low genotypic coefficient of variation was observed in days to 50 per cent flowering followed by number of branches per plant. The presence of moderate amount of genetic variability was indicated for number of nodes per plant and number of pods per plant. The relative magnitude of variability exhibited by various characters maintained a parallel trend at phenotypic level. In general, all characters exhibited high values of coefficients of variation both at phenotypic and genotypic levels under Kharif (1976) in comparison to Rabi (1975-76). However, yield per plant exhibited highest value of genotypic and phenotypic coefficient of variation in Rabi (1975-76) in comparison to Kharif (1976). There were much differences in mean values of this traits in both the environments.

It is essential to assess the relative effect of genotype and environment and to have an estimate of extent of improvement possible. The success of selection would depend upon the correspondance between genotype and phenotype if the selection is practised based on the selection of phenotypes. Heritability, which measures the relationship between genotype and phenotype is an important consideration for success in a breeding programme since selective capacity in a population depends upon the amount of heritable variability present. It is important to know in what manner this variability functions in order to be able to estimate it and use it explicity.

Heritability estimates in the present investigation have been made in broad sense which includes variances due to all types of gene interactions. When the heritability of quantitative traits become high, the phenotypic appearance would provide a fairly close measure of genotypic value and thus the breeder could base his selection on the phenotypic appearance. Heritability estimates obtained under two environments were found to be high for all characters except number of branches per plant. This is an indication that the substantial source of variation is available for yield components and yield. These results are in agreement with the findings of Anand and Torrie (1951), Johnson __et al__. (1955a) and Yoshino __et al__. (1955), Lal and Fazlul Haque (1972), Malhotra (1973), Chandra __et al__. (1975), Ardeleon (1975), Bhagmal (1969), Hiremath and Talwar (1971), Wishwanath __et al__. (1975), Chand __et al__.(1975), Naphade __et al__. (1972) and Singh __et al__. (1973). However, the present results are not in agreement with those of Mahmud and Kramer (1951) found low estimates of heritability for plant height, Nandpuri __et al__. (1973) observed low estimates of heritability for days to first flowering.

Relatively low estimates of heritability under both the environments for the number of branches per plant are in agreement with the findings of Aylesworth and Lambert (1969), Long *et al*. (1950), Anand and Torrie (1963), Rodin (1973), Ardeleon (1975), Johnson *et al*. (1955a), Yoshino *et al*. (1955), Thseng and Hosokawa (1973), Bartley and Weber (1952), Hanson and Weber (1962), Kwon and Torrie (1964) and Rubaihayo and Onim (1975).

Low estimates of heritability for number of branches per plant is in sharp contrast to the findings of Hiremath and Talawar (1971), Naphade *et al*. (1973), Nandpuri *et al*. (1973) and Chandra *et al*. (1975), high estimates of heritability for number of pods per plant was also reported by Hanway (1975), Bhagmal (1969), Naphade *et al*. (1972), Nandpuri and Kramer (1973), Singh *et al*. (1973) and Mahmud and Kramer (1951).

Though the heritability estimates were found to be high for most of the characters but there were differences in the magnitude of the estimates under two environments. This is happening probably due to genotype into environment interaction which the breeders ignore in the individual environment. The selection pressure applied in the Kharif environment (1976) could prove successful for better genetic gains in the soybean improvement programmes.

Noteworthy feature of the heritability estimates made in the present study is that the heritability estimates are rather high for all attributes except number of branches per plant. It is probable that a substantial portion of genotypic variance used to calculate heritability percentages was of non-additive genetic type. Broad sense heritabilities in the present study is likely to be biased upward by dominance and epistatic effects. The bias from these sources was not estimated but the possibility of their influence should not be ignored. Similar results were also reported by Dalal (1975).

The use of heritability estimate to predict advance from selection for hypothetical testing programmes appears to be advantageous. The heritability value alone, however, provides no indication of the amount of genetic progress that would result from selecting the best individuals. Johnson et al. (1955a) in their studies on soybean pointed out that heritability value, along with genetic advance, was more useful than heritability estimate alone in predicting the resultant effect for selecting the best individuals limitation of heritability in the broad sense, as obtained in the present study, includes both the additive and epistatic gene effects which will be reliable if accompanied by high genetic advance (Ramanujam and Tirumalachar, 1967).

Plant height had high estimates of heritability value together with high genetic advance which is probably due to additive gene effects (Panse, 1957). This is in agreement with the findings of Dalal (1975) and Jain (1979). Moderate genetic advance was recorded for number of nodes per plant, number of pods per plant and days to 50 per cent flowering. Similar results were observed by Hiremath and Talawar (1971), Naphade *et al*. (1972), Nandpuri *et al*. (1973), Khangura and Sandhu (1973), Lal and Mehta (1973) Chand *et al*. (1975), Anand and Torrie (1963) and Johnson *et al*. (1955a).

The number of branches per plant and yield per plant gave low genetic advance. These results are in agreement with the findings of Hiremath and Talawar (1971) Nandpuri *et al*. (1973). These estimates are however, in sharp contrast to the findings of Jaimini *et al*. (1971). Days to 50 per cent flowering, number of nodes per plant, pods per plant and yield per plant had high heritability but moderately low genetic advance which suggested that high heritability for this character was probably due to non-additive (dominance and epistasis) gene effects (Panse, 1957).

Correlation Studies

The observed phenotypic correlation between two metric traits stands from two causes, genetic and environmental. The environmental correlation is of little interest to the breeder, but it provides information about relationship of characters irrespective of genotypic differences in the plant material. Estimates of genetic associations along with phenotypic correlations, not only display a clear picture of the extent of inherent association but also indicate how much of the phenotypically expressed correlation is influenced by the environments.

The phenotypic and genotypic correlations were similar in direction, while in magnitude genotypic correlations were mostly higher than corresponding phenotypic correlations which is in agreement with the results of Weber and Moorthy (1952), Johnson et al. (1955b), Anand and Torrie (1963), Kwon and Torrie (1964), Lal and Fazlul Haque (1971), Wakankar et al. (1974), Gautham and Singh (1977) and Singh et al. (1979). The low phenotypic correlations could result due to the masking and modifying effect of environment on the association of characters at genic level.

Number of nodes per plant had positive association with yield under environment Kharif (1976) and number of pods per plant showed positive association with yield under environment in Rabi (1975-76). On the other hand days to 50 per cent flowering and plant height had strong negative influence on yield. Number of pods per plant had a significant positive influence on plant height, days to 50 per cent flowering and number of nodes per plant. These results are not in conformity with those of Shih (1948), Anand and Torrie (1963), Burnside and Colville (1964), Lal and Fazlul Haque (1971), Dalal (1975), Jain (1979), Gautham and Singh (1977) and Singh et al. (1979).

Number of pods per plant had significant positive association with days to 50 per cent flowering, plant height and number of nodes per plant and these correlation coefficients were found to be consistent over two environments. Under second environment during Kharif (1976) days to 50 per cent flowering exhibited positive association with number of branches per plant. However, this was found to be negative in Rabi (1975-76). Apart from this the significant positive correlation between days to 50 per cent flowering and number of nodes per plant in Kharif (1976) was turned out to be nonsignificant in 1975-76 Rabi. However, the correlation coefficients of plant height with days to 50 per cent flowering was found to be significant with slight variation under both the environments.

These estimates are however, in sharp contrast to the findings of Stewart (1923), Weber and Moorthy (1952), Kwon and Torrie (1964), Shkuropat (1970), Sengupta and Kataria (1971), Lal and Fazlul Haque (1971), Kaw and Menon (1972), Gautham and Singh (1977), Dalal (1975), Jain (1979) and Singh et al. (1979).

It is interesting to note that number of nodes per plant and plant height exhibited highly significant correlation among themselves. But none of them had a positive association with yield under rabi environment. Jain (1979) also observed negative correlation between days to 50 per cent flowering and seed yield.

Correlation coefficients at environmental level were considerably less in magnitude. The variation between genotypic and environmental correlations probably arises because of differential response of component character to the change in environments. Hence the environmental correlation coefficients between the same components under the varying environments were found to be vary widely even for the same material. If such variation is very high it will create problem for selection. Therefore, in the breeding experiments mostly magnitude of genotypic correlation coefficients are taken into consideration followed by phenotypic, while environmental correlations are less relied upon.

The environmental correlation coefficients include mainly the effects of soil heterogeneity, cultural irregularities and other chance errors occurring while conducting the experiment (Sikka and Maini, 1962). These factors would be responsible for harmonic changes in plant behaviour and could be easily explained in terms of physiological adjustments.

The relative comparison of correlation coefficients of two environments revealed that kharif environment was favourable for more profuse vegetative growth of soybeans that leads to the association of number of pods per plant with yield. At the same time there was no simultaneous increase in number of pods per plant during kharif season.

On the other hand, Rabi environment favoured for early maturity and slow growth of the genotypes due to warm climatic conditions. This leads to increase in the number of pods per plant by increasing number of pods per node. This ultimately resulted into positive association of number of pods per plant with yield under Rabi environment.

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CHAPTER VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

Eight varieties of soybean (*Glycine max* (L.) Merrill) were grown in randomized complete block design with four replications at Livestock Farm, Department of Plant Breeding and Genetics, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. During Rabi (1975-76) (environment-1) and Kharif (1976) (environment-2), observations were recorded on days to 50 per cent flowering, plant height (cm), number of branches per plant, number of nodes per plant, number of pods per plant and yield per plant (gm).

The analysis of variances indicated existence of considerable amount of genetic variability for various characters under study except that relatively less variability was observed for number of branches per plant.

The pooled analysis of variances indicated significant varietal differences for plant height, number of nodes per plant and yield per plant. The variety into environmental interaction was found to be significant for all the characters.

A wide range of phenotypic variability was observed for plant height, number of nodes per plant, number of pods per plant and plant yield under the two environments. The genotypic variability was higher for plant height, number of nodes per plant, number of pods per plot during the Kharif (1976). Yield per plant had highest genotypic co-efficient of correlation during Rabi (1975-76).

High heritability estimates ranging from 77.36 to 98.60 per cent for all characters during the individual environment were observed. The exception being in number of branches per plant which had low estimates of herit-ability.

The value of genetic advance as percentage of mean ranged from 13.77 to 45.17, 85.82 to 102.32, 17.26 to 37.47, 80.67 to 115.20, 26.17 to 75.46 and 122.05 to 52.03 for days to 50 per cent flowering, plant height, number of branches per plant, number of nodes per plant, number of pods per plant and yield per plant under environment-1 (Rabi 1975-76) and environment-2 (Kharif 1976) respectively.

Yield per plant was found to be negatively associ-ated with plant height and days to 50 per cent flowering under both the environments. Number of nodes per plant was found to be major contributing factor for yield under Kharif environment whereas number of pods per plant exerted maximum influence on yield in Rabi environment. At pheno-typic and genotypic levels under different environments, number of branches per plant had no association with seed yield per plant under both environment.

Number of pods per plant had positive correlation with days to 50 per cent flowering, plant height and number nodes per plant. Plant height showed positive correlation with days to 50 per cent flowering. The correlation coefficients of days to 50 per cent flowering with number of branches per plant and number of nodes per plant were found to be inconsistent under the two environments.

Conclusions

It could be concluded from this study that the yield components such as number of nodes per plant and number of pods per plant exert differential influence under different environments. Kharif environment was favourable for more profuse vegetative growth of soybeans that leads to the association of number of nodes per plant with yield. On the other hand Rabi environment favoured for early maturity and slow growth of the genotypes due to warm climatic conditions.

Suggestions for future work

The following relevant suggestions are given to wider the scope of the present investigation.

1. The available genetic variability in soybean genotypes should be exploited for the development of soybean cultivars.

2. Divergent genotypes should be used in the breeding programme to get the better combinations of yield components.

3. Rabi environment was found to be the best suited for the soybean selection experiment.

4. The available genotypes should be raised in Kharif and Rabi season over years in order to made specific recommendations for both the seasons.

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* Original not seen

APPENDIX-I

Climatological data from November 1975 to December 1976

Month	Average temperature in °C		Average relative humidity %	Number of rainy days
	Maximum	Minimum		
November 75	26.6	10.6	92.4	-
December 75	24.7	6.9	92.3	-
January 76	24.5	9.3	90.5	1
February 76	27.7	11.9	80.9	-
March 76	32.8	16.0	65.3	2
April 76	37.0	21.5	49.7	2
May 76	40.3	26.9	35.9	3
June 76	35.6	25.8	70.6	10
July 76	29.6	23.9	87.4	21
August 76	29.1	24.0	93.5	21
September 76	29.9	23.5	89.5	12
October 76	32.0	18.5	84.8	-
November 76	30.0	17.1	89.8	2
December 76	26.0	11.2	88.3	1

APPENDIX II

Mean values for various agronomical traits of soybean in each environment

S. No.	Varieties	Days to 50% flowering		Plant height (cm)		Number of branches per plant		Number of nodes per plant		Number of pods per plant		Yield per plant (gm)	
		Rabi 75-76	Kharif 1976	Rabi 75-76	Kharif 1976	Rabi 75-76	Kharif 1976	Rabi 75-76	Kharif 1976	Rabi 75-76	Kharif 1976	Rabi 75-76	Kharif 1976
1.	JN 670	83	37.00	72.75	80.50	6.1	4.58	16.75	17.15	28.78	38.62	2.53	3.34
2.	JS 72-1	84	47.75	77.68	91.05	5.6	2.98	17.38	16.25	30.98	42.00	0.64	4.57
3.	JS 71-5	86	37.00	47.12	42.10	3.9	3.75	15.62	12.18	25.15	24.92	3.15	4.75
4.	JS 72.20	80	36.50	71.45	78.92	5.1	3.65	13.00	12.48	20.48	28.62	1.53	3.63
5.	Kalitur	89	46.75	96.50	103.65	4.6	3.75	19.92	23.75	37.25	39.30	0.50	1.82
6.	Bragg	78	35.00	57.80	58.87	5.3	4.15	21.00	17.72	29.35	34.75	3.89	4.26
7.	Ankur	83	36.75	88.55	94.35	5.2	4.02	13.52	15.10	27.30	24.20	1.50	3.03
8.	PK 73-61	86	38.50	81.78	85.42	5.5	2.85	11.25	13.10	29.48	29.95	1.92	4.14

V I T A

Chandrika Prasad Tiwari, the author of this thesis was born on September 15, 1955 in village Richhai, Jabalpur district of Madhya Pradesh and taken higher secondary education from Hitakarni Higher Secondary School, Govindganj, Jabalpur. He was graduated B.Sc. (Agri.) from College of Agriculture, J.N. Krishi Vishwa Vidyalaya, Jabalpur. He joined in the department of Plant Breeding & Genetics, College of Agriculture, JNKVV Jabalpur in 1975 as an M.Sc. (Agri.) student.