GENETIC ANALYSIS OF PRODUCTIVITY AND QUALITY PARAMETERS IN RICEBEAN (*Vigna umbellata* [Thunb] Ohwi & Ohashi)

By

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DECLARATION

I hereby declare that this thesis entitled "Genetic analysis of productivity and quality parameters in ricebean (*Vigna umbellata* (Thunb) Ohwi & Ohashi", is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "Genetic analysis of productivity and quality parameters in ricebean (*Vigna umbellata* (Thunb) Ohwi & Ohashi", is a record of research work done independently by Mr. Suresh Kumar N.S. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

INTRODUCTION

Pulses constitute an important group among the various food crops of the tropics which are the main source of vegetable protein in the human diet. The place of pulses in the human diet is seen even in the ancient Indian literature. They occupy a unique position in the world agriculture due to high protein content and ability to fix atmospheric nitrogen. Over and above this, they supplement the limiting amino acids of cereals like lysine and tryptophan. In a balanced diet, per capita requirement of pulses is 60g/day by an adult to meet the daily protein requirement (Swaran Pasricha 1992). But, the present availability is less than 45g/day (Anonymous, 1986). India grows a variety of pulses but inspite of its large acreage of 22.56 million ha. the production is only 12.05 million tonnes (Directorate of Economics and Statistics). Increasing pulse production is the only means of meeting the day to day increase in demand of grain legumes.

Rice bean (<u>Vigna umbellata</u>) (Thunb) Ohwi & Ohashi Syn. <u>Phaseolus calcaratus</u> Rox.) is known by different local names like Sutri in Hindi and Gaimung in Bengali. It is one as tribal pulse (Arora et al. 1980). It stands out among the pulses due to its resistance against serious diseases like YMV, bacterial leaf spot and above all its extreme resistance against pulse beetle during storage. Ricebean can be grown up to an elevation of 1800 m above mean sea level and is drought tolerant. In north India it is grown during the Kharif and is photosensitive. Rice bean is an excellent source of protein and can be used as food, fodder and cover crop. In comparison with soyabean, rice bean is rich in essential aminoacids like lysine, methionine, histidine and minerals like iron. Despite its multipurpose uses, high nutritive value and wider adaptability, only very little attention has been given by the research workers for its improvement.

The prerequisite for improvement of any crop is the availability of variability and information regarding its extent. Plant breeding aims at developing high yielding genotypes with wider adaptability, yield stability and quality. Superior genotypes with high yield potential are selected from a variable population. Yield, being a complex character, is produced by the action and interaction of several factors and environment. Direct selection based on yield may not be effective due to its inter relationship with other characters. In such a situation it would be better to findout the association between yield and yield contributing factors so that high yielders can be selected using these tools.

The present study was carried out with the objective of identifying important yield contributing characters which influence yield and quality in rice bean.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Pulses are an important ingredient in the human food next to cereals. It supplies protein and essential aminoacids. Rice bean is one of the under-exploited pulses and it has many advantages like drought tolerance and pest resistance apart from its high protein content.

Selection of superior genotypes from genetically diverse population is done with the help of certain parameters like variability, correlation, heritability, genetic advance and path analysis. All attempts have been made to review the hitherto literature of work done in ricebean. However, the available published works on this crop is limited. Hence this review is extended to aspects of similar nature in other pulse crops also.

I Variability

Success of any crop improvement programme depends mainly on the efficient management and utilization of variability. For achieving genetic improvement in a crop the primary prerequisite is genetic variability. Genetic parameter which provides an efficient estimation of variability is the co-efficient of variation.

Many workers have studied the extent of variability in pulse crops. Their findings are briefly reviewed below.

Ramakrishnan *et al*. (1978) observed that the genotypic co-efficient of variation (gcv) was the lowest (6.14) for pod length and highest (102.1) for plant height in horsegram.

Sreekumar *et al*. (1979) obtained high gcv for haulm yield (47.07) and lowest for total duration in cowpea (4.48). Phenotypic co-efficient of variation (pcv) was highest for haulm yield (54.73) and lowest for days to flowering (6.14).

Arunachala (1979) obtained high gcv for yield per plant, pod number and plant height in field bean.

Ramachandran *et al*. (1980) reported maximum gcv of 57.12 for yield per plant followed by pods/plant (56.56) in cowpea. The lowest value of gcv was recorded by pod length (6.44).

Pandita *et al*. (1980) observed high amount of variability in pod size, number of pods/plant, number of flowers per cluster and infloresence length in Indian beans.

Nandan and Pandya (1980) reported that in 49 diverse strains of lentil substantial genetic variability was observed for all characters except plant height.

Variability studies in 50 diverse genotypes of cowpea revealed that in all the forage yield components viz dry matter, green forage and seed yield, environment co-efficient of variation exceeded genotypic variance except for number of days to first flowering (Kumar and Mishra, 1981).

Bainiwal <u>et al</u>. (1981) observed maximum variability for secondary branches followed by primary branches and seed yield in 29 genotypes of pigeonpea.

Ganeshiah <u>et al</u>. (1982) obtained the lowest values for gcv and pcv for seeds/pod, days to maturity, 100 seed weight, days to flower and number of pods/plant in horsegram.

Patel and Shah (1982) recorded high gcv for pod length and plant height in blackgram.

Radhakrishnan and Jebaraj (1982) obtained high genotypic co-efficient of variation for number of pods per plant in cowpea.

Jagshoram (1983) recorded high magnitude of range for phenotypic variability for all the characters except seeds/pod. High gcv was obtained for pods/plant, days to maturity, plant height and days to flower in pigeon pea.

Liu et al. (1984) recorded high gcv for seed weight/plant and pod number/plant in greengram.

Variability studies on 40 genotypes of cowpea showed greater variability for harvest index, number of pods and seed yield. Least variability was shown by number of seeds per pod, pod length and 100 seed weight (Dharmalingam and Kadambavanasundaram, 1984).

Ragaswamy and Shanmugam (1984) obtained high pcv and gcv for fresh root weight in greengram.

Rao and Sharma (1985) reported in 28 genotypes of soyabean substantial genetic variability was observed for days to 50 per cent flowering, pod yield per plant, number of seeds/plant and 100 seed weight.

In pea, Singh (1985) obtained high degree of genetic variability for grain yield per plant, plant height, number of pods per plant and number of branches per plant.

Sidhu et al. (1985) reported highest genetic variability for number of pods and lowest for the number of seeds/pod in pigeonpea.

In geonoptypic and phenotypic variability studies by Gupta et al. (1986) in 9 parents and their 36 F_1's in peas, the maximum gcv was observed for 100 seed weight followed by branches/plant, pods/plant, seed yield/plant and length of fruiting zone.

Patil and Baviskar (1987) obtained high gcv and pcv for pod cluster per plant, pod/plant, seed yield/plant and 100 seed weight in cowpea.

In horsegram Birari et al. (1987) reported a maximum gcv in the case of number of seeds/pod (29.96) followed by that for seed yield/ha (20.37). Low gcv was obtained for number of days to first pod maturity.

Maloo and Sharma (1987) reported that in gram estimates of genotypic coefficient of variation ranged from 1.58 for days to maturity to 40.26 for grain yield per plant.

Singh and Dhiman (1988) reported that high gcv and pcv were observed for plant height, pods per plant and number of leaves per plant in rice bean.

Variability studies in 35 genotypes of cowpea recorded maximum gcv for drymatter yield followed by plant height, green forage yield, pods/plant, seed weight and green pod yield (Sharma et al., 1988).

Singh et al. (1988) reported maximum gcv and pcv for 100 seed weight and minimum for number of seeds/pod in faba bean.

In greengram Natarajan et al. (1988) obtained high gcv for seed yield, pod number and plant height.

High gcv and pcv for number of secondary branches/plant followed by 100 seed weight in chickpea was reported by Sharma et al., (1990).

Natarajan et al. (1990) obtained the highest gcv for pod number followed by cluster number and seed yield and the lowest for seeds/pod in pigeonpea.

Elizebeth (1991) reported maximum gcv for days to flowering in horsegram.

II. CORRELATION

In plant breeding programmes, correlation studies are of great importance since they provide estimates of the degree of association of a character with its components and also among the various components. In improving the yield potential of a crop, information on interrelationship between yield and yield contributing characters is of great importance.

Correlation studies conducted by various workers in different pulse crops are reviewed below.

Gupta and Singh (1969) and, Singh and Malhotra (1970) in greengram obtained negative correlation between yield and 100 seed weight.

Tikka et al. (1977) found that number of pods/plant was positively correlated with yield in moth bean.

Sandhu et al. (1978) obtained positive correlation of seed yield with number of pods/plant, pod length and seeds/pod in blackgram and negative correlation of seed yield with days to flowering and number of branches. Seed protein content exhibited negative association with seed yield, seed/pod, pod length and number of pods/plant.

Sreekumar et al. (1979) obtained positive correlation between yield and seeds/pod and 100 grain weight in cowpea.

Arunachala (1979) reported a positive correlation of pod yield was with number of pods, height, pod length and width and seed length and width and a negative correlation of pod yield with protein content in field bean.

Positively correlation of grain yield with pods/plant, pod length, seeds/pod and 100 seed weight was reported but Sandhu et al., (1979) but did not find any association of grain yield with protein content.

In horsegram pod length exhibited maximum genotypic correlation with seed yield (Suraiya, 1980)in hoursegram.

In fieldbean Pandey et al. (1980) revealed high positive correlation of yield with days to flowering, 100 seed weight, pod width and protein content.

Imam (1980) reported that protein content in Phaseolus was positively correlated with number of pods/peduncle, pods/plant, seeds per pod and seeds/plant and negatively correlated with days to first ripe pod, yield/plant and seed size. In Vigna it was positively correlated with number of flowers/peduncle.

Waldia *et al*. (1980) found that seed yield/plant and number of branches/plant were both positively correlated with number of cluster and pods per plant in blackgram.

In horsegram Ganeshiah (1980) observed positive association of number of pods with seeds per pod.

Pandita *et al*. (1980) reported that infloresence length and pod length were highly and positively correlated with yield, in contrast to the negative correlation of days to flowering with yield in Indian beans.

Studies on 49 diverse strains of lentil by Nandan and Pandya (1980) revealed that number of pods and number of branches per plant are correlated with seed yield.

Sandhu *et al*. (1980) reported that seed yield was positively correlated with cluster per plant, pods/plant and seeds/pod in blackgram. Protein content was negatively correlated with these characters as well as seed yield.

Bainiwal *et al*. (1981) found that primary branches, secondary branches and plant height were correlated with yield in pigeonpea. Genotypic correlation coefficients were higher than phenotypic correlation coefficients.

In chickpea Tyagi et al. (1982) reported that grain yield/plant was positively correlated with pods/plant, secondary branches and 100 seed weight, pods/plant had positive association with number of primary and secondary branches but seed protein exhibited negative correlation with grain yield/plant and plant height.

In blackgram grain yield/plant showed positive correlation with number of branches, pods and cluster/plants (Patel and Shah, 1982).

Liu et al. (1984) reported that in greengram 100 seed weight was negatively correlated with pod number/plant.

Singh (1985) observed that days to 50 per cent flowering, days to maturity, plant height, number of pods/plant and number of primary branches were positively correlated with grain yield and among themselves in pea.

Positive corelation of seed yield with plant height and pods/plant was reported by Sidhu et al., (1985) in pigeonpea.

In broadbean Naidu et al. (1985) reported that seed yield was negatively correlated with flowering time, maturity and height, and positively with branches, pods/plant and seeds/pod.

Chikkadyavaiah (1985) observed that seed yield was positively correlated with number of branches/plant, pods/plant, seeds/pod and 100 seed weight in cowpea.

In horsegram seed yield was positively correlated with number of seeds/plant, primary branches and height. (Kallesh, 1986).

Henry et al. (1986) reported that in 36 genotypes of clusterbean seed yield was positively correlated with number of pods/plant, 100 seed weight, plant height and number of branches per plant.

Bhadra et al. (1987) observed that seed protein percentage, 100 seed weight and seed yield were not correlated with one another in greengram.

In pigeonpea seed yield was positively correlated with plant height and pods/plant both at genotypic and phenotypic level (Marekar and Nerkar 1987).

Studies on 28 genotypes of chickpea revealed that nodule weight and root weight was correlated with yield (Islam et al. 1987).

In horsegram Birari _et al_. (1987) strong positive correlation of yield with number of days to first pod maturity, number of pods/plant and number of seeds/pod.

In cowpea choulwar and Borikar (1987) reported that seed yield/plant was significantly correlated with plant height, pod length and 100 seed weight.

Patil and Bhapkar (1987) observed that seed yield was positively correlated with pods/plant and seeds/pod in cowpea and these were negatively correlated with each other.

According to Maloo and Sharma (1987) grain yield had positive association with number of pods/plant, number of primary branches and 100 seed weight in grain.

Positive association of seed yield with number of pods, days to maturity, plant height and branches in pigeonpea was reported by Sagar _et al_. (1987).

Senanayake and Wijerathne (1988) observed that seed yield was negatively correlated with number of primary branches and positively with 100 seed weight and pod length in cowpea. Protein content was not associated with yield or its components.

Positive correlation of seed yield with number of seeds per pod and branches/plant in greengram was reported by Raut et al. (1988).

In gram, seed yield was associated with days to maturity, primary branches/plant, pods/plant and 100 seed weight (Pandya and Gupta 1988).

Sharma et al. (1988) reported that seed yield was positively correlated with pods/plant, seeds/pod, days to first flowering and days to 50% maturity.

Studies on 89 genotypes of greengram revealed positive correlation of seed yield with 100 seed weight, seeds/pod and pods per plant (Patil and Deshmukh 1988).

In greengram Khan (1988) reported that seed yield was positively correlated with pods, branch number, plant height and seed number/pod.

In chickpea, Mishra et al. (1988) found that grain yield has positive association with number of primary branches/plant and number of pods/plant.

Studied on 22 genotypes of cowpea revealed that branches/plant and seeds/pod were positively correlated with yield in cowpea (Tyagi and Koranne, 1988)

A positive correlation of yield with pod number and pod length was reported by Wanjari (1988) in blackgram.

Sharma <u>et al</u>. (1989) reported positive correlation of seed yield with number of pods/plant, primary branches/plant and plant height in chickpea.

Sandhu <u>et al</u>. (1989) observed that grain yield was positively correlated with pods/plant, seeds/pod and secondary branches in chichpea. Grain protein was negatively correlated with pods/plant.

According to Sadhu and Mandal (1989) seed yield was positively correlated with primary and secondary branches, pod number and seed number. Seed weight was negatively correlated with seed number and seeds/pod.

In cowpea Patil <u>et al</u>. (1989) reported that grain yield was correlated with pods/plant, 100 grain weight, pod length and days to 50% flowering.

Tiwari and Gautam (1989) observed positive correlation between green pod yield and primary branches/plant, 100 seed weight and seeds/pod in cowpea.

In lentil, high positive correlation was observed between seed yield and plant height, branch number/plant and pods/plant (Ramgiry _et al_., 1989).

Studies on 121 lines of greengram showed significant positive correlation of seed yield with plant height, number of branches/plant, pods/plant, seeds/pod, pod length and days to maturity (Satyan _et al_. 1989).

According to Thiyagaragan and Rajasekaran (1989) seed yield in cowpea was positively correlated with days to maturity, plant height, number of branches, pods/plant, pod length and seeds/pod. Days to 50% flowering and 100 seed weight were negatively correlated with yield.

Jindal (1989) reported that in 39 strains of cowpea studies the characters like green forage yield, number of branches and plant height were positively correlated among themselves.

In fababean, seed yield and pods/plant were positively correlated, and pods/plant was positively correlated with seeds/pod. Seeds/pod showed negative correlation with seed yield. (Katiyar and Singh 1990).

Singh and Dhiman (1990) reported that high correlation existed between fresh weight of nodules and plant height in rice bean.

In blackgram highest positive correlation with seed yield/plant was found for pods/plant (Raut et al., 1990).

Henry and Krishna (1990) reported that seed yield in pigeonpea was positively correlated with plant height, number of branches and seed/pod. In the same crop Natarajan et al. (1990) obtained positive correlation of seed yield with pod number and plant height.

In sem (Dolichos lablab var. lignosus L.) Dahiya et al. (1991) found seed yield was positively correlated with pod length both at phenotypic and genotypic level.

Positive correlation between seed yield and harvest index and also pods/plant, where as height and days to maturity recorded negative correlation with yield in horsegram (Elizebeth, 1991).

Siddique and Gupta (1991) observed significant positive correlation of seed yield with days to 50% flowering and pods/plant in cowpea.

In chickpea, seed yield was positively correlated with primary branches and pods/plant. Primary branches, pods/plant and seeds/pod were positively correlated among themselves (Sandhu et al., 1991).

Sarma et al. (1991) reported that seed yield showed positive correlation with plant height, branches and pods/plant at phenotypic level in ricebean. At genotypic level, yield was correlated with these traits and also with seeds/pod.

In rice bean Baisakh (1992) reported that pods/plant showed positive correlation with yield both at genotypic and phenotypic level, whereas plant height, pods/plant only at genotypic level. These characters had positive correlation among themselves. High positive correlation between yield components seen between days to 50% flowering and pod cluster/plant, seeds/pod and 100 seed weight, pods/plant and seeds/pod, pods/plant and pod length and pods/plant and seeds/pod.

Holkar and Raut (1992) reported that in greengram, seed yield was relatively correlated with 100 seed weight, pods/plant and pod length.

III. HERITABILITY AND GENETIC ADVANCE

Heritability of a character is the degree or extent to which the variability of a quantitative character is transferable to the progeny. Lush (1940) defined heritability in the broadsense as the percentage of total genotypic variance over phenotypic variance. In narrow sense heritability is the ratio of additive genetic variance to total variance. Consideration of phenotypic variability alone, without estimating the heritable part of the character under selection, will not be of much value. Johnson et al. (1955) suggested that heritability estimates along with genetic gain is usually more useful in predicting the resultant effect through selection of the best individual.

Heritability and genetic advance estimated by workers in different pulses crops are reviewed below.

Tikka et al. (1977) reported that estimates of heritability and of genetic advances were high for number of pods per plant in moth bean.

In blackgram estimates of broadsense heritability ranged from 23.89 per cent for yield per plant to 95.52 per cent for days to flowering was reported by Sandhu et al. (1978).

Sreekumar et al. (1979) recorded high heritability for 100 seed weight and high genetic advance for yield of haulms (83.32) followed by 100 seed weight and lowest genetic advance for total duration (6.48) in cowpea.

High heritability and genetic advance were recorded by Sreekumar and Abharam (1979) for number of branches, pods/plant and grain yield whereas plant height, length of pods, days to flowering and seeds/pod showed low genetic advance with high heritability in green gram.

Ramachandran et al. (1980) reported high heritability for days to flower (95.18) in cowpea. Maximum genetic advance was recorded for seeds/pod followed by yield and pods per plant.

Imam (1980) observed that heritability of protein content was 53.1% for Phaseolus and 80.2% for Vigna sp.

High expected genetic advance with high heritability estimates were recorded for pod size and yield in Indian beans by Pandita et al. (1980).

Nandan and Pandya (1980) reported highest heritability for 100 seed weight (80.53 %) followed by number of pods per plant (80.25) and lowest value for number of seeds per pod (30.46 %) in lentil.

The expected genetic advance was high for seed yield, secondary branches, plant height and primary branches in pigeonpea (Bainiwal et al., 1981).

In 22 cultivars of pigeonpea, Kumar and Reddy (1982) observed high heritability for all traits except number of primary branches and seed yield per plant. High genetic advance was observed for pod cluster per plant and 1000 seed weight.

Patel and Shah (1982) reported high heritability and genetic advance for pod length and plant height in blackgram. High heritability with low genetic advance was obtained for seeds per pod, 100 seed weight and pods per cluster.

High genetic gain was recorded for number of pods and cluster per plant, while days to maturity and plant height showed low genetic gain in cowpea (Radhakrishnan and Jebaraj 1982).

According to Jagshoram (1983) high heritability accompanied by moderate to high genetic advance for pods/plant, days to maturity, plant hight and days to flower was observed in pigeonpea.

In cowpea Dharmalingam and Kadambavanasundaram (1984) observed high heritability for pod length, 100 seed weight and harvest index in cowpea.

Rangaswamy and Shanmugam (1984) recorded moderate to high broadsense heritability for fresh and dry weight of roots with high genetic advance in greengram.

Heritability estimates were high among 30 varieties of pea for grain yield per plant, plant height, number of pods per plant and number of branches per plant (Singh, 1985).

Sidhu et al. (1985) revealed high heritability for all the traits except seed size and seed/pod in pigeonpea. Genetic advance was maximum for pods per plant.

In cowpea, Chikkadyavaiah (1985) recorded high heritability and genetic advance for plant height.

In horsegram, high heritability and genetic advance were obtained for primary branches, seeds per plant and pods per plant (Kallesh, 1986).

Patil and Baviskar (1987) observed that heritability was highest for 100 seed weight followed by days to maturity and pod length in cowpea.

Maloo and Sharma (1987) reported high genetic advance and heritability for grain yield, number of pods per plant and number of primary branches per plant in gram.

Studies on 50 genotypes of cowpea revealed high heritability for 100 seed weight, seeds/pod and days to maturity. The genetic gain was maximum for 100 seed weight, plant height, branches per plant and seeds per pod (Apte <u>et al</u>., 1987).

Singh and Dhiman (1988) reported high heritability estimates for 100 seed weight, plant height and pods per plant. Genetic advance ranged from 4.40 per cent for pods per plant to 68.79 per cent for plant height in rice bean.

Highest heritability of 98 per cent for days to 50 per cent flowering and lowest 46.9 per cent for green pod yield was recorded by Sharma <u>et al</u>. (1988) in cowpea.

According to Singh <u>et al</u>. (1988) studies on 40 genotypes of faba bean revealed highest heritability and genetic advance for 100 seed weight, days to 50 per cent flowering and branches per plant.

In chickpea, Mishra et al. (1988) reported that heritability estimates were high for all the characters and high heritability with genetic advance were obtained for number of secondary branches/plant, number of pods per plant and seed yield per plant.

Sandhu et al. (1989) reported that both grain yield and protein content showed high heritability in chickpea.

Sadhu and Mandal (1989) recorded high heritability estimates and genetic grain for seed weight in chickpea.

High heritability was recorded for 100 seed weight and pod length, moderate heritability for seeds per pod and yield recorded minimum heritability in green gram (Anitha, 1989).

In lentil, Ramgiry et al. (1989) reported that yield per plant, number of branches per plant and harvest index recorded high heritability.

Studies on 7 parents and F1 hybrids of cowpea revealed high heritability and genetic advance for plant height, number of seeds per pod and 100 seed weight (Thiyagarajan, 1989).

Roquib and Patnaik (1990) reported high estimates of length for plant height, pod length, days to 50% flowering and maturity and seed yield/plant in cowpea. These characters and effective nodules had high estimates of genetic advance.

Sharma et al. (1990) reported that heritability was highest for 100 seed weight, days to maturity and plant height in chickpea.

Pod number, cluster number and seed yield in pigeonpea recorded high heritability and genetic advance (Natarajan et al., 1990).

Sandhu et al. (1991) obtained high heritability for grain yield and 100 seed weight in chickpea.

Studies on 19 lines of rice bean revealed high heritability estimates for 100 seed weight, days to maturity and pod length (Sarma et al., 1991).

Elizebeth (1991) reported high heritability for 100 seed weight, days to flowering and days to maturity and low heritability for harvest index in horsegram. Maximum genetic advance was recorded for days to flowering followed by 100 seed weight.

IV Path coefficient analysis

The association between different yield contributing characters are of much importance in plant breeding. When the number of characters are high, the study of correlation between these characters will be difficult. Path coefficient analysis is the solution to this problem which provides estimates of direct and indirect effect of each component on yield.

Some of the path analysis done in different pulse crops are reviewed below.

Tikka et al. (1977) reported that in mothbean number of pods per plant showed positive direct effect on yield.

Sreekumar et al. (1979) in greengram recorded highest positive direct effect of number of clusters on yield followed by length of pod. Direct effect of pods per plant was negative.

Maximum positive direct effect of pod length on seed yield in horsegram was recorded by Suraiya (1980).

Waldia et al. (1980) observed that in urdbean cluster/plant had the highest positive direct effect on seed yield followed by 100 seed weight.

In lentil Nandan and Pandya (1980) found that number of pods per plant and number of branches per plant had larger effect on seed yield.

In horsegram, pod weight and 100 seed weight contributed more to yield than number of seeds per pod (Ganeshiah, 1980).

Sandhu et al. (1980) observed that in urd bean, for high grain yield select plants with lesser plant height, early flowering and longer pods. For high protein select medium high plants with less branches and more number of pods.

In blackgram plant height had negligible direct effect on yield. Number of pods per plant, 100 seed weight and seeds/pod had high direct effect on yield. Pod length and yield showed negative direct effect (Usharani and Rao, 1981).

Tyagi *et al*. (1982) revealed that primary branches, seed/pods and 100 seed weight had high positive direct effect on grain yield but negative direct effect on seed protein content in chickpea.

Studies on 22 cultivars of pigeonpea revealed that pod number, plant height and number of primary branches had positive direct effect on yield per plant (Kumar and Reddy, 1982).

Kumari and George (1982) suggested that in greengram yield increase can be obtained by selecting for more number of pods per plant, 100 seed weight and number of nodes per plant.

Patel and Shah (1982) observed that in blackgram cluster/plant had maximum positive direct effect on grain yield followed by pods/plant.

In pigeonpea Sidhu *et al*. (1985) found that pods/plant, plant height and seed size are the major contributors to seed yield.

Path analysis in cowpea revealed the direct effect of pods/plant and seeds per pod on seed yield. (Chikkadyavaiah, 1985).

In horsegram Kallesh (1986) reported that number of pods/plant and number of fruiting nodes are the major yield contributing characters.

Naidu et al. (1986) observed strong direct effect on yield by seeds/pod and pods/plant in moth bean

According to Henry et. al (1986) plant height and number of branches/plant affect seed yield via pods/plant in cluster bean.

In pigeonpea, Marekar and Nerkar (1987) reported days to first flowering, days to maturity, plant height and number of pods/plant had the highest positive direct effect.

Islam et al. (1987) observed that nodule weight had the highest positive direct effect on yield. Days to maturity and shoot weight had negative direct effects on yield in chickpea.

In cowpea highest direct effect on seed yield/plant was exhibited by 100 seed weight followed by pod length and number of seeds/pod (Choulwar and Borikar 1987)

Patil and Bhapkar (1987) suggested selection for pods/plant, seeds/pod and 1000 seed weight to improve seed yield in cowpea.

Path analysis in gram revealed that number of pods/plant had the highest direct effect on grain yield followed by 100 grain weight and days to flower (Maloo and Sharma, 1987).

In pigeonpea Sagar et al. (1987) reported that number of pods/plant was the important component of yield.

According to Raut et al. (1988) in greengram 100 seed weight, seeds/pod and pods/plant have positive direct effect on seed yield. Similar results were obtained by Pandya and Gupta (1988) in gram.

Patil and Deshmukh (1988) reported that number of days to flowering and 100 seed weight had the greatest positive direct effect on seed yield and but days to maturity and seeds/pod had negative direct effects on yield in mungbean.

Path analysis in mung bean revealed positive direct effect of pod length on yield followed by branch number and plant height (Khan, 1988).

Tyagi and Koranne (1988) observed highest positive direct effect of seeds per pod on yield in cowpea.

Wanjari (1988) reported that in blackgram days to maturity has strong positive direct effect on yield, while negative direct effect of days to flowering on yield.

In green gram Natarajan et al. (1988) found pods/plant followed by seeds/pod had highest positive direct effect on seed yield.

Sharma et al. (1989) reported highest positive direct effect by pods per plant on yield.

Path analysis in 123 genotypes of chickpea revealed that 100 seed weight, seeds/pod, pods/plant and primary branches are important grain yield contributing characters (Sandhu, 1989). Similar results were reported by Patil et al. (1989) in cowpea.

In winged bean selection for pods/plant and pod weight were suggested for yield improvement by Pandita et al., 1989).

Bhavsar and Birari (1989) reported that days to 50 per cent flowering and pods/plant are the important components of yield in moth bean.

In mung bean 100 seed weight, pod length, pods/plant and plant height are suggested for selection of higher yielders (Patil and Narkede, 1989).

Thiyagarajan and Rajasekaran (1989) reported that number of primary branches/plant, days to 50 per cent flowering and pods/plant had high positive direct effect on yield in cowpea.

Anitha (1989) in greengram revealed highest positive direct effect of pods/plant on yield. Plant height, days to flowering, pod length also had positive direct effect.

Branches/plant was found to be the major component for fodder yield in cowpea (Jindal, 1989).

Katiyar and Singh (1990) observed that number of pods per plant, seeds/pod and seed weight are the main yield contributors in faba bean.

In cowpea Patnaik and Roquib (1990) suggested selection for days to 50 per cent flowering, days to maturity and seeds/plant to improve yield.

Singh (1990) reported that in horsegram pods/plant is the most important yield component.

Path analysis in pigeonpea revealed that number of pods per plant had maximum direct effect on seed yield whereas plant height, number of branches per plant, seeds per plant effected seed yield via., pods per plant (Henry and Krishna, 1990).

In pigeonpea Natarajan _et al_. (1990) reported that pod number and plant height is important to ivolve high yielding varieties.

In rice bean Prema _et al_. (1990) suggested that pods/plant, pod length and seeds/pod are the contributors to seed yield.

In moth bean straw yield, pod/plant and 100 seed weight had direct positive effect on seed yield/plant. Number of branches had negative direct effects on harvest index (Bhandari, 1991).

In sem (_Dolichos lablab_) yield increase is reported to be effective by selecting for pods/plant, plant height and pod weight (Dahiya, 1991).

Sandhu et al. (1991) reported that in chickpea plant height showed highest direct effects while 100 seed weight had highest negative direct effect on grain protein.

In mung bean pod length and pods/plant are the main yield components (Wani et al., 1992).

Mishra and Yadav (1992) reported positive direct effect of plant height and number of branches on grain yield in mung bean.

MATERIALS AND METHODS

MATERIALS AND METHODS

A. MATERIAL

Twenty one varieties of rice bean (Vigna umbellata) (Thunb) Ohwi & Ohashi Syn. Phaseolus calcaratus) exhibiting distinct diversity in characters constituted the material for the study. These varieties were obtained from the germplasm collection maintained at the NBPGR Regional Station, Vellanikkara.

Table 1. gives the particulars of these varieties which are numbered from V_1 to V_{21}.

B. METHODS

The experiment was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani during Kharif (May-Sept) 1993.

Experiment Design and layout

The experiment consisting of 21 varieties was laid out in a Randomised Block Design with three replication. The crop was raised adopting Package of Practice Recommendations (Anonymous, 1993) for cowpea of the KAU.

Table 1. Particulars of the twenty one varieties of ricebean used in the study

Variety	Source	Treatment number
100 Lg	NBPGR Regional station, Vellanikkara	V_1
8 Lg	" "	V_2
50 DB	" "	V_3
9 BR	" "	V_4
50 green	" "	V_5
558 LB	" "	V_6
7 greenish brown	" "	V_7
23 Lg	" "	V_8
638 blackish mottle	" "	V_9
23 LB	" "	V_{10}
100 green	" "	V_{11}
7 BR	" "	V_{12}
5 DB	" "	V_{13}
5 masik green	" "	V_{14}
9 green	" "	V_{15}
558 red	" "	V_{16}
3 LB	" "	V_{17}
3 BR	" "	V_{18}
638 black	" "	V_{19}
6 LB	" "	V_{20}
5 LB	" "	V_{21}

Ten plants were selected at random from each plot leaving a single border row and data on the following characters were recorded and the mean worked out.

1. Plant Height

The plant height on 60^{th} day after sowing was measured from ground level to the tip of the terminal bud and expressed in centimeters.

2. Number of branches

All the branches in the observation plants were counted and recorded on 60^{th} day after sowing.

3. Days to first flowering

The number of days taken for the first flower to open from the date of sowing was recorded on plot basis from individual plots.

4. Length of pods

All the pods from individual observational plants were collected and the length measured in centimeters.

5. Number of pods per plant

The total number of pods harvested from the observational plants was recorded.

6. Number of seeds/pod

All the pods from observational plants were collected and the number of seeds per pod was recorded from each pod.

7. Seed yield

Seed yield from each observational plant in each plot was weighed after normal drying and were expressed in grams.

8. 100 Seed weight

100 well dried seeds chosen at random from each treatment were weighed and expressed in grams.

9. Days to maturity

The number of days taken for maturity from the date of sowing was noted when majority of the pods became fully dried up.

10. Yield of haulms

Haulm yield was recorded on plot basis. For this the plants were uprooted after removing all the pods and were weighed excepting the root portion.

11. Root weight

The observational plants were uprooted without damaging roots, root portion removed, washed in water, dried and weighed which was expressed in grams.

12. Nodule weight

The uprooted observational plants were taken and nodules removed by hand after cleaning the roots free of soil. Nodules from each plant were weighed and expressed in milligrams.

13. Fodder acceptability

This was studied in the dairy farm of the Department of Animal Husbandary, College of Agriculture, Vellayani. For this 1kg fooder of each variety was given to the cattle during its usual feeding time. Those varieties consumed by cattle were taken as acceptable and others unacceptable.

II Quality factors

1. Protein

The seeds were oven dried at 80 ± 5°C and ground finely in wiley mill. The total nitrogen was calculated employing modified microkjeldahl method (Jackson, 1967).

Protein content of the grain was calculated by multiplying the percentage of nitrogen by the factor 6.25 (Simpson et al. 1965).

2. Cooking qualities

Cooking quality and organoleptic studies were conducted at the Department of Home Science, College of Agriculture, Vellayani.

(i) Optimum cooking time

This was estimated by the method suggested by Bhattacharya and Sowbhagya (1971). For this 60ml of distilled water was taken in uniform sized test tubes with cap and kept in a boiling water bath. When the water in the test tubes attained boiling point 10g seed was dropped. From the 10^{th} minute onwards, few seeds were drawn and pressed between 2 glass plates. When the opaque core become soft, the time was noted. From this the optimum cooking time of the sample was calculated.

(ii) Water uptake

After the optimum cooking of the sample, the content were cooled for a minute and drained and the adhering moisture of kernels is removed by gently pressing the seeds between folds of filter paper sheets. From the difference in the masses of the cooked and the uncooked seed for the sample of seed taken, water uptake ratio, that is water absorbed (g) per gram of seed was calculated.

(iii) Cooked volume

Volume of expansion of the seed was determined as follows. Five grams of the sample was cooked in 30ml of water in uniform sized test tubes. The length of the test tube was measured. The initial length when seed was dropped was measured and then cooked to optimum time. The final increase in length of the cooked seed was also measured. From this percentage of expansion was calculated.

3. Organoleptic studies

For conducting the study, 20 panel members for acceptability trials at the laboratory level were selected. Triangle test (Jellinek, 1964) was employed to select the panel members. In the triangle test three sets of sugar solution of different concentration were used. Out of the three sets, two were of identical concentration and the person were asked to identify the third sample which is of different concentration.

The acceptability trials on panel members were done using the scoring method. A score card developed for the study is presented in Appendix I. The major quality attributes included in the score card were appearance, colour, flavour, texture and taste on a 4 point hedonic scale. Each of the above mentioned quality is assessed by a 4-point rating scale. The judges were requested to taste one sample at a time and score it. They were requested to taste the second sample after washing their mouth. The testing was conducted in the afternoon between 3 pm and 4 pm.

Statistical techniques

I Analysis of variance and co-variance

Analysis of variance and co-variance were done for the following (Kempthorne, 1957).

1. To test whether there was any significant difference between the varieties, with respect to the various traits.

2. To estimate the variance components and

3. To estimate the correlation co-efficients.

The extend of phenotypic variance of any character is the sum of the genetic and environmental effects and can be determined by the method given by Kempthorne (1957)

$$V(P) = V(G) + V(E) + 2\ \text{cov.}\ (G, E)$$

where $V(P) = \sigma p^2(X)$ = Variance due to phenotype

$V(G) = \sigma g^2(X)$ = Variance due to genotype

$V(E) = \sigma e^2(X)$ = Variance due to environment

If the genotype and the environment are independent cov. (G, E) is equal to zero, so that

$$V(P) = V(G) + V(E)$$

$$\sigma p^2(X) = \sigma g^2(X) + \sigma e^2(X)$$

If there are observations on two characters X and Y on each individual, the extent of co-variance between X and Y due to the genotype and environment can be estimated, as suggested by Kempthorne (1957) as follows.

$$\text{cov. } p\ (X,Y) = \text{cov. } G(X,Y) + \text{cov. } E\ (X,Y)$$

or

$$\sigma p\ (X,Y) = \sigma g(X,Y) + \sigma e\ (X,Y)$$

where $\sigma p(X,Y)$ = phenotypic co-variance between X and Y

$\sigma g(X,Y)$ = genotypic co-variance between X and Y

$\sigma e(X,Y)$ = environment co-variance between X and Y

If the experiment is designed in a randomised complete block design with 'V' treatments and 'r' replication, the estimates of $\sigma p^2(X)$, $\sigma g^2(X)$, $\sigma g^2(Y)$, $\sigma e^2(X)$, $\sigma e^2(Y)$, $\sigma p(X,Y)$, $\sigma g(X,Y)$ and $\sigma e(X,Y)$ are obtained from the variance co-variance analysis (Table 2).

II Co-efficient of variation

The co-efficient of variation is a unitless measurement and is used for comparing the extent of variation between different characters measured in different scales.

Phenotypic co-efficient of variation (PCV):

$$\text{PCV for character X} = \frac{\sigma p(X)}{\overline{X}} \times 100$$

Genotypic co-efficient of variation (GCV):

Table 2. Analysis of variance/covariance

Source	d.f.	M.S. (x,x)	Expectation of M.S. (x,x)	M.S.P. (x,y)	Expectation of M.S.P. (x,y)	M.S. (y,y)	Expectation of M.S. (y,y)
Block	(r - 1)	Bxx		Bxy		Byy	
Treatment	(v - 1)	Txx	$\sigma^2 e(x) + r\sigma^2 y(x)$	Txy	$\sigma e(xy) + r\sigma y(xy)$	Tyy	$\sigma^2 e(y) + r\sigma^2 y(y)$
Error	(r - 1) (v - 1)	Exx	$\sigma^2 e(x)$	Exy	$\sigma^2 e(xy)$	Eyy	$\sigma^2 e(y)$
Total	rv - 1	Sxx		Sxy		Syy	

Hence we have the following estimates

$$\sigma^2 g(x) = \frac{1}{r}(Txx - Exx),\ \sigma^2 e(x) = Exx$$

$$\sigma^2 g(y) = \frac{1}{r}(Tyy - Eyy),\ \sigma^2 e(y) = Eyy$$

$$\sigma^2 g(xy) = \frac{1}{r}(Txy - Exy),\ \sigma^2 e(xy) = Exy$$

$$\text{GCV for character X} = \frac{\sigma g(X)}{\overline{X}} \times 100$$

Where p(X) and g(X) are the phenotypic and genotypic standard deviation respectively and $\overline{X}$ is the mean of the character X

III correlation

The phenotypic correlation co-efficient between X and Y was estimated as :

$$p(X,Y) = \frac{\sigma p\ (X,Y)}{\sigma p(X)\sigma p(Y)}$$

where p(X,Y) is the phenotypic covariance between X and Y

$\sigma p(X)$ = standard deviation of the character X

$\sigma p(Y)$ = standard deviation of the character Y

The genotypic correlation co-efficient between X and Y was estimated as

$$g(X,Y) = \frac{\sigma g(X,Y)}{\sigma g(X)\sigma g(Y)}$$

where g(X,Y) ie the genotypic covariance between X and Y

$\sigma g(X)$ = standard deviation of the character X

$\sigma g(Y)$ = standard deviation of the character Y

IV Heritability (H^2)

Heritability in the broad sense is the fraction of the total variance which is heritable and was estimated as a percentage, following Jain (1986) as :

$$H^2 = \frac{\sigma g^2 \times 100}{\sigma p^2}$$

where H^2 = Heritability in the broad sense.

Heritability provides a measure of genetic variance ie., the variance upon which all the possibilities of changing the genetic composition of the population through selection depends. Heritability per cent was categorised as suggested by Robinson et al. (1949) viz. low (0-30), moderate (30-60) and high (above 60).

V Genetic advance under selection (G.A)

Genetic advance is a measure of the change in the mean phenotypic level of the population produced by the selection and depends upon heritability of the character and selection differential. G.A was estimated as per method suggested by Lush (1940) and Johnson et al. (1955).

$$G.A = K\, h^2 \sqrt{Vp}$$

where G.A -genetic advance

h^2 - heritability in the broad sense

Vp - phenotypic variance

K - selection differential which is 2.06 in the case of 5% selection in large samples (Miller et al., 1958 and Allard 1960).

Genetic advance was categorised into low (less than 10%) moderate (10-20%) and high (more than 20%) as suggested by Johnson et al. (1955).

VI Path analysis

The path co-efficients were worked out by the method suggested by Wright (1921). The simultaneous equations which gives the estimates of path co-efficients are as follows

$$\begin{bmatrix} r_y \\ \vdots \\ r_{iy} \\ \vdots \\ r_{ky} \end{bmatrix} = \begin{bmatrix} 1 & r_{12} & r_{13} \cdots r_{1j} \cdots r_{1k} \\ & 1 & r_{23} \cdots\cdots\cdots r_{2k} \\ & & \\ & & \cdots r_{ij} \cdots r_{ik} \\ & & \\ & & 1 \end{bmatrix} X \begin{bmatrix} P_1 \\ P_2 \\ \vdots \\ P_i \\ \vdots \\ P_k \end{bmatrix}$$

ie., $\underline{Ry} = RX \; \underline{P}$

so that $\underline{P} = RX^{-1} \; \underline{RY}$

Where rij is the genotypic correlation between xi and x_j

i, j = 1,2 .... k

riy is the genotypic correlation between x_i and Y and P_i is the path coefficient of X_i.

The residual factor (R) which measures the contribution of other factors not defined in the causal scheme was estimated by the formula

$$R = (1 - \sum_{i=1}^{k} P_i \; r_{iy})^{1/2}$$

Indirect effect of different characters on yield obtained as $P_i r_{ij}$ for the i^{th} character via j^{th} character.

RESULTS

RESULTS

The results of the present experiment are given below.

1. Variability analysis

The mean data collected on 13 characters were subjected to analysis of variance for testing the significance of the difference among varieties and the ANOVA is furnished in the table 3.

The 21 varieties of ricebean studied showed that significant differences existed among varieties with respect to the ten characters studied viz. plant height, days to first flowering, length of pod, seed yield, 100 seed weight days to maturity, yield of haulms, root weight, nodule weight and protein content.

The mean values recorded on 21 varieties with respect to yield and other 12 characters are presented in Table 4.

The variety 23Lg had the maximum plant height (133.07cm) followed by 9BR (131.67cm). 23Lg was on par with

... variance of thirteen characters

Sl. No.	Characters	Mean square Replication df-2	Treatment df-20	Error df-40	F value (Treatment)
1.	Plant height	3257.3170	689.5281	215.4482	3.20**
2.	Number of primary branches	1.0544	0.5743	0.4013	1.43
3.	Days to first flowering	0.6190	17.6333	5.7524	3.07**
4.	Length of pod	0.3599	0.4066	0.1244	3.27**
5.	Number of pods/plant	612.1036	120.8777	67.4474	1.79
6.	Number of seeds/pod	0.7995	0.2548	0.2258	1.13
7.	Seed yield	75.1540	14.0541	5.7492	2.44**
8.	100 seed weight	0.2546	0.9930	0.0927	10.71**
9.	Days to maturity	7.4628	16.9844	6.7769	2.51**
10.	Yield of haulm	220357.9000	670605.8000	73381.8300	9.14**
11.	Root weight	0.8024	3.0610	0.3205	9.47**
12.	Nodule weight	28816.7700	5534.0480	2242.8340	2.47**
13.	Protein content	4.0833	25.6375	2.3990	10.69**

** Significant at 1 % level

Table 4. Mean value of thirteen characters in rice bean

Sl. No.	Varieties	Plant height (cm)	Number of primary branches	Days to first flowering	Length of pod (cm)	Number of pods/ plant	Number of seeds/ pod
1.	100Lg	112.77	2.867	41.667	7.063	21.40	5.485
2.	8Lg	113.07	3.133	42.333	6.686	27.63	5.722
3.	50DB	98.70	2.300	42.333	7.398	18.40	5.853
4.	9BR	131.67	3.067	43.333	7.652	29.77	6.280
5.	50 green	119.97	2.667	42.333	7.082	16.50	5.604
6.	558LB	91.90	2.133	36.333	6.641	23.17	5.507
7.	7 greenish brown	117.50	2.833	42.333	7.375	23.47	5.997
8.	23Lg	133.07	2.767	45.333	7.190	25.00	5.312
9.	638 blackish mottle	104.83	2.133	43.000	6.457	26.17	5.952
10.	23LB	106.27	2.900	39.667	7.380	16.37	5.788
11.	100 green	130.07	2.967	45.667	6.978	25.07	6.312
12.	7BR	121.67	2.867	44.333	6.821	24.97	5.626
13.	5DB	129.00	3.367	43.000	6.790	41.97	5.851
14.	5 masik green	111.10	3.333	44.333	7.215	24.20	5.725
15.	9 green	127.13	3.300	45.667	7.432	20.47	5.884
16.	558 red	120.00	2.967	39.333	7.158	39.50	5.744
17.	3LB	127.00	3.333	39.333	7.395	26.90	6.118
18.	3BR	78.00	2.533	44.000	6.973	25.60	5.608
19.	638 black	87.60	3.867	43.333	6.314	28.73	6.260
20.	6LB	123.13	3.033	39.000	7.088	31.30	5.744
21.	5LB	113.00	2.367	42.333	7.676	24.17	6.354
	C.D (at 5% level)	24.212	—	3.957	0.582	—	—

(Contd......)

Table 4. (Contd.....)

Sl. No.	Varieties	Seed yield (g)	100 seed weight (g)	Days to maturity	Yield of haulms (g)	Root weight (g)	Nodule weight (mg)	Protein content (%)
1.	100Lg	7.95	5.257	126.67	1166.67	4.439	163.17	19.25
2.	8Lg	9.40	4.977	127.67	693.33	3.278	190.87	17.50
3.	50DB	5.62	4.887	123.67	516.67	2.933	115.90	19.25
4.	9BR	7.32	5.333	126.33	963.33	3.892	150.13	15.75
5.	50 green	4.40	4.773	122.67	1113.33	4.593	92.77	15.75
6.	558LB	7.05	4.403	125.33	806.67	3.209	142.13	17.50
7.	7 greenish brown	7.22	5.700	126.00	950.00	3.626	149.00	19.25
8.	23Lg	5.33	6.313	124.00	1110.00	4.030	113.50	15.75
9.	638 blackish mottle	7.77	4.557	125.67	770.00	2.920	160.37	19.25
10.	23LB	5.67	6.347	123.67	810.00	3.559	118.90	8.75
11.	100 green	7.27	5.490	125.00	1623.33	5.435	150.87	14.00
12.	7BR	7.77	5.467	126.00	1300.00	4.294	152.93	17.50
13.	5DB	13.65	6.010	133.00	740.00	3.325	275.23	19.25
14.	5 masik green	7.48	5.887	126.00	1013.33	3.884	155.87	14.00
15.	9 green	7.10	6.243	126.00	2233.33	6.042	148.70	15.75
16.	558 red	11.25	5.557	130.00	453.33	2.861	231.17	17.50
17.	3LB	7.45	5.147	125.67	1176.67	4.238	155.73	17.50
18.	3BR	5.27	5.887	123.67	2286.67	6.745	113.97	10.50
19.	638 black	9.52	4.537	128.33	1308.33	4.589	198.10	17.50
20.	6LB	10.37	6.243	128.67	951.67	3.881	213.40	12.25
21.	5LB	7.83	6.077	126.00	1013.33	3.988	164.17	15.75
	C.D	3.957	0.503	4.297	447.007	0.934	78.148	25.556

all the varieties except 23Lb, 638 blackish mottle, 50DB, 558LB, 638 black and 3BR. The plant height was minimum for 3Br (78cm) which was on par with 50DB, 558Lb and 638 black.

Number of primary branches showed no significant difference among the varieties.

The number of days to first flowering varied from 45.67 for the variety 100 green to 36.33 for the variety 558LB. 100 green was on par with all the varieties except 100Lg, 23LB, 558red, 3LB, 6LB and 558LB. The variety 558LB was on par with 23LB, 558 red, 3LB and 6LB.

5LB had the maximum length of pod (7.68cm) and was on par with 9BR, 9 green, 50DB, 3LB, 23LB, 7 greenish brown, 5 masikgreen, 23Lg and 558 red. Pod length was minimum for 638 black which was on par with 7BR, 5DB, 8Lg, 558LB and 638 blackish mottle.

There were no significant differences among the varieties with respect to number of pods per plant.

Number of seeds/pod also showed non significant differences among the varieties.

Plate 1

Experimental Plot Of Ricebean

For the character seed yield per plant, maximum value of 13.65g was exhibited by 5DB and was on par with 558 red (11.25g) and 6LB (10.37g). Lowest value was obtained for 50 green (4.4) which was on par with all the varieties except 5DB, 558 red, 6LB, 638 black and 8Lg.

The variety 23LB had the maximum 100 seed weight of 6.35g which was on par with 23Lg, 9 green, 6LB, 5LB, 5DB, 5 masik green and 3BR. Lowest 100 seed weight was recorded by 638 black (4.54) which was on par with 8Lg, 50DB, 50 green and 638 blackish mottle.

5DB recorded the highest number of days to maturity of 133 which was on par with 558 red, 6LB and 638 black. Lowest value was obtained for 50 green which was on par with all the varieties except 5DB, 558 red, 6LB, 638 black and 8Lg.

Yield of haulms was highest for 3BR (2286.67g) which was on par with 9 green. Lowest haulm yield was recorded by 558 red (453.33g) which was on par with 23LB, 558LB, 638 blackish mottle, 5DB, 8Lg and 50DB.

3BR recorded the maximum root weight (6.75g) which was on par with 9 green. Lowest value was recorded by

558 red (2.86) which was on par with 7 greenish brown, 23LB, 5DB, 8Lg, 558LB, 50DB and 638 blackish mottle.

The nodule weight was highest for 5DB (275.23mg) which was on par with 558 red, 6LB and 638 black. Lowest value was obtained for 50 green (92.77) which was on par with all the varieties except 5DB, 558 red, 6LB and 638 black and 8 Lg.

The highest protein content (19.25%) was recorded in the varieties 100Lg, 50DB, 7 greenish brown, 638 blackish mottle and 5DB, and these varieties were on par with 558LB, 8Lg, 7BR, 558 red, 3LB and 638 black. Lowest protein content was recorded by 23LB (8.75%) which was on par with 3BR.

Fodder acceptability studies showed that out of the 21 varieties tested all were acceptable except the variety 8Lg.

II. Coefficient of variation

Phenotypic variance, genotypic variance and coefficients of variation are presented in table 5.

Table 5. Phenotypic and genotypic variance, mean, and phenotypic and genotypic coefficient of variation

Character	Phenotypic variance	Genotypic variance	Mean $\bar{X}$	Phenotypic coefficient of variation (%)	Genotypic coefficient of variation (%)
Height of plant	373.475	158.027	114.163	16.93	11.01
Number of primary branches	0.459	0.058	2.892	23.43	8.30
Days to first flowering	9.713	3.960	42.333	7.36	4.70
Length of pod	0.218	0.094	7.084	6.60	4.33
Number of pods/ plant	85.257	17.810	25.749	35.86	16.39
Number of seeds/ pod	0.235	0.010	5.845	8.30	1.68
Seed yield	8.518	2.768	7.746	37.68	21.48
100 seed weight	0.393	0.300	5.528	11.34	9.91
Days to maturity	10.179	3.403	126.19	2.53	1.46
Yield of haulms	272456.47	199074.670	1095.238	47.66	40.74
Root weight	1.226	0.905	4.084	27.11	23.30
Nodule weight	3339.906	1097.071	159.860	36.15	20.72
Protein content	10.145	7.746	16.167	19.70	17.22

1. Phenotypic coefficient of variation

PCV presented in the table indicated that highest value was recorded by haulm yield (47.66%) followed by seed yield (37.68), nodule weight (36.15) and number of pods/plant (35.86). The lowest value was recorded by the character days to maturity (2.53).

2. Genotypic coefficient of variation

The haulm yield showed the highest value (40.74)) followed by root weight (23.30%) and seed yield (21.48%). The lowest value was recorded for the character days to maturity (1.46%).

III. Correlation analysis

Genotypic and Phenotypic correlation coefficients were estimated. The data on correlation have been split up and are presented under two heads.

i. Correlation between yield and other characters

ii. Correlation between pairs of characters other than yield.

The estimates of correlation coefficients at the genotypic and phenotypic levels are given in Table 6. and 7.

Table 6. Genotypic and phenotypic correlation coefficients between yield and other characters

Sl. No.	Character	Correlation coefficient Genotypic	Phenotypic
1.	Plant height	0.2156	0.2215
2.	Number of primary branches	0.3341	0.5188**
3.	Days to first flowering	-0.3520	-0.0589
4.	Length of pod	-0.6215	-0.0969
5.	Number of pods/plant	0.9935	0.8137**
6.	Seeds/pod	0.2170	0.2028
7.	100 seed weight	-0.0016	0.0986
8.	Days to maturity	1.0206	0.9676**
9.	Haulm yield	-0.5983	-0.0951
10.	Root weight	-0.6367	-0.0857
11.	Nodule weight	0.9986	0.9982**
12.	Protein content	0.4303	0.2534

** Significant at 1% level

i. Correlation between yield and other characters (Table 6.)

Yield showed positive genotypic correlation with plant height, number of primary branches, number of pods/plant, number of seeds/pod, days to maturity, nodule weight and protein content. Days to maturity showed the highest positive genotypic correlation (1.0236) with yield per plant followed by nodule weight (0.9986), number of pods/plant (0.9935), protein content (0.4303), number of primary branches (0.3341), seeds/pod (0.2170) and plant height (0.2156).

Root weight showed the maximum negative genotypic correlation of -0.6367 followed by length of pod (-0.6215) haulm yield (-0.5983), days to first flowering (-0.3520) and 100 seed weight (-0.0016).

At phenotypic level significant positive correlation was observed for nodule weight (0.9982), days to maturity (0.9676), pods/plant (0.8137) and number of primary branches (0.5188).

ii. Correlation between pairs of characters other than yield (Table 7).

Table 7. Correlation coefficient between pairs of characters other than yield

	Plant height	Number of primary branches	Days to first flowering	Length of pod	Pods/plant	Seeds/pod	100 seed weight	Days to maturity	Haulm yield	Root weight	Nodule weight	Protein content
Plant height	--	0.2999	0.1718	0.2590	0.2150	-0.0125	0.2350	0.1987	0.0743	0.0736	0.2154	0.0662
Number of primary branches	0.3199	--	0.1689	0.1205	0.4052**	0.2134	0.1439	0.5308**	0.3741*	0.3908**	0.5191**	0.0304
Days to first flowering	0.2903	0.4046	--	0.0838	-0.0045	0.1230	0.0446	-0.0283	0.3740*	0.4023**	-0.0624	-0.0543
Length of pod	0.5969	-0.4828	-0.0297	--	-0.0164	0.4153**	0.3840*	-0.0194	0.0967	0.1221	-0.0935	-0.1652
Pods/plant	0.3072	0.2618	-0.2490	-0.6487	--	0.1556	0.1176	0.8208**	-0.0686	-0.0178	0.8164**	0.2059
Seeds/pod	0.6579	0.6359	0.3627	-0.4499	0.1587	--	-0.0964	0.2097	0.0647	0.0406	0.2063	0.0266
100 seed weight	0.3674	-0.0335	0.0779	0.5832	0.0445	-0.6407	-	0.1216	0.2309	0.2135	0.1077	-0.4640**
Days to maturity	0.2914	0.4749	-0.2931	-0.6244	1.0045	0.0259	0.0418	--	-0.0757	-0.0691	0.9661**	0.2785
Haulm yield	-0.2590	-0.00772	0.6762	-0.0230	-0.5104	0.0329	0.2413	0.5353	--	0.9543**	-0.0888	-0.3103*
Root weight	-0.2474	0.0203	0.6109	0.0323	-0.5785	0.1374	0.2160	-0.5732	0.9903	--	-0.0772	- 0.3614*
Nodule weight	0.2066	0.3867	-0.3301	-0.5956	1.0028	0.3007	0.0145	1.0208	-0.5659	-0.6011	--	0.2391
Protein content	0.2025	-0.1919	0.0329	-0.3221	0.3101	0.1829	-0.6125	0.4414	-0.4361	0.5038	0.3993	--

* Significant at 5% level   Upper off diagonal elements - phenotypic correlation coefficient

** Significant at 1% level   Lower off diagonal elements - genotypic correlation coefficient

1. **Plant height**

Height of the plant had positive genotypic correlation with number of primary branches, days to first flowering, length of pod, number of pods/plant, number of seeds/pod, 100 seed weight, days to maturity, nodule weight and protein. Highest value was observed for seeds/pod (0.6579). Negative genotypic correlation was observed for haulm yield and root weight The maximum negative genotypic correlaion was observed for haulm yield.

None of the characters showed significant phenotypic correlation with plant height

2. **Number of primary branches**

Positive genotypic correlation was observed for plant height days to first flowering, pods/plant, seeds/pod, days to maturity, root weight and nodule weight. Highest value of 0.6359 was recorded for seeds per pod. Negative genotypic correlation was recorded for length of pod, 100 seed weight, haulm yield, and protein. Maximum negative genotypic correlation was recorded for length of pod

Primary branches showed positive significant phenotypic correlation with pods per plant days to maturity, haulm yield, root weight and nodule weight.

3. Days to first flowering

High positive genotypic correlation was observed with haulm yield (0.6762) followed by root weight and mumber of primary branches, seeds/pod and plant height. 100 seed weight and protein content showed low positive correlation. Negative genotypic correlation was observed for length of pod, pods/plant, days to maturity and nodule weight. Maximum negative genotypic correlation was observed for nodule weight (-0.3301).

Haulm yield and root weight had significant positive phenotypic correlation.

4. Length of pod

Plant height, 100 seed weight and root weight showed positive genotypic correlation whereas number of primary branches, days to first flowering pods/plant, seeds/pod, days to maturity, haulm yield, nodule weight and protein had negative genotypic correlation. Maximum positive genotypic correlation was obtained for 100 seed weight and maximum negative correlation was obtained for pods\plant

Significant positive phenotypic correlation was recorded for seeds/pod (0.4153) and 100 seed weight (0.3840)

5 Pods/Plant

Positive genotypic correlation was observed for, plant height, number of primary branches, seeds/pod, 100 seed weight, days to maturity, nodule weight and protein content of which highest value was recorded for days to maturity (1.0045). Days to first flowering length of pod, haulm yield and root weight recorded negative correlation with pods/plant. Maximum negative genotypic correlation was observed for length of pod.

Significant positive phenotypic correlation was recorded for number of primary branches, days to maturity (0.8208) and nodule weight.

6 Seeds/pod

Seeds/pod had positive genotypic correlation will all characters except length of pod and 100 seed weight. 100 seeds weight recorded maximum negative genotypic correlation of (-0.0467).

7 100 Seed weight

Positive genotypic correlation was recorded for plant height, days to first flowering, length of pod, days to maturity, haulm yield, root weight and nodule weight. Whereas negative genotypic correlation was observed for number of primary branches, seeds per pod and protein content. Maximum positive genotypic correlation was obtained for length of pod and maximum negative genotypic correlation for seeds per pod.

At phenotypic level this character showed positive significant correlation with length of pod and negative significant correlation with protein content.

8 Days to maturity

Positive genotypic correlation was observed for plant height, number of primary branches, pods per plant, seeds per pod, 100 seed weight, haulm yield, nodule weight and protein content whereas days to first flowering, length of pod and root weight showed negative correlation. Maximum positive genotypic correlation was observed for nodule weight followed by pods per plant. Maximum negative correlation was obtained for length of pod.

Positive significant phenotypic correlation was recorded for number of primary branches, pods/plant and nodule weight.

9 Haulm yield

There was significant positive genotypic correlation between days to first flowering, seeds per pod, 100 seed weight, days to maturity and root weight, of which the maximum was recorded for root weight. All other characters showed negative genotypic correlation. Maximum negative genotypic correlation was observed for nodule weight.

Significant positive phenotypic correlation was observed for number of primary branches; days to first flowering and root weight. Haulm yield had significant negative phenotypic correlation with protein content.

10 Root weight

Root weight showedpositive genotypic correlation with plant height pods/plant, days to maturity and nodule weight and maximum negative genotypic correlation was obtained for nodule weight. Significant positive phenotypic correlation of this character was noticed for number of primary branches, days to first flowering and haulm yield. Protein had significant negative phenotypic correlation with this character.

11 Nodule weight

Days to first flowering, length of pod, haulm yield and root weight had negative genotypic correlation. All other characters had positive genotypic correlation with nodule weight. Maximum genotypic correlation with this character was noticed for days to maturity followed by pods\plant. Maximum negative genotypic correlation was of root weight (-0.6011) followed by length of pod (-0.0956). At phenotypic level nodule weight had significant positive correlation with number of primary branches, pods\plant and days to maturity.

12. Protein content

This had positive genotypic correlation with plant height, days to first flowering, pods/plant, seeds/pod, days to maturity, root weight and nodule weight. Maximum genotypic correlation of this character was noticed with root weight. Number of primary branches, length of pod, 100 seed weight and haulm yield recorded negative genotypic correlation with this characters. 100 seed weight recorded maximum negative genotypic correlation with protein content.

None of the characters had significant positive phenotypic correlation with protein content. 100 seed weight, haulm yield and root weight showed significant negative phenotypic correlation with this characters.

IV Heritability in the broad sense

High values of heritability was recorded for 100 seed weight (76.40%) followed by protein content (76.35%), root weight (73.85%) and yield of haulms (73.07%) Moderate heritability values were obtained for length of pod (43.05%) plant height (42.31%) days to first flowering (40.77%) days to maturity (33.43%) nodule weight (32.85%) and seed yield (32.50%). Low heritability was shown by number of primary branches, number of pods per plant and seeds/pod (4.11%). (Table 8).

V Expected genetic advance

The results are presented in the table 8. Haulm yield recorded the maximum genetic advance (71.74%).

Table 8. Heritability and expected genetic advance

Sl. No.	Character	Heritability h^2 (%)	Expected genetic advance as % of mean
1.	Plant height	42.31	14.75
2.	Number of primary branches	12.57	6.06
3.	Days to first flowering	40.77	6.18
4.	Length of pod	43.05	5.85
5.	Number of pods/plant	20.89	15.43
6.	Number of seeds/pod	4.11	7.03
7.	Seed yield	32.50	25.22
8.	100 seed weight	76.40	17.84
9.	Days to muturity	33.43	1.74
10.	Yield of haulm	73.07	71.74
11.	Root weight	73.85	41.24
12.	Nodule weight	32.85	24.46
13.	Protein content	76.35	30.99

followed by root weight (41.24%) protein content (30.99%), seed yield (25.22%) and nodule weight (24.46%).

Moderate values of genetic advance was recorded by 100 seed weight (17.84%), pods/plant (15.43%) and plant height (14.75%).

Low values of genetic advances were obtained for seeds/pod (7.03%), days to first flowering (6.18%), number of primary branches (6.06%), pod length (5.85%) and days to maturity (1.74%).

VI Path analysis

To get a clear picture of the cause effect relationship of various component characters and yield, path coefficient analysis was under taken. The characters which showed positive genotypic correlation with yield viz. plant height, number of primary branches, pods/plant, seeds/pod, days to maturity, nodule weight and protein content were subjected to path analysis and were partitioned into their corresponding direct and indirect effects and the results are presented in Table 9.

Table 9. Direct and indirect effect of the various characters on yield in rice bean

	Plant height	Number of primary branches	Pods/ plant	Seeds/ pod	Days to maturity	Nodule weight	Protein content	Genotypic correl-ation
Plant height	$\underline{\bar{0}.0150}$	0.0031	0.0675	$\bar{0}.0180$	0.0282	0.1365	0.0132	0.2156
Number of primary branches	$\bar{0}.0048$	$\underline{0.0097}$	0.0575	$\bar{0}.0174$	0.0460	0.2556	$\bar{0}.0126$	0.3341
Pods/plant	$\bar{0}.0046$	0.0025	$\underline{0.2196}$	$\bar{0}.0043$	0.0974	0.6627	0.0203	0.9935
Seeds/pod	$\bar{0}.0099$	0.0062	0.0348	$\underline{\bar{0}.0274}$	0.0025	0.1987	0.0120	0.2170
Days to maturity	$\bar{0}.0044$	0.0046	0.2206	$\bar{0}.0007$	$\underline{0.0969}$	0.6746	0.0289	1.0206
Nodule weight	$\bar{0}.0031$	0.0038	0.2202	$\bar{0}.0082$	0.0989	$\underline{0.6609}$	0.0261	0.9986
Protein content	$\bar{0}.0030$	$\bar{0}.0019$	0.0681	$\bar{0}.0050$	0.0428	0.2639	$\underline{0.0654}$	0.4303

Underlined figures are the direct effect off diagonol element are the indirect effect Residue - 0.00076

Highest positive direct effect of 0.6609 on yield was recorded by nodule weight. It exerted positive indirect effect through number of branches, pods/plant, days to maturity and protein content. It showed negative indirect effect through plant height and seeds per pod.

Pods/plant recorded the second highest positive direct effect on seed yield and positive indirect effect through nodule weight (0.6627), days to maturity (0.0974), protein content (0.0203) and number of branches (0.0025). Negative indirect effect was recorded for plant height (-0.0046) and seeds/pod (-0.0043).

Days to maturity recorded a positive direct effect of 0.0969 on seed yield and positive indirect effect was exerted by nodule weight (0.6746), pods/plant (0.2206), number of branches (0.0046) and protein (0.0289). Days to maturity recorded negative indirect effect on seed yield via plant height (-0.0044) and seeds/pod (-0.0007).

Protein content showed a positive direct effect (0.0654) and its positive indirect effect through pods/plant (0.0681), days to maturity (0.0428) and nodule weight (0.2639). Protein content exerted negative indirect effect via plant height (-0.0030), number of branches (-0.0019) and seeds/pod (-0.0050).

Number of primary branches recorded a low positive direct effect (0.0097) and positive indirect effect through nodule weight (0.2556), pods per plant (0.0575) and days to maturity (0.0460). This character exerted negative indirect effect via seeds/pod (-0.0174), protein (-0.0126) and plant height (-0.0048).

The correlation between seeds per pod and yield was positive (0.2170) while its direct effect is negative (-0.0274). This character recorded positive indirect effect via nodule weight (0.1987), pods/plant (0.0348), protein (0.0120), number of branches (0.0062) and days to maturity (0.0025). Seeds per/pod exerted a negative indirect effect via plant height -0.0099 on yield.

Plant height recorded a negative direct effect of -0.0150, while this character recorded positive genotypic correlation with seed yield and positive indirect effect through nodule weight (0.1365), pods/plant (0.0675), days to maturity (0.0282), protein (0.0132) and number of primary branches (0.0031). Seeds/pod recorded a low negative indirect effect of -0.018 on yield.

VII. Cooking qualities

1. Optimum cooking time

Highest cooking time was recorded by 100 green (70 mts) followed by 638 blackish mottle (65 mts), 50 green (55 mts), 100 < g (53 mts), 3 BR and 9 BR (52 mts). Lowest value was recorded by 50 DB (40 mts) (Table 10). The frequency distribution of varieties according to optimum cooking time is presented in table 11. Out of twenty one, fourteen varieties (66%) were included in the class with optimum cooking time of 41 to 50 mts.

2. Water uptake

The variety 3 LB recorded the least value for water uptake of 0.79g/g and highest by 3 BR (1.2 g/g) followed by 5 DB (1.19) (Table 10). The frequency distribution of varieties according to water uptake is presented in table 12. Out of twenty one varieties, eleven varieties (52%) were inclueded in water uptake group 1.0 - 1.09 g/g.

3. Volume of expansion

The variety 50 DB recorded the maximum volume of expansion of 68.42 % followed by 638 blackish mottle and 6LB

Table 10. Particulars of the optimum cooking time, water uptake and volume of expansion of 21 rice bean varieties

Sl. No.	Variety	Optimum cooking time (minutes)	Water uptake (g/g)	Volume of expansion(%)
1.	100 Lg	53	1.0	63.64
2.	8 Lg	45	1.1	58.33
3.	50 DB	40	1.0	68.42
4.	9 BR	52	1.0	65.00
5.	50 green	55	1.1	58.33
6.	558 LB	50	0.9	58.33
7.	7 greenish brown	50	1.0	64.29
8.	23 Lg	45	1.1	60.53
9.	638 blackish mottle	65	1.0	66.67
10.	23LB	45	0.85	65.85
11.	100 green	70	1.0	60.61
12.	7 BR	45	1.0	64.29
13.	5DB	42	1.19	65.91
14.	5 masik green	50	0.9	58.33
15.	9 green	48	1.0	58.33
16.	558 red	45	1.1	62.16
17.	3 LB	45	0.79	65.12
18.	3 BR	52	1.2	65.00
19.	638 black	45	1.0	63.64
20.	6 LB	50	1.0	66.67
21.	5 LB	50	1.0	58.33

Table 11. Frequency distribution showing optimum cooking time

Optimum cooking time (mts.)	No. of varieties	Varieties
Below 40	1	50 DB
41 - 50	14	23LB, 7BR, 5DB, 3LB 558 red, 23 Lg, 8Lg 638 black, 6LB, 5LB 5 masik green, 558LB 7 greenish brown, 9 green
51 - 60	4	9BR, 3BR, 100Lg, 50 green
61 - 70	2	638 blackish mottle 100 green

Table 12. Frequency distribution showing water uptake

Water uptake (g/g)	No. of varieties	Varieties
Below 0.80	1	3LB
0.80 - 0.89	1	23LB
0.90 - 0.99	2	5 masik green, 558LB
1.0 - 1.09	11	9BR, 7BR, 6LB,50DB 5LB, 638 blackish mottle, 100 green 100 Lg, 7 greenish brown, 9 green, 638 black
1.1 - 1.19	5	558 red, 23Lg, 8Lg 50 green, 5 DB
1.2 - 1.29	1	3 BR

Table 13. Frequency distribution showing volume of expansion

Volume of expansion (%)	No. of varieties	Varieties
58.0 - 60.5	7	5LB, 8Lg, 5 Masik green, 558LB, 9green 50 green, 23Lg
60.6 - 63.1	2	100 green, 558 red
63.2 - 65.7	7	100Lg, 638 black, 7BR, 7 greenish brown, 9BR, 3BR, 3LB
65.8 - 66.3	2	23LB, 5DB
66.4 - 68.9	3	6LB, 638 blackish mottle, 50DB

with 66.67 %. Least value was recorded by 5 LB, 8 Lg, 5 masik green, 558 LB, 9 green and 50 green with 58.33% expansion (Table 10). The frequency distribution of varieties according to volume of expansion is given in table 13. Of the twenty one varieties, seven varieties (33%) were included in the group 62.5 - 67.5%.

VIII Organoleptic studies

With respect to taste highest mean value was observed for the variety 558 red (3.45) followed by 50 DB (3), 23 Lg (3), 7 greenish brown (2.94) and 7 BR (2.85) Lowest was recorded by 5 masik green (2.05) (Table 14).

Regarding colour 23 Lg (4) recorded the maximum value followed by 638 blackish mottle (3.84), 5 DB (3.8), 50 DB (3.8), 5 masikgreen (3.79). Lowest value was recorded by 638 black (1.39) (Table 14).

The variety 558 red recorded the maximum value for appearance of 3.35 followed by 6 LB (3.2), 3 BR (3.1), 8 Lg (3), 100 Lg (3), 7 greenish brown (3), 9 green (3). Lowest value was recorded by 638 black (2.17) (Table 14).

Table 14. Mean values showing the organoleptic characters of twenty one rice bean varieties

Sl. No.	Variety	Organoloptic characters Colour	Appearance	Flower	Texture	Taste	Total Mean score
1.	100 Lg	3.00	3.00	2.75	2.69	2.56	14.00
2.	8 Lg	3.32	3.00	2.68	2.79	2.58	14.37
3.	50 DB	3.80	2.80	2.75	2.45	3.00	14.80
4.	9 BR	3.25	2.70	2.65	3.00	2.80	14.40
5.	50 green	2.67	2.83	2.78	2.83	2.72	13.83
6.	558 LB	3.78	2.61	2.44	2.78	2.50	14.11
7.	7greenish brown	3.00	3.00	2.78	3.06	2.94	14.78
8.	23 Lg	4.00	2.83	2.88	2.88	3.00	15.59
9.	638 blackish mottle	3.84	2.47	2.53	2.58	2.32	13.74
10.	23LB	3.40	2.84	3.00	2.50	2.65	14.39
11.	100 green	1.84	2.32	2.58	2.79	2.79	12.32
12.	7 BR	3.70	2.70	2.90	2.80	2.85	14.95
13.	5DB	3.80	2.95	3.15	2.65	2.65	15.20
14.	5 masik green	3.79	2.74	2.95	2.42	2.05	13.95
15.	9 green	3.06	3.00	2.61	2.56	2.50	13.73
16.	558 red	2.05	3.35	3.30	3.40	3.45	15.55
17.	3LB	3.75	2.85	2.90	2.80	2.65	14.95
18.	3BR	2.39	3.10	2.53	2.26	2.26	12.54
19.	638 black	1.39	2.17	2.83	2.94	2.17	11.50
20.	6LB	3.55	3.20	2.85	2.90	2.55	15.05
21.	5LB	3.00	2.72	2.61	2.66	2.77	13.76

For texture highest value was recorded by 558 red (3.4) followed by 7 greenish brown (3.06), 9 BR (3), 638 black (2.94) and 6 LB (2.9) Lowest value was recorded by 3 BR (2.26) (Table 14)

558 red variety had the highest acceptable score of 3.3 for flavour followed by 5 DB (3.15), 23 LB (3), 5 masik green (2.95), 7 BR (2.9) and 3LB (2.9). The least acceptable variety was found to be 558LB (2.44) (Table 14).

DISCUSSION

DISCUSSION

The genetic improvement in any crop aims at increasing the production potential and quality by altering the genetic makeup of the existing varieties. To achieve this goal, plant breeder requires information on certain genetic parameters like variability, heritability genetic advance and association between characters. For development of superior varieties selection is the fundamental process which utilises the available variability in a crop. Selection based on yield and its components could be more efficient than yield alone (Evans, 1978).

Only very limited information is available on the genetic variability, correlation components having direct effect on yield and cooking quality in rice bean. The present study was hence taken up to determine the extent of variability and association between different characters along with cooking qualities so as to provide a basic information for selection of superior varieties with good quality in rice bean.

The results obtained are discussed below.

I. Variability

The natural variability in a self pollinated crop like ricebean is very limited. However, a knowledge of the available genetic variation could be of use to the plant-breeder for selection. The naturally occurring variation in population of self pollinated species is the primary basis for improvement of these species (Allard, 1960).

In this study, significant differences between genotypes were observed for most of the characters viz. plant height, days to first flowering, length of pod, seed yield, 100 seed weight, days to maturity, yield of haulms, root weight, nodule weight and protein content. The estimates of variance components indicate that there existed only a little difference between phenotypic and genotypic variances for number of primary branches, length of pods, seeds/pod, 100 seed weight and root weight. This also indicates that variation observed in these characters due to genetic factors and there is only little effect of environment on these characters. Hence there is better scope for improvement of these characters through selection.

Plant height, pods/plant, yield of haulms and nodule weight showed wide differences between phenotypic and genotypic variance denoting the greater influence of environment on the characters.

II. Coefficient of variation

High genotypic coefficient of variation (gcv) was observed for plant height, pods/plant, seed yield , yield of haulms, root weight, nodule weight and protein which indicates that there exists high genetic variability and better scope for the improvement of these characters through selection.

On the other hand number of primary branches per plant, days to first flowering, length of pod, seeds/pod, 100 seed weight and days to maturity recorded low genotypic coefficient of variation indicating the presence of low variability and thus limiting the scope for their improvement through selection.

The high genotypic coefficient of variation obtained in this study for plant height is in agreement with the findings of Ramakrishnan et al.(1978) in horsegram, Arunachala (1979) in field bean, Patel and Shah (1982) in blackgram, Singh and Dhiman (1988) in ricebean, Natarajan et al. (1988) in greengram.

Number of primary branches showed a low genotypic coefficient of variation in contrary to the findings of Bainiwal et al.(1981) in pigeonpea, Singh (1985) and Gupta et al.(1986) in pea.

The low gcv obtained for number of days to first flowering is in conformity with the findings of Kumar and Mishra (1981) in cowpea, but in contrast to the report of high gcv by Jagshoram (1983) in pigeonpea and Elizebeth (1991) in horsegram.

Length of pod recorded low gcv in this study which is in agreement with the findings of Ramachandran et al. (1980) in cowpea. Ramakrishnan et al.(1978) in horsegram, and Patel and Shah (1982) in blackgram reported high gcv for pod length.

High gcv recorded for pods/plant is in conformity with the results of Arunachala (1979) in field beam, Pandita et al. (1980) in Indian beans, Ganeshiah et al. (1982) in horsegram, Radhakrishnan and Jebaraj (1982) in cowpea, Liu et al. (1984) in greengram, Sharma et al. (1988) in cowpea and Singh and Dhiman (1988) in rice bean.

Seeds/pod recorded a low gcv. Similar results were reported by Ganeshiah et al.(1982) in horsegram, Dharmalingum and Kadambavanasundram (1984) in cowpea and Singh et al. (1988) in faba bean. However Birari et al. (1987) reported high gcv for seeds/pod in horsegram.

High gcv observed for seed yield is in agreement with the findings of Arunachala (1979) in field bean, Liu et al.(1984) in greengram, Gupta et al. (1986) in pea, Patil and Baviskar (1987) in cowpea and Natarajan et al. (1988) in greengram.

100 seed weight recorded a low gcv in the present study. Concurring results were reported by Ganeshiah et al. (1982) in horsegram and Dharmalingam and Kadambavanasundram (1984) in cowpea. In contrary to this Patil and Baviskar (1987) in cowpea and Singh et al.(1988) in faba bean obtained high gcv for 100 seed weight.

Days to maturity recorded a low gcv which is in agreement with the findings of Ganeshiah et al.(1982) and Birari et al.(1987) in horsegram, Maloo and Sharma (1987) in gram. High gcv for this character was, however, reported by Jagshoram (1983) in-pigeonpea.

The high gcv obtained for haulm yield is in agreement with the findings of Sreekumar et al. (1979) and Sharma et al. (1988) in cowpea.

Root weight showed a high gcv which is similar to the findings of Rangaswamy and Shanmugam (1984) in greengram.

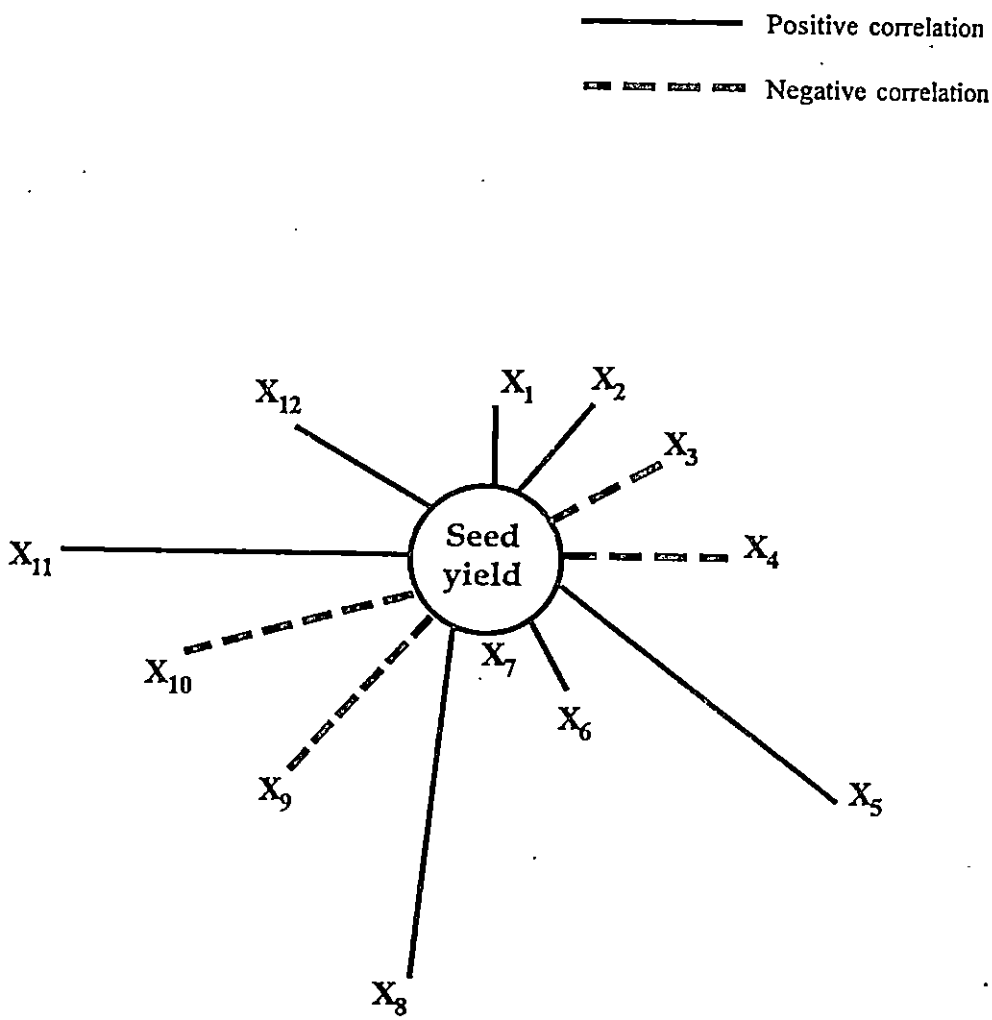
CORRELATIONS

Yield is a highly complex character resulting from the action of different growth components of the plant. Hence a study of the inter relationship between yield and its components will be of much help to the breeders in crop improvement. This study would enable the breeder to apply selection so as to achieve simultaneous improvement of one or more yield contributing characters.

In the present study plant height, number of primary branches, number of pods per plant, seeds/pod, days to maturity, nodule weight and protein content exhibited positive genotypic correlation with yield.

Positive genotypic correlation between yield and pods/plant agrees with the findings of Tikka et al. (1977) in moth bean, Sreekumar et al. (1979) in cowpea, Nandan and

Fig. 1. Genotypic correlation between yield and 12 characters in ricebean



X_1 - Plant height	X_2 - Number of primary branches	X_3 - Days to first flowering
X_4 - Length of pod	X_5 -Pods/plant	X_6 - Seeds/pod
X_7 - 100 seed weight	X_8 - Days to maturity	X_9 - Haulm yield
X_{10} - Root weight	X_{11} - Nodule weight	X_{12} - Protein content

Pandya (1980) in lentil, Naidu et al. (1985) in broad bean, Birari et al. (1987) in horsegram, Raut et al.(1990) in blackgram, Dahiya et al. (1991) in *Dolichos lablab*, Elizebeth (1991) in horsegram, Sarma et al. (1991) and Baisakh (1992) in ricebean. However, Holkar and Raut (1992) reported negative correlation between seed yield and pods/plant in greengram.

The positive genotypic correlation between yield and plant height is in conformity with the results of Chaulwar and Borikar (1987) in cowpea, Khan (1988) in greengram, Ramgiray et al. (1989) in lentil, Satyan et al. (1989) in greengram, Sarma et al. (1991) and Baisakh (1992) in ricebean.

Number of primary branches showed positive genotypic correlation with yield. Similar results were reported by Sandhu et al. (1978) in blackgram, Nandan and Pandya (1980) in lentil, Henry et al.. (1986) in cluster bean, Khan (1988) Satyan et al.(1989) in greengram, Tyagi and Koranne (1988) in cowpea, Sandhu et al. (1991) in chickpea and Sarma et al. (1991) in ricebean.

The Positive genotypic correlation observed between seed yield and seeds per pod is in agreement with the findings of Birari *et al*. (1987) in horsegram, Patil and Bhapkar (1987) Tyagi and Karanne (1988), Tewari and Gautam (1989) Thiyagarajan and Rajasekaran (1989) in cowpea, Patil and Deshmukh (1988) Khan (1988) Satyan *et al*. (1989) in greengram, Katiyar and Singh (1990) in fababean and Sarma *et al*. (1991) in ricebean. Katiyar and Singh (1990), however, obtained negative correlation between seed yield and seeds per pod in faba bean.

Positive genotypic correlation between seed yield and days to maturity is in agreement with the findings of Birari *et al*. (1987) in horsegram, Sagar *et al*. (1987) in pigeonpea, Pandya and Gupta (1988) in gram, Satyan *et al*.(1989) in greengram and Thiyagarajan and Rajasekaran (1989) in cowpea.

Islam *et al*. (1987) in Chickpea reported positive correlation of nodule weight on yield which is in agreement with the results obtained in the present study.

Positive genotypic correlation observed between yield and protein content is in agreement with the findings of Pandey *et al*. (1980) in field bean. However Sandhu *et al*.(1978) in blackgram, Tyagi *et al*.(1982) in Chickpea reported negative correlation between yield and protein content.

Days to first flowering showed negative genotypic correlation with seed yield. Similar results were obtained by Sandhu et al. (1978) in blackgram, Pandita et al. (1980) in Indian beans, Naidu et al. (1985) in broad bean. However Pandey et al. (1980) in fieldbean reported positive correlation between yield and days to first flowering.

The negative correlation observed between seed yield and pod length in the present study is in agreement with the findings of Holkar and Raut (1992) in greengram. However positive correlation was recorded by Patil et al.(1989) in cowpea, Satyan et al. (1989) in greengram, Dahiya et al. (1991) in *Dolichos lablab*.

In agreement with the present findings, Gupta and Singh (1969) in greengram recorded negative correlation between 100 seed weight and yield. But positive correlation between this character and yield was reported by others (Patil and Deshmukh (1988) in greengram, Patil et. al (1989), Tewari and Gautam (1989) in cowpea).

Haulm yield per plant recorded negative correlation with yield. Root weight also showed negative correlation with yield which is contradictory to the findings of Islam et al. (1987) in chickpea.

IV Heritability

Selection acts on genetic differences and gains from selection for a particular character depends largely on the heritability of that character (Allard 1960). Burton (1952) had suggested that gcv together with heritability would give a better picture of the amount of genetic advance to be expected by selection.

The characters which showed high heritability were 100 seed weight, protein content, root weight and yield of haulms. Characters showing high heritability indicate that they are less influenced by environment. High heritability recorded for protein content is in agreement with the findings of Imam (1980) in Plaseolus and Vigna sp and Sandhu et al. (1989) in chickpea. The present investigation revealed high heritability for 100 seed weight. Many other workers also recorded similar results (Sreekumar et al. (1979) in cowpea, Nandan and Pandya (1980) in lentil, Patil and Shah (1982) in blackgram, Singh and Dhiman (1988) and Sarma et al.

(1991) in ricebean and Singh et al. (1988) in faba bean). High heritability shown by root weight is in agreement with findings of Rangaswamy and Shanmugam (1984) in greengram.

Moderate heritability values were obtained for length of pod, plant height, days to first flowering, days to maturity nodule weight and seed yield. Moderate heritability recorded for days to maturity, days to first flowering and plant height is in agreement with the findings of Jagshoram (1983) in Pigeonpea. In contrast to this high heritability was recorded by Sreekumar and Abharam (1979) in green gram, Patil and Baviskar (1987) in cowpea, Anitha (1989) in greengram and Sarma et al. (1991) in rice bean the present study recorded moderate heritability for length of pod. Sandhu et al. (1978) in blackgram, Anitha (1989) in greengram recorded low heritability for seed yield whereas Sandhu et al. (1991) and Natarajan et al. (1990) recorded high heritability.

Low heritability was shown by primary branches, pods/plant and seeds/pod. Nandan and Pandya (1980) recorded low heritability value for seeds/pod in lentil and Sidhu et al. (1985) in pigeonpea. Low heritability values obtained for number of primary branches is in agreement with the findings of Kumar and Reddy (1982) in pigeonpea. Low heritability obtained for pods/plant is contradictory to the results obtained by Tikka *et al*. (1977) in moth bean, Nandan and Pandya (1980) in lentil and Natarajan *et al*. (1990) in pigeonpea.

V GENETIC ADVANCE

Heritability values alone may not provide a clear predictability of the breeding value. Heritability in conjunction with genetic advance is more effective and reliable in predicting the resultant effect of selection, than heritability alone (Johnson *et al*. 1955).

In the present study high genetic advance was obtained for haulm yield, root weight, protein content, seed yield and nodule weight. Moderate values of genetic advance was recorded by 100 seed weight, pods/plant and plant height. Low values were recorded by seeds/pod, days to first flowering, number of primary branches, pod length and days to maturity.

High genetic advance obtained for root weight is in conformity with the result obtained by Rangaswamy and Shanmugam (1984) in greengram. Sreekumar *et al*. (1979) in cowpea recorded high genetic advance for haulm yield as obtained in the present study. High genetic advance obtained for seed yield in this study is in agreement with the findings of Sreekumar and Abraham (1979) in greengram, Pandita et al. (1980) in Indian beans, Ramachandran et al. (1980) in cowpea and Natarajan et al. (1990) in pigeonpea. High genetic advance obtained for nodule weight is in conformity with the findings of Roquib and Patnaik (1990) in cowpea. Pods/plant recorded moderate genetic advance but Tikka et al. (1977) in mothbean, Sreekumar and Abraham (1980) in lentil, Mishra et al. (1988) in chickpea reported high genetic advance for pods per plant. Plant height recorded moderate genetic advance in the present study but Sreekumar and Abraham (1979) in green gram, Radhakrishnan and Jebaraj (1982) in cowpea recorded low genetic advance. Bainiwal et al. (1981) Jagshoram (1983) in pigeonpea, Apte et al. (1987) in cowpea, Singh and Dhiman (1988) in ricebean reported high genetic advance for plant height. Moderate genetic advance was recorded by 100 seed weight in the present study where as Sreekumar et al. (1979) Apte et al. (1987) in cowpea, Singh et al. (1988) in fababean, Thiyagarajan and Rajasekaran (1989) in cowpea, Elizebeth (1991) in horsegram obtained high genetic advance while Patel and Shah (1982) recorded low

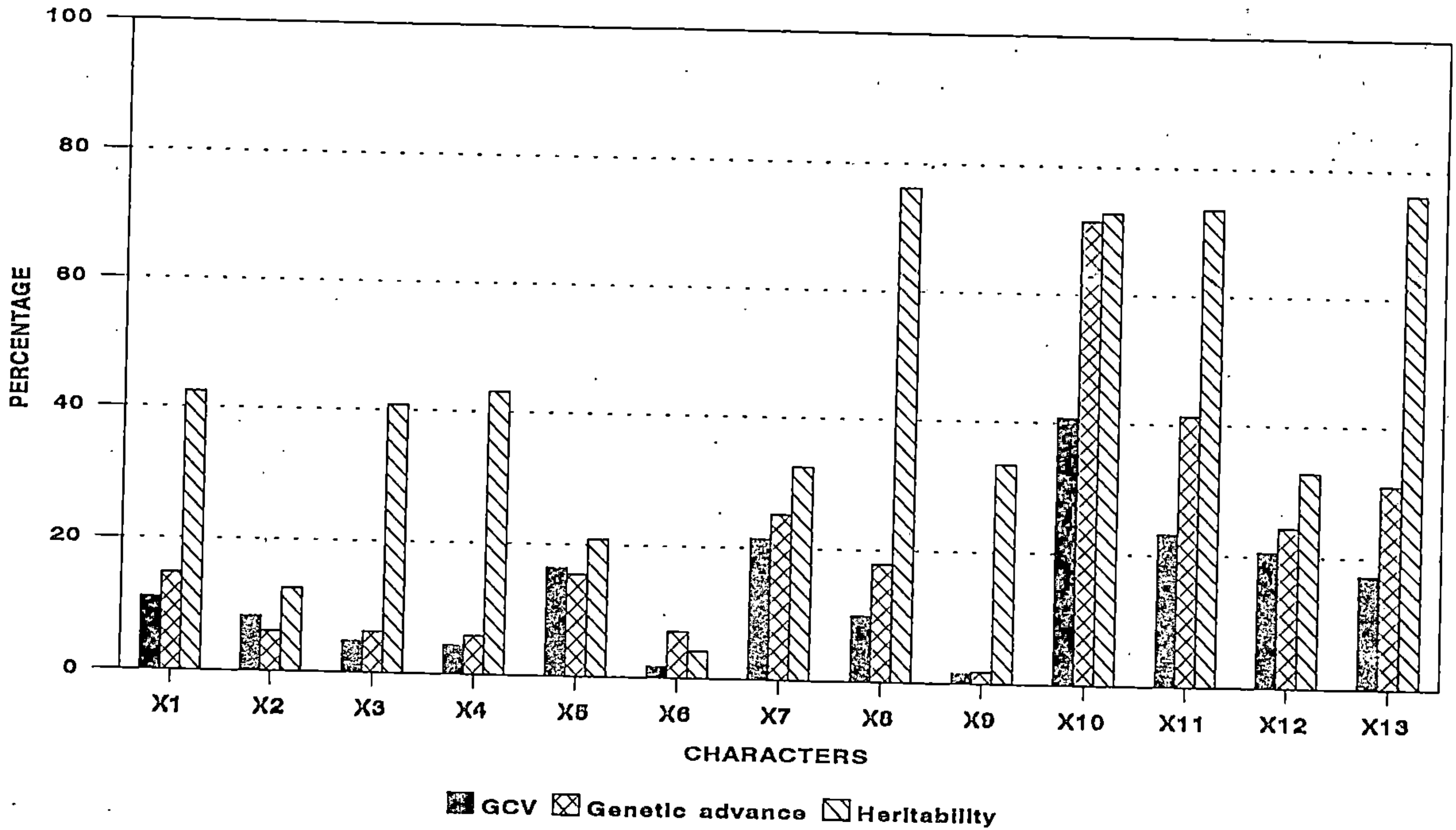


Fig. 2. Genetic parameters

X1 - Plant height, X2 - No. of primary branches, X3 - Days to first flowering, X4 - Length of pod;
X5 - No. of pods/plant, X6 - No. of seeds/pod, X7 - Seed yield, X8 - 100 seed weight,
X9 - Days to maturity, X10 - Yield of haulm, X11 - Root weight, X12 - Nodule weight, X13 - Protein content

genetic advance. Seeds/pod recorded low genetic advance which is in conformity with the results obtained by Sreekumar and Abraham (1979) in greengram and Patel and Shah (1982) in blackgram. Days to maturity showed low genetic advance which is similar to the results obtained by Radhakrishnan and Jebaraj (1982) in cowpea. Number of primary branches recorded low genetic advance in contrast to the results obtained by Apte et al. (1987) in cowpea, Sigh et al. (1988) in fababean.

In the present study high heritability with high genetic advance was recorded by haulm yield, root weight and protein content. Moderate heritability and moderate genetic advance were recorded by plant height. Low values of heritability and genetic advance were recorded by seeds/pod and number of primary branches. Moderately high heritability with low genetic advance was recorded for pod length, days to first flowering and days to maturity. Pods/plant recorded low heritability and moderately high genetic advance. Seed yield and nodule weight recorded moderate heritability and high genetic advance while 100 seed weight recorded high heritability and moderate genetic advance.

High heritability along with high genetic advance indicates the role of additive gene action for the character concerned as suggested by Panse (1957). High heritability with low genetic advance indicates non-additive gene action which reduces the scope for improvement of these characters through selection. Low heritability and low genetic advance indicate the high influence of environment on the expression of the character (Panse, 1957).

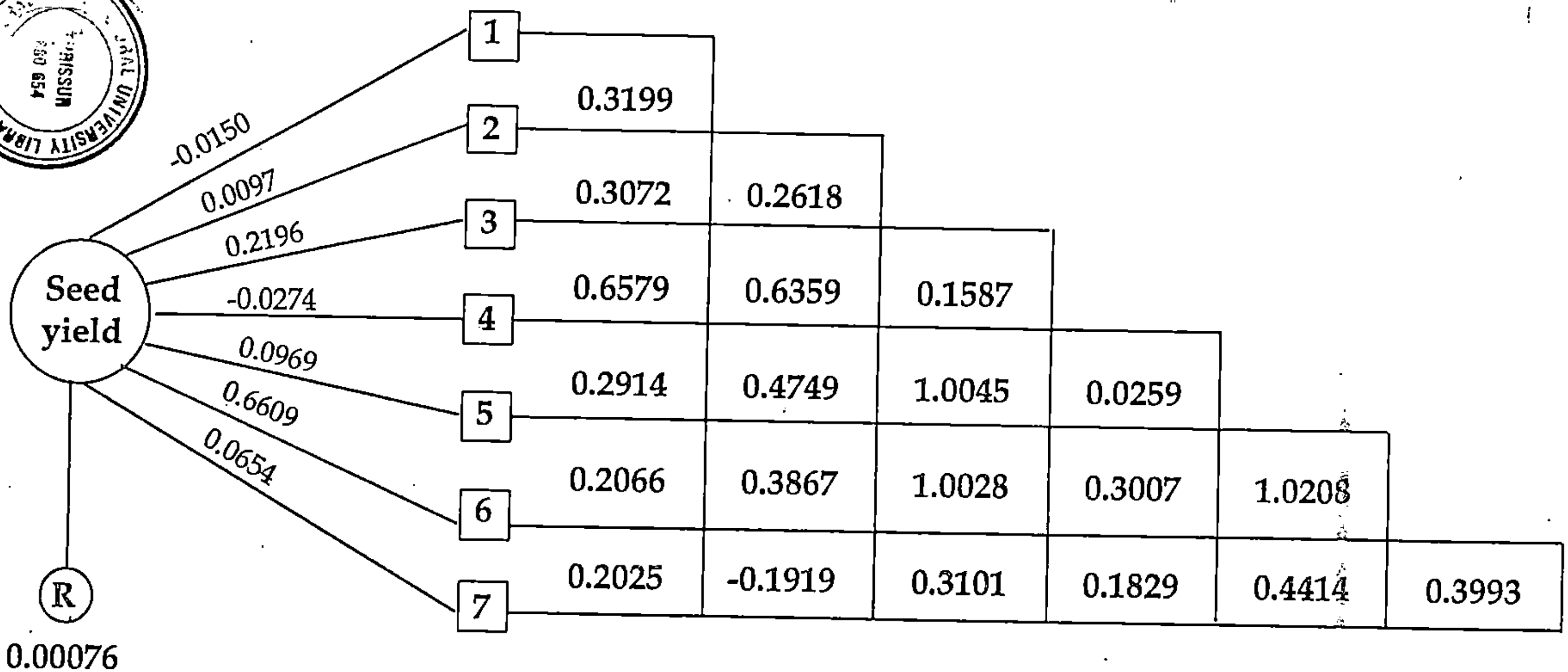
VI PATH ANALYSIS

Path analysis revealed that nodule weight had the highest positive direct effect on seed yield followed by pods/plant, days to maturity, protein content and number of primary branches. Plant height and seeds/pod showed a negative direct effect.

The highest positive direct effect of nodule weight found in this study is in agreement with the findings of Islam <u>et al</u>. (1987) in chickpea.

Pods/plant showed a positive direct effect on yield. Similar results were obtained by Tikka <u>et al</u>. (1977) in mothbean Nandan and Pandya (1980) in lentil, Ganeshiah (1980), Kallesh (1986) and Singh (1990) in horsegram, Kumari

Fig. 3. Path Diagram



Direct effects shown in arrows. Correlations are shown in steps

1 Plant height 2 Number of primary branches 3 Pods/plant 4 Seeds/pod 5 Days to maturity
6 Nodule weight 7 Protein content

and George (1982) and Raut et al. (1988) in greengram, Naidu et al. (1986), Bhavsar and Birari (1989) and Bhandari (1991) in moth bean, Patil et al. (1989) in cowpea and Prema et al. (1990) in rice bean.

Positive direct effect of days to maturity on yield observed in the present study is in conformity with the findings of Marekar and Nerkar (1987) in pigeonpea, Wanjari (1988) in blackgram, Patnaik and Roquib (1990) in cowpea but is contrary to the results obtained by Patil and Deshmukh (1988) in mungbean who reported negative direct effect.

Protein content showed a positive direct effect on yield which is contradictory to the result obtained by Tyagi et al. (1982) in chickpea.

Number of primary branches showed a positive direct effect on yield. Similar results were obtained by Nandan and Pandya (1980) in lentil, Tyagi et al. (1982) in chickpea, Kumar and Reddy (1982) Sandhu (1989) in Chickpea, Patil et al. (1989) Thiyagarajan and Rajasekaran (1989) in cowpea and Mishra and Yadav (1992) in mungbean.

Plant height had negative direct effect on yield eventhough the correlation with yield is positive. These negative direct effect are counter balanced by the strong positive indirect effects through pods/plant and nodule weight. Similar result was obtained by Sandhu et al. (1980) in urdbean. Sidhu et al. (1985) Marekar and Nerkar (1987) and Natarajan et al. (1990) in pigeonpea, Khan (1988); Patil and Narkhede (1989) Mishra and Yadav (1992) in mung bean, Dahiya (1991) in Dilichos lablab reported positive direct effect of plant height on yield.

Seeds/pod showed a negative direct effect on yield eventhough the correlation was positive. Here positive indirect effect seems to be the cause for correlation and the indirect causal factors such as nodule weight, pods/plant, number of branches, days to maturity and protein content are to be considered simultaneously during selection programme. Patel and Deshmukh (1988) in greengram reported similar negative direct effect on yield by seeds per pod whereas Prema et al. (1990) reported positive direct effect in rice bean.

On the basis of the present investigation carried out in ricebean high yielding varieties can be obtained by selecting for nodule weight, pods/plant, number of primary branches, protein content and days to maturity. The varieties 5DB, 558 red, 6LB, 638 black and 8 Lg were found fit in this model.

Cooking qualities

In the present study cooking time of 21 varieties of rice bean ranged between 40 mts (50 DB) to 70 mts (100 green). Except the variety 100 green (70 mts) all the other 20 varieties had the cooking time ranging between 30 minutes and 1 hr. which is similar to the findings reported by Kurein et al. (1972) in legumes. Majority of the varieties came under the group where the cooking time is between 41 and 50 mts which is similar to the result obtained by Sood et al. (1991) in blackgram. Water uptake ranged between 0.79 g/g (3LB) to 1.2 g/g (5DB). Similar results were obtained by Narasimha and Desikachar (1978) in redgram varieties where water uptake ranged between 52-150 percentage. In the present study volume expansion ranged between 68.42% (50DB) and 58.33% (5LB, 8LG, 5 masik green, 558LB, 9 green, 50 green).

Organoleptic studies

Based on the organoleptic evaluation of cooked grain of rice bean varieties it was found that the varieties

23 Lg, 558 red, 6LB, 3LB and 7BR are superior based on the total mean score.

Based on the above evaluation it was found that the varieties 558 red and 6LB at superior yielding varieties with high acceptability.

SUMMARY

SUMMARY

A field experiment was conducted at the College of Agriculture, Vellayani during May-Sept. 1993 with 21 varieties of ricebean (Vigna Umbellata) (Thumb) Ohwi and Ohashi) adopting a Randomised Block Design with three replications. Observations were made on seed yield and other 12 characters viz. plant height, number of primary branches, days to first flowering, length of pod, pods/plant, seeds/pod, 100 seed weight, days to maturity, haulm yield, root weight, nodule weight and protein content.

The analysis of variance revealed significant difference among the varieties with respect to all characters except number of primary branches, pods/plant and seeds/pod.

The genotypic co-efficient of variation was maximum for haulm yield followed by root weight and seed yield. For characters, 100 seed weight, root weight and protein content there was only a little difference in phenotypic and genotypic co-efficient of variation. For all other characters there was wide difference between phenotypic and genotypic co-efficient of variation indicating higher environmental influence.

Grain yield per plant showed positive genotypic correlation with the characters studied except days to first flowering, length of pod, 100 seed weight, haulm yield and root weight. Days to maturity, nodule weight and pods/plant showed high genotypic correlation with seed yield.

Heritability estimate was maximum for 100 seed weight and minimum for seeds/pod. Protein content, root weight and haulm yield also had high heritability values indicating lesser influence of environment.

Genetic advance expressed as percentage of mean showed that haulm yield had maximum genetic gain followed by root weight, protein content, seed yield and nodule weight. Moderate to high heritability with moderate to high genetic advance was obtained for characters like 100 seed weight, protein content, root weight, yield of haulms and plant height indicating the reliability of these characters during selection for improvement of yield. Seeds/pod and number of primary branches showed low heritabilty with low genetic advance.

Path co-efficient analysis at genotypic level revealed that number of primary branches, pods/plant, days to maturity, nodule weight and protein content exerted positive direct influence on yield.

Cooking quality studies showed that optimum cooking time ranged from 40mts to 70mts and the variety 100 green recorded the maximum time, water uptake ranged from 0.79 g/g for the variety 5DB to 1.2 g/g for 3BR. Cooked volume ranged form 68.42% to 58.33%.

Organoleptic studies revealed that the variety 23Lg is the most acceptable followed by 558 red, 6LB, 3LB and 7BR.

The above results thus projects that a selection model based on number of primary branches, pods/plant, days to maturity, nodule weight and protein content should be given more emphasis while making selection for high seed yield in ricebean.

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APPENDIX

Appendix - I

SCORE CARD FOR ACCEPTABILITY TRIAL

	Scores given for samples (Varieties)
	1 2 3 4 5 6 7 8 21

1. Colour

Light brown	-	4
Brown	-	3
Dark brown	-	2
Black	-	1

2. Appearance

Very acceptable	-	4
Acceptable	-	3
Fairly acceptable	-	2
Unacceptable	-	1

3. Flavour

Very acceptable	-	4
Acceptable	-	3
Fairly acceptable	-	2
Unacceptable	-	1

4. Texture

Very soft	-	4
Soft	-	3
Hard	-	2
Very hard	-	1

5. Taste

Very good	-	4
Good	-	3
Fair	-	2
Poor	-	1

ABSTRACT

A study on the variability, correlation and path coefficient analysis was undertaken in 21 varieties of ricebean along with the cooking qualities. The study was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani during kharif 1993.

The varieties showed significant difference in all the characters studied except number of primary branches, pods/plant and seeds/pod. Genotypic coefficient of variation was maximum for haulm yield and minimum for days to maturity. At genotypic level grain yield per plant showed positive correlation with plant height, number of primary branches, pods/plant, seeds/pod, days to maturity, nodule weight and protein content. High heritability estimates were observed of 100 seed weight, protein content, root weight and haulm yield. High genetic advance with high heritability was observed for haulm yield, root weight and protein content indicating the presence of additive gene action. Path coefficient analysis indicated that number of primary branches, pods/plant, days to maturity, nodule weight and protein content exerted positive direct effect on seed yield.

Cooking quality studies showed that optimum cooking time ranged between 40-70mts, water uptake ranged between 0.79 g/g to 1.2 g/g and volume of extraction ranged between 58.33% to 68.42%. Organoleptic studies revealed that the variety 23Lg is the most acceptable.

The study indicated that the model for selection for ricebean varieties should be one with more number of primary branches and pods per plant, more number of days to maturity, high nodule weight and protein content.