VARIABILITY OF BIOLOGICAL NITROGEN FIXATION TRAITS AND YIELD COMPONENTS IN BLACKGRAM (*Vigna mungo* (L.) Hepper)

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Variability of Biological Nitrogen Fixation Traits and Yield Components in Blackgram [*Vigna mungo* (L.) Hepper]"** 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 the thesis entitled **"Variability of Biological Nitrogen Fixation Traits and Yield Components in Blackgram [*Vigna mungo* (L.) Hepper]"** is a record of research work done independently by **Mr.Siby Thomas**, 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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Dedicated to
my loving parents

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Introduction

INTRODUCTION

The grain legumes commonly known as pulses, form an important and ancient component of Indian agricultural system. They occupy a unique position in the world agriculture by virtue of their high protein content and their capacity for directly using the inexhaustible stock of atmospheric nitrogen. The pulses serve as a valuable supplement to the cereal based diet especially in areas where animal protein is less available. Pulses contain 22-24 per cent protein which is much more than that available in cereals. The present production of pulses grown in an area of 22 million hectare in India is 12.97 million tonnes with a per hectare yield of 537 kg. In Kerala, pulses occupy an area of 24285 hectares with an annual production of 18552 tonnes with a productivity of 764 kilogram per hectare (Econ. Rev., 1990).

Blackgram, one of the most important pulse crops of Kerala is cultivated during rabi season in uplands and in summer rice fallows during the third crop season. The cultivation of legumes were beneficial to the succeeding cereal crop (Nambiar *et al.*, 1988). They also play an important role in the rice based cropping system and the nitrogen fixing capacity of legume-rhizobium symbions is affected by the genotype of legume, the rhizobium, the interaction between legume and the rhizobium and the environment. The amount of nitrogen fixed per hectare per year was estimated to be 125-335 kg for alfalfa, 80-150 kg for pea, 65-115 kg for soyabean and 65-130 kg for cowpea (Alexander, 1977). Singh and Murthy (1988), suggested the possibility of breeding legumes for improved nitrogen fixation for increasing the contribution of biological nitrogen.

Genetic variation for nodulation and nitrogen fixation has been studied in green gram (Singh and Murthy, 1988). High heritability estimates together with the large variation present for nitrogen fixation traits (total nitrogen, total dry weight per plant and nodule fresh weight per plant) reported by Seetin and Barnes (1977) in alfalfa and Singh and Murthy (1988) in green gram, indicates that selection for increasing nitrogen fixation is possible. Such studies are lacking in blackgram.

Hence this study was programmed to assess the genetic variability for biological nitrogen fixation traits and yield components in blackgram as a preliminary step to develop high yielding varieties with good biological nitrogen fixation capacity.

Review of Literature

REVIEW OF LITERATURE

Blackgram is one of the most important and highly nutritious pulse crop. It occupies an important place in the diet of the people in the State, next to cereals. There is much scope for increasing the production of pulses by genetic improvement. The potential area available for expanding the cultivation of blackgram in the State is the summer rice fallow during the third crop season. Availability of a variety with appreciable grain yield and good nitrogen fixation ability can increase the area of cultivation and improve the nitrogen content of the soil. The estimation of genetic variability and correlations will be useful to the breeder in identifying the components contributing to grain yield and nitrogen fixation traits which can be new for the genetic improvement and identification of varieties with good nitrogen fixation capacity. Therefore, a brief review of the available literature on similar works in blackgram and other pulses are presented.

2.1 Variability

a. Blackgram

Veeraswamy *et al.* (1973a) studied variability in twenty five varieties for six characters, viz., height of the plant, number of branches per plant, number of pod clusters per plant, number of pods per plant, length of pod and number of seeds per pod and reported wide range of variation for all the characters. The maximum genotypic coefficient of variation was reported for number of pods per plant (90.73%) and the minimum value for number of seeds per pod (7.3%).

The effect of inoculation and phosphate manuring on nodulation, nitrogen content in shoot and root and yield of blackgram and horse gram was studied by Sahu (1973). The results revealed that inoculation or phosphatization increased nodulation, nitrogen content in shoot and root, dry matter content in shoot and root portions and yield. The nitrogen status of the soil was reported to be appreciably increased, the order being blackgram and horse gram.

Singh *et al.* (1975) studied variability in thirty six varieties for the characters such as number of branches per plant, plant height, number of pod clusters per plant and grain yield per plant. Maximum genotypic and phenotypic coefficients of variation were reported for height of the plant (25.7% and 26.2% respectively) and the minimum values for grain yield per plant (4.13% and 4.62% respectively).

Soundarapandian *et al.* (1975) in their study on genetic variability for yield attributes in sixteen varieties, reported high genotypic coefficient of variation for height of the plant (29.82%) and grain yield per plant (26.42%) and very low values for length of pod (8.35%) and number of seeds per pod (4.88%).

Sagar *et al.* (1976) while studying variability in twenty seven varieties, observed a high degree of variation for grain yield per plant, number of pods per plant, days to flowering and number of branches per plant.

Goud *et al.* (1977) in their study on twelve varieties recorded maximum genotypic coefficient of variation for grain yield per plant (23.0%) and the minimum value for length of pod (2.90%).

Sandhu *et al.* (1978) studied 268 varieties and reported high genotypic coefficients of variation for number of pods per plant (28.3%), number of branches per plant (26.4%), grain yield per plant (24.9%), height of the plant (24.8%), days to flowering (23.4%) and number clusters per plant (22.1%). Length of pod had the minimum valaue of 5.6 per cent in their studies.

Pillai (1980) recorded high genotypic coefficient of variation for height of the plant (31.4%) followed by number of branches per plant (25.8%) and the lowest value for the number of days to maturity (5.2%).

Patel and Shah (1982) reported high genotypic coefficient of variation for length of pod (40.5%) and height of the plant (35.8%) by evaluating twenty varieties.

Ramaswami and Oblisami (1984) conducted field experiments with 430 collections of blackgram comprising of short, medium and long duration varieties in a red sandy loam soil under both inoculated and uninoculated conditions and reported that short duration varieties recorded significantly higher harvest index than medium or long duration varieties, and the inoculation with rhizobia significantly increased the grain yield and harvest index.

Chandrababu *et al.* (1985) in their study on twenty varieties, found significant cultivar differences for leaf area, net photosynthetic rate and total dry matter production.

Philip (1987) reported high genotypic coefficient of variation for Leaf Area Index at blooming (35.87%) followed by number of branches per plant (16.14%) and the minimum value was recorded for the number of seeds per pod (2.79%) under partially shaded conditions in coconut garden.

Abraham *et al.* (1992a) studied the genetic variability, correlations of grain yield and other components on harvest index in black gram, grown under partially shaded conditions and reported that a high leaf area index at 50 per cent flowering, more number of longer pods, more number of seeds per pod and high dry matter accumulation would result in a higher harvest index.

b. Greengram

Singh and Malhotra (1970b) in their study on seventy five varieties have suggested that the characters having high genotypic coefficient of variation such as number of pod clusters per plant (23.3%), grain yield per plant (22.5%) and number of pods per plant (22.0%) are useful for the genetic improvement of this crop by means of selection.

Veeraswamy *et al.* (1973c) in their studies on twenty five varieties observed the maximum genotypic coefficient of variation for number of pod clusters per plant (35.3%) followed by number of pods per plant (34.5 %), number of branches per plant (33.1%) and height of the plant (30.5%).

Rathnaswamy *et al.* (1978) reported highest genotypic coefficient of variation for number of pods per plant (19.14%) and the lowest value for grain yield per plant (7.84%) in twenty four varieties.

Sreekumar and Abraham (1979) have reported comparatively high values of genotypic coefficient of variation for the characters viz., height of the plant (14.97%), grain yield per plant (12.83%) and number of pods per plant (9.95%) and the minimnum value for number of branches per plant (0.38%).

Paramasivan and Rajasekharan (1980) reported high values of genotypic coefficient of variation for height of the plant (45.0%), number of clusters per plant (42.5%), grain yield per plant (41.6%) and number of pods per plant (41.5%). Number of seeds per pod had the minimum value of 7.24 per cent in their studies.

Rathnaswamy *et al.* (1986) evaluated seventy seven green gram genotypes for the nodulating ability under field conditions and reported large variation for nodule number among the host genotypes both at flowering and maturity phases. They have found that the nodulating ability and DMP components behaved independently in the population and suggested that selection may be useful for high nodulating ability as well as yield potential.

Singh and Murthy (1988) studied the genetics of nitrogen fixation traits in green gram (*Vigna radiata* (L.) Wilczek) and reported that there was considerable variation for total nitrogen, total dry matter and nodule fresh weight/plant in 49 purelines.

Studies by Ilhamuddin *et al.* (1989) in mungbean showed significant differences for eight quantitative characaters. High genotypic and phenotypic variances were recorded for plant height and 1000 seed weight. Genotypic and phenotypic coefficients of variation were highest for yield per plant.

c. Cowpea

Singh and Mehndiratta (1969) studied variability in forty varieties and reported that number of pods per plant had the maximum genotypic coefficient of variation (52.52%) followed by number of pod clusters per plant (33.02%) and grain yield per plant (22.43%). The number of days to maturity (5.52%) had the minimum value in their studies.

Veeraswamy *et al.* (1973b) observed a wide range of variability for the characters viz., height of the plant, number of branches per plant, number of pod clusters per plant, number of pods per plant, number of grains per pod, length of pod and grain yield per plant, in twelve varieties. High genotypic coefficients of variation were estimated for grain yield per plant (34.9%), number of pods per plant (28.7%), number of branches per plant (24.2%), height of the plant (23.4%) and number of pod clusters per plant (20.9%).

Ramachandran *et al.* (1980) studied eight varieties and reported that genotypic coefficient of variation was maximum for grain yield per plot (57.12%)

followed by number of pods per plant (56.56%) and minimum for length of pod (6.44%).

Radhakrishnan and Jebaraj (1982) reported that the number of pods per plant had the maximum genotypic coefficient of variation (48.2%) followed by number of pod clusters per plant (36.6%) and number of branches per plant (27.5%). The number of days to maturity had the minimum value of 4.7 per cent in their trial.

Dharmalingam and Kadambavanasundaram (1984) in their studies on genetic variability on forty varieties observed high genotypic coefficient of variation of harvest index (35.69%), number of pods per plant (29.92%) and grain yield per plant (24.16%) and the minimum value for number of seeds per pod (12.88%).

d. Redgram

Joshi (1973) studied 100 varieties and reported high values of genotypic coefficient of variation for grain yield per plant (21.01%) and height of the plant (16.9%).

Rathnaswamy *et al.* (1973) while studying genetic variability in twenty one varieties recorded high genotypic coefficient of variation for the characters viz., number of pod clusters per plant (67.6%), number of pods per plant (54.5 %), number of branches per plant (52.1%) and the minimum value for number of days to maturity (37.7 %).

Godawat (1980) studied twenty six varieties and reported that grain yield per plant had a high genotypic coefficient of variation of 29.58 per cent, followed by number of branches per plant (20.58%).

Varietal difference in pigeonpea with respect to nitrogen fixation was reported by Sreekumar (1982). Variety Bahar was found to be much superior than var. T-24 in his experiments.

Singh and Yadav (1991) studied genetic variability and heritability from data on 5 yield related traits, in pureline pigeonpeas, of diverse phenotypes.

e. Other pulses

Wahua and Miller (1978) reported that nitrogen fixation by soyabean grown with tall sorghum was reduced by 99% due to reduction in number of nodules per plant (77%), weight per nodule (50%) and specific nodule activity SNA (96%).

Ganeshiah (1980) studied 100 horse gram varieties and reported significant variation for 18 characters. Genotypic and phenotypic coefficients of variation was reported to be high for number of secondary branches. High heritability estimates was recorded for number of days to flowering and maturity.

Nakaseko (1984) while studying *Glycine max, Vigna angularis* and *Phaseolus vulgaris*, found differences in dry matter accumulation between the three crops and between varieties within the crops.

Pods per plant, plant height, days to 50 per cent flowering and days to maturity showed the highest and 100 seed weight showed the lowest genotypic variance in horse gram according to Suraiya *et al.* (1988). In their studies, all these characters except 100 seed weight, exhibited high heritability and genetic advance, while seed yield per pod and pods per plant showed low heritability and genetic advance.

A high level of phenotypic variability was recorded for pods per plant, pod size and primary branches per plant in pea, by Solanki *et al.* (1988). Association of high heritability with genetic advance for fruit size and pod yield per plant was also noted.

f. Fodder legumes

Nair (1970) evaluated the performance of a few strains of Rhizobia on nodulation, yield and N fixation in Daincha, Pillipesara, *Sesbania speciosa* and sunhemp; and reported that there was an increase in the N fixation. The N fixation varied from 8 to 14 kg per hectare and the production of dry matter was significantly increased due to inoculation except in the case of *Sesbania speciosa* in which case, the benefit of inoculation was seen by way of increased N content of the crop.

Seetin and Barnes (1977) studied Alfalfa (*Medicago sativa* L.) cultivars and reported that morphological traits such as many fibrous roots, many nodules and high top and root weights were associated with high levels of acetylene reduction.

Hardarson and Jones (1979) reported in white clover that the host plant can influence with rhizobium strains. This specificity in nodulation is broadly heritable and can be enhanced by selection.

Smith *et al.* (1982) reported a high heritability estimate for N fixation characters like nodule number, nodule fresh weight, plant dry weight and nitrogen content in crimson clover. This finding gave feasibility for the selection for increased nitrogen fixation in this species.

Barnes *et al.* (1984) observed that alfalfa genotypes varied for nitrogenase activity and found that it is positively correlated with shoot weight, root weight, number of fibrous roots and nodule mass.

2.2 Heritability and genetic advance

a. Blackgram

Veeraswamy *et al.* (1973a) in their study with twenty five varieties reported that height of the plants had the maximum heritability of 96.18 per cent and number of pods per plant had the lowest (56.1%).

Singh *et al.* (1975), while studying thirty six varieties reported that plant height had the highest heritability estimate (97.3%) along with a high genetic advance (25.6%). Number of pod clusters per plant recorded the lowest heritability (61.8%) with the lowest genetic advance (4.0%).

Soundarapandian *et al.* (1975) observed high heritability estimates with high genetic advance for plant height (73.2% and 52.5% respectively) followed by yield per plant (60.7% and 42.0% respectively).

Goud *et al.* (1977) noticed high heritability for the length of pod (96.0%), plant height (93.0%) and number of seeds per pod (91.11%). Grain yield per plant was found to have the lowest heritability estimate of 52.92 per cent.

Sandhu *et al.* (1978) in their study on 268 lines for ten characters observed high heritability along with high genetic advance for number of days to flowering (95.5% and 46.2% respectively) followed by plant height (45.5% and 34.4% respectively), and number of branches per plant (33.8% and 39.8% respectively) and low heritability values for number of clusters per plant (25.8%), number of pods per plant (33.2%), length of pod (35.9%), number of seeds per pod (33.0%) and grain yield per plant (23.9%).

Patel and Shah (1982) estimated various genetic parameters in twenty varieties and observed high heritability coupled with high genetic advance for plant height (86.2% and 68.5% respectively) and length of pod (46.9% and 57.2% respectively). High heritability along with low genetic advance was observed for number of seeds per pod (42.7% and 6.6% respectively).

A study of 25 strains of blackgram by Patil and Narkhede (1987) indicated high heritability along with high genetic advance for yield per plant, pod length and plant height.

Lakshmiah *et al.* (1989) reported that heritability values ranged from 77 to 99 per cent and the highest value was recorded for days to 50 per cent maturity, in blackgram.

b. Greengram

Singh and Malhotra (1970b) reported high heritability of 65.1 per cent for number of days to flowering with a genetic advance of 11.4 per cent. Characters such as number of clusters per plant, number of pods per plant and grain yield per plant showed moderate heritability along with high genetic advance.

Veeraswamy *et al.* (1973c) observed high heritability coupled with high genetic advance for number of pod clusters per plant (83.8% and 66.5% respectively) and number of branches per plant (78.9% and 60.8% respectively).

Rathnaswamy *et al.* (1978) reported high heritability values associated with high genetic advance for number of pods per plant (65.3% and 31.9% respectively). High heritability with low genetic advance was noted for length of pod (93.9% and 19.2% respectively) and number of seeds per pod (86.2% and 12.9% respectively). Yield per plant showed a heritability of 27.5 per cent with a low genetic advance of 8.5 per cent.

Sreekumar and Abraham (1979) reported high heritability along with high genetic advance for number of branches per plant (84.3% and 38.0% respectively), number of pods per plant (56.9% and 29.6% respectively) and grain yield per plant (78.4% and 44.0% respectively). High heritability with low genetic advance was observed for height of the plant, length of pod, days to flowering, number of clusters per plant, number of pods per plant and number of seeds per pod.

Paramasivan and Rajasekharan (1980) evaluated ninety varieties and reported high heritability along with high genetic advance for length of pod (97.2% and 24.9% respectively), number of pod clusters per plant (92.6% and 12.0% respectively) and seed yield per plant (89.5% and 10.5% respectively).

c. Cowpea

Singh and Mehndiratta (1969) studied forty varieties and reported that days to flowering (88.8%), length of pod (80.5%) and days to maturity (78.3%) expressed high heritability estimates. Seed yield per plant recorded the lowest heritability (35.6%). High genetic advances was observed for number of pod clusters per plant (48.1%), number of pods per plant (31.6%), pod length (27.7%) and seed yield per plant (27.6%).

Veeraswamy *et al.* (1973b) recorded the maximum heritability for pod length (99.5%) and the minimum for number of seeds per pod (33.3%). Genetic advance was found to be high for pod length (53.8%) followed by number of pods per plant (46.9%) and grain yield per plant (46.4%). High heritability coupled with high genetic advance was observed for pod length (97.5% and 53.8% respectively).

Rajendran *et al.* (1979) recorded high heritability estimates and genetic advance for the characters days to flowering (95.2% and 57.1% respectively), days to first pod harvest (93.7% and 40.3% respectively) and number of seeds per pod (83.5% and 100% respectively).

Sreekumar *et al.* (1979) observed moderate to high heritability estimates for number of days to flowering (69.2%), total duration (49.2%), number of grains per pod (40.6%) and grain yield per plot (43.4%).

Radhakrishnan and Jebaraj (1982) recorded high heritability coupled with high genetic advance for number of pods per plant (98.9% and 94.1% respectively), number of pod clusters per plant (94.0% and 73.1% respectively), while the number of days to maturity and plant height registered high heritability and low genetic advance.

Dharmalingam and Kadambavanasundaram (1984) reported the maximum heritability estimates for length of pod (87.37%) followed by harvest index (69.58%).

In nigerian cowpea, Thiagarajan *et al.* (1989) observed high heritability and genetic advance for height, number of clusters per plant, number of pods per plant, number of seeds per pod and seed yield per plant.

High heritability was reported for plant height, seed number per plant, pods per primary branch, pod length and breadth, days to 50 per cent flowering, maturity and seed yield, in cowpea by Roquib and Patnaik (1990). Most of these traits had high estimates of genetic advance also.

d. Red gram

Joshi (1973), while studying 100 varieties observed high heritability along with high genetic advance for plant height (88.6% and 32.8% respectively), but all other characters studied viz., seed yield per plant, number of branches per plant, number of pods per plant, number of seeds per pod and length of pod showed low heritability estimates and low genetic advance.

Godawat (1980) reported high heritability values associated with high genetic advance for number of primary branches per plant (89.1% and 39.9% respectively) followed by grain yield per plant (51.0% and 43.5% respectively).

Bainiwal *et al.* (1981) observed high heritability estimates with low genetic advance for number of days to flowering (71.5% and 11.2% respectively) and days to maturity (78.9% and 7.5% respectively) and moderate heritability with low genetic advance for height of the plant (49.8% and 15.1% respectively), number of branches per plant (39.4% and 15.1% respectively) and number of seeds per pod (42.0% and 5.7% respectively).

Shoram (1983) in his study on 100 varieties for eight characters reported high estimates of heritability along with high genetic advance for number of pods per plant (89.81% and 69.14% respectively), number of days to maturity (97.3% and 49.0% respectively) and number of days to flowering (97.2% and 48.4% respectively).

e. Other pulses

In 50 cultivars of horse gram, studied by Patil and Deshmukh (1982) seed yield, number of primary and secondary branches and pods per plant showed high heritability and genetic advance.

Singh *et al.* (1994) reported highest variability estimate for days to 50 per cent flowering. It was lowest for pod weight. The expected genetic advance was maximum for yield per plant and the minimum for days to 50 per cent flowering. Yield per plant had high GCV, genetic advance and heritability. Yield was positively correlated with pods per plant; but negatively with days to flower.

2.3 Correlation

2.3.1 Association between yield and its components

a. Blackgram

Singh *et al.* (1975) in their studies with thirty six varieties estimated significant positive genotypic and phenotypic correlation of number of primary branches per plant, height of the plant and number of pod clusters per plant with grain yield per plant.

Soundarapandian *et al.* (1976) reported significant positive genotypic association of grain yield with number of pod clusters per plant, number of pods per plant, number of seeds per pod, length of pod and height of the plant.

Sandhu *et al.* (1978) observed significant positive genotypic correlation of grain yield with the number of pod clusters per plant, number of pods per plant, length of pod and number of seeds per pod. The number of days to flowering and number of branches per plant had a negative association with grain yield in their studies.

Sandhu *et al.* (1980) reported positive genotypic and phenotypic correlation of grain yield with number of pod clusters per plant, number of pods per plant, length of pod and number of seeds per pod.

Pillai (1980) in his study on fifty six varieties found that the characters such as number of days to flowering, days to maturity, height of the plant, number of primary branches per plant, number of pod clusters per plant, number of pods per plant, length of pod and number of seeds per pod had significant and positive genotypic and phenotypic correlations with grain yield per plant.

Muthiah and Sivasubramanian (1981) recorded significant positive genotypic correlations of grain yield with plant height, number of branches per plant, number of pod clusters per plant, number of pods per plant, pod length and number of seeds per pod.

Usha and Sakharam (1981) in their study on various yield components reported significant positive genotypic correlation of grain yield with plant height, number of clusters per plant, number of pods per plant, length of pod and number of seeds per pod.

Patel and Shah (1982) in their correlation studies on twenty varieties recorded significant positive genotypic correlation of grain yield with number of branches per plant, number of pods per plant and number of pod clusters per plant.

Chandrababu *et al.* (1985) evaluated twenty varieties and reported positive genotypic correlation between photosynthetic rate and grain yield at the pod development stage.

Singh *et al.* (1986) reported that, seed yield in black gram was positively correlated with pods per cluster and pods per plant and negatively correlated with days to flowering.

Philip (1987) had reported high positive genotypic correlation of grain yield per plant with the characters - days to pod harvest initiation, number of pod clusters per plant, number of pods per plant, length of pod and number of seeds per pod, in a trial conducted under partially shaded conditions.

Patil and Narkhede (1987) showed that, seed yield was positively and significantly correlated with pods per plant, 100 seed weight, pod length and seeds per pod, in blackgram.

Waryari (1988) reported that pod number, pod length, cluster number per plant and 100 seed weight in blackgram had positive association with yield.

Abraham *et al.* (1992b) recorded significant positive genotypic association of grain yield per plant with number of pod clusters per plant, number of pods per plant, length of pod, number of grains per pod, leaf area index at 50 per cent flowering and harvest index.

Singh and Singh (1994) reported significant positive association of grain yield with 100 seed weight, pods per plant, pod length and plant height in black-gram.

b. Greengram

Singh and Malhotra (1970a) recorded significant positive genotypic association of seed yield with number of pod clusters per plant, number of pods per plant, number of seeds per pod and length of pod. The number of pods per plant had the highest positive genotypic correlation in their studies.

Malhotra *et al.* (1974) reported that yield was significantly and positively correlated with number of pods per plant, number of pod clusters per plant, number of primary branches per plant, number of seeds per pod, plant height and number of days to flowering at the genotypic level.

Estimation of correlation by Singh *et al.* (1977) revealed significant and positive genotypic correlation of seed yield with number of primary branches per plant and number of pods per plant.

Rathnaswamy *et al.* (1978) reported highly significant positive genotypic correlation of grain yield with number of pods per plant and number of seeds per pod.

Saraswathy *et al.* (1979) recorded significant and positive genotypic correlation of grain yield with number of pod clusters per plant, length of pod, number of pods per plant and number of seeds per pod.

Upadhaya *et al.* (1980) observed that grain yield was significantly and positively correlated at the genotypic level, with number of branches per plant, number of pods per plant and number of seeds per pod.

Boomikumaran and Rathinam (1981) in their correlation studies on forty nine varieties found significant and positive genotypic correlation of grain yield with plant height, number of branches per plant and number of seeds per pod. Characters like number of clusters per plant and number of pods per plant had significant positive phenotypic correlations and low genotypic correlations with grain yield.

Prasannakumari and George (1982) reported that grain yield showed significant positive genotypic correlations with number of pods per plant, plant height, number of seeds per pod, pod length and number of pod clusters per plant.

Khan (1988) observed positive correlation of pod length and negative association of pod number per cluster with seed yield, in green gram.

Raut *et al.* (1988) in green gram, reported positive correlation of seed yield with number of seeds per pod, number of branches per plant and clusters per plant.

Singh and Murthy (1988) observed that total nitrogen showed very high positive correlation with total dry weight and nodule fresh weight indicating that selection for total nitrogen may be based on total dry weight or nodule fresh weight. Total nitrogen estimated from the plant showed significant positive correlation with grain yield and harvest index while the correlation of total nitrogen with other components viz. total biomass, days to flower, plant height, number of pods per plant and pod length were non-significant.

Association studies by Patil and Narkhede (1989) in mungbean, revealed that 100 seed weight, pod length, pods per plant and plant height had significant positive correlation with yield.

According to Satyan *et al.* (1989), seed yield in green gram was positively and significantly correlated with plant height, number of branches per plant, number of clusters per plant, number of pods per plant, number of pods per cluster, number of seeds per pod, pod length and days to maturity.

c. Cowpea

Rajendran *et al.* (1979) evaluated nineteen varieties and reported significant positive genotypic correlation of grain yield with height of the plant, number of days to first flowering, numnber of pod clusters per plant, number of primary branches per plant and number of seeds per pod.

Sreekumar *et al.* (1979) recorded significant positive genotypic correlation of grain yield with number of days to blooming, total duration and number of grains per pod.

Singh *et al.* (1982) reported that yield was significantly and positively correlated at the genotypic level with height of the plant, number of pods per plant and number of seeds per pod.

Natarajaratnam *et al.* (1985) estimated phenotypic correlation of yield and yield components in ten varieties and found that grain yield showed positive phenotypic correlation with number of pods per plant, number of pod clusters per plant and height of the plant.

Miller *et al.* (1986) reported a positive and significant correlation between nitrogenase activity, nodule weight and nodule number, in cowpea. However the correlation coefficients between top dry weight and the other three nitrogen fixation variables were reported to be nonsignificant.

Positive and significant correlation of pods per plant, seeds per pod, days to first flowering and days to 50 per cent maturity with seed yield was observed by Sharma *et al.* (1988).

Tyagi and Koranne (1988) also noted positive and significant correlation of yield with number of branches per plant and seeds per pod, in cowpea. Similar results were obtained by Patil *et al.* (1989).

d. Redgram

Veeraswamy *et al.* (1973d) in their studies revealed that grain yield had significant positive genotypic correlations with number of pod clusters per plant, number of branches per plant, height of the plant, number of days to flowering and number of pods per plant.

Joshi (1973) recorded significant positive genotypic correlation of grain yield per plant with number of pods per plant, number of branches per plant and number of seeds per pod.

Veeraswamy *et al.* (1975) reported that plant height, number of branches per plant, number of pod clusters per plant and number of pods per plant exhibited positive genotypic association with seed yield.

Godawat (1980) evaluated twenty six varieties and reported that grain yield per plant had significant and positive genotypic correlation with number of primary branches per plant, number of pods per plant and length of pod.

Bainiwal *et al.* (1981) found non-significant positive genotypic correlation between seed yield and plant height, number of days to flowering and number of days from seedling to maturity.

e. Other pulses

Joshi (1972) in his study on twenty varieties of Bengalgram estimated high positive correlation for the characters viz. number of pods per plant, number of seeds per pod and number of branches per plant with grain yield per plant.

Rupela and Dart (1981) studied in detail about the genetics of nodulation and N fixation in chickpea. They found that the correlation between nodulation parameters and grain yield were statistically significant.

In Soyabean Rashid and Islam (1982) reported high genotypic correlations of seed yield per plant with number of pods per plant and number of branches per plant.

Singh and Ghai (1984) reported a positive association between N fixation with plant height, nodes on the main stem, first pod bearing node, inter node length, grains per plant, total plant weight and grain yield in pea.

Naidu *et al.* (1985) in a field study on eighty four varieties of broad bean noticed that seed yield was significantly and negatively correlated with days to flowering, days to maturity and height of the plant while seed yield was significantly and positively correlated with number of branches per plant, number of clusters per plant, number of pods per plant and number of seeds per pod at the genotypic level.

Das *et al.* (1989) stated that, in soyabean, seed yield was significantly correlated with plant height and number of pods, nodules per plant and seeds per pod.

Amaranatha *et al.* (1990) observed that, in soyabean, seed yield per plant showed significant positive correlation, with number of seeds, pods and branches per plant, 100 seed weight, days to maturity, days to 50 per cent flowering and plant height.

Lokesha and Shivasankar (1990) observed strong association of pod and seed yield, with plant dry weight, number of leaves at 60 days and number of single podded clusters, in cluster bean.

2.3.2 Inter correlation among yield components

a. Blackgram

Singh *et al.* (1975) reported positive genotypic correlation among all combinations of characters such as number of primary branches per plant, height of the plant and number of pod clusters per plant.

Sandhu *et al.* (1978) reported that number of pod clusters per plant, number of pods per plant, length of pod and number of seeds per pod had significant positive genotypic correlations among themselves.

Sandhu *et al.* (1980) observed significant positive genotypic correlation among the characters such as number of pod clusters per plant, number of pods per plant, length of pod and number of seeds per pod.

Muthiah and Sivasubramanian (1981) evaluated fifty varieties and reported positive genotypic correlation among the characters viz. height of the plant, number of branches per plant, number of pod clusters per plant, number of pods per plant, length of pod and number of seeds per pod.

b. Greengram

Singh and Malhotra (1970a) estimated inter relationship between yield components in seventy five varieties and found that number of pods per plant had positive genotypic correlation with number of seeds per pod and number of pod clusters per plant and negative genotypic correlation with length of pod.

Malhotra *et al.* (1974) observed significant genotypic correlation between number of branches per plant, number of pod clusters per plant, number of pods per plant and number of seeds per pod.

Ratnaswamy *et al.* (1978) reported negative genotypic correlation between number of pods per plant and length of the pod.

Upadhaya *et al.* (1980) found significant positive genotypic correlation between number of seeds per pod and number of days to maturity, height of the plant and number of seeds per pod, number of pods per plant and number of branches per plant and between length of pod and number of seeds per pod.

Boomikumaran and Rathinam (1981) observed that characters like plant height, number of branches per plant, number of clusters per plant, number of pods per plant and number of seeds per pod were significantly and positively correlated with each other at the genotypic level.

c. Cowpea

Singh and Mehndiratta (1969) reported high positive genotypic correlation between number of pods per plant and number of pod clusters per plant and between days to flowering and days to maturity. Negative genotypic correlation was reported for length of pod with number of pod clusters per plant and number of pods per plant.

Angadi (1976) reported positive genotypic correlation between number of pod clusters per plant and number of branches per plant; number of seeds per pod and height of the plant; and between number of seeds per pod and length of pod. But the genotypic correlations estimated between number of branches per plant with number of seeds per pod; height of the plant with length of pod; length of pod with number of pod clusters per plant; number of pods per plant with number of seeds per pod and number of pod clusters per plant with number of pods per plant were found to be negative.

Natarajaratnam *et al*. (1985) evaluated ten varieties and reported highly significant positive genotypic correlation between length of pod and number of seeds per pod.

d. Redgram

Joshi (1973) studied inter-correlation among yield components in 100 varieties and reported significant positive genotypic association between number of branches per plant and number of pods per plant and negative genotypic correlation between number of seeds per pod and number of pods per plant.

Veeraswamy *et al*. (1973d) have reported that plant height had significant positive genotypic correlation with number of days to flowering, number of branches per plant, number of pod clusters per plant and number of pods per plant. The number of branches per plant had positive genotypic correlation with number of clusters per plant, number of pods per plant and number of days to flowering.

Number of clusters per plant had positive genotypic correlation with number of days to flowering.

In soyabean Rashid and Islam (1982) have reported high positive genotypic correlation of number of seeds per pod with number of branches per plant and number of pods per plant; height of the plant with number of branches per plant and number of pods per plant, and number of days to maturity with height of the plant and number of pods per plant.

Materials and Methods

MATERIALS AND METHODS

The research programme was carried out at the Department of Agricultural Botany, College of Horticulture, Vellanikkara, Trichur during October-March 1993-'94.

3.1 Materials

Thirty three varieties of Blackgram (*Vigna mungo* (L.) Hepper) collected from the Tamil Nadu Agricultural University, Coimbatore (20 varieties) and Regional Agricultural Research Station, Pattambi (13 varieties), were used for the study. The details of 33 varieties are presented in Table 2.

3.2 Methods

The programme involved a pot culture study and a field experiment. The field experiment was laid out in the Botany Crop Museum, Department of Agricultural Botany, College of Horticulture, Vellanikkara during October-January 1993-'94. Observations on nitrogen fixation traits, such as length of primary root, number of secondary roots, shoot/root ratio and weight of nodules in the secondary roots were collected from the pot culture and used for comparing the data generated from field experiment anticipating the difficulties in getting all the nodules and roots intact while uprooting the plant from the field. The data generated from the field experiment was tabulated, analysed and utilised for the thesis preparation.

Table 2. Particulars of thirty three genotypes of blackgram (*Vigna mungo* L. Hepper) used for the study

Sl.No.	Genotypes	Source
1	LBG-639	TNAU, Coimbatore
2	LBG-622	,,
3	LBG-683	,,
4	Co-5	,,
5	LBG-648	,,
6	LBG-17	,,
7	VB-3	,,
8	LBG-402	,,
9	LBG-623	,,
10	WBG-13	,,
11	WBU-108	,,
12	PUSA-2	,,
13	TAU-12	,,
14	LBG-685	,,
15	TAU-5	,,
16	PANT-4-19	,,
17	T-9	,,
18	WBU-104	,,
19	UL-338	,,
20	UPU-89-67	,,
21	AKU-3	RARS, Pattambi
22	AKU-4	,,
23	CO-BG-10	,,
24	NGG-13	,,
25	LBG-22	,,
26	PDU-17	,,
27	PDU-90-3	,,
28	VB-4	,,
29	CO-BG-305	,,
30	UPU-82-2	,,
31	UPU-85-4	,,
32	UH-82-11	,,
33	UG-218	,,

Plate 1. Experimental plots at fifty per cent flowering stage

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A replicated field experiment was conducted for evaluating the varieties as detailed below.

Design	:	RBD
Entries	:	33
Replication	:	2
Spacing	:	25 x 15 cm
Plot size	:	6 m^2
Season	:	Rabi/summer 1993-'94

From the field experiments biometric observations on nitrogen fixation traits and yield components were collected.

Seed treatment with KAU cultures BG-2 and BG-12 was done to get uniform population of rhizobium in the field. The cultural and management practices were followed as per the package of practices recommendations of the Kerala Agricultural University (KAU, 1989).

Ten observational plants were selected at random from each plot and data on the following characters were recorded from these plants and averaged.

1. Length of primary root

The sample plants were uprooted carefully and length of the primary roots were measured in centimetres at the time of harvest.

2. Number of secondary roots

The sample plants were uprooted carefully at the time of harvest and the number of secondary roots were counted.

3. Shoot/root ratio

The ratio of shoot dry weight to root dry weight was expressed as shoot/root ratio. From each sample plant uprooted at the time of harvest, shoot and root portions were taken separately, sun dried and then oven dried at 60-70°C for 24 hours and their dry weights were recorded and ratio found out.

4. Weight of nodules in the secondary roots

The weight of nodules in the secondary roots were studied at 50 per cent flowering period. The sample plants were uprooted carefully and the root portion cleaned and the nodules were then carefully stripped off. Immediately the weight of the nodules in the ten sample plants were recorded using a monopan electronic balance (sartarius-basic). They are then averaged and the weight of nodules in the secondary roots of a single plant was recorded.

5. Dry weight of plants

From each sample plot, a random sample of ten sample plants were uprooted carefully at the time of harvest and the root portions cleaned. The plants were then sun dried and then oven dried at 60-70°C for 24 hours and the dry weights were recorded.

6. Nitrogen content in the plant at 50 per cent flowering

From each plots, sample plants were randomly selected at 50 per cent flowering period. They were then sun dried and then oven dried at 60-70°C for 24 hours. The dried plants were taken out, crushed into a fine powder and from this, 0.1 g of powder was used for estimating the nitrogen content in the plant at 50 per cent flowering period by Microkjeldahl method.

7. Number of days to 50 per cent flowering

Number of days from the date of sowing to fifty per cent flowering in each plot was observed and recorded.

8. Plant height at maturity

Height of the plants were measured in centimeters from the ground level to the tip of the main stem at the time of harvest and the mean value recorded.

9. Number of pods

Number of pods in each observational plant was counted and averaged.

10. Number of seeds per pod

Single pod from each observational plant was threshed separately and the number of seeds in each pod was counted and the average worked out.

11. Grain yield

The total yield of grains from ten sample plants, was recorded in grams and averaged.

12. Biological yield

The total biological yield from ten sample plants was recorded, averaged and expressed in grams.

13. Harvest index

Harvest index for each observational plant was calculated by using the following formula

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

Total grain yield from each observational plant was recorded as the economic yield and dry weight of all the other plant parts and the grain yield were considered as biological yield.

3.2.1 Statistical techniques

1. Analysis of variance and covariance

Analysis of variance and covariance were done

(i) to test whether there was any significant difference among the varieties, with respect to various traits

(ii) to estimate the variance components and

(iii) to estimate correlation coefficients (Singh and Choudhary, 1979).

The extent of phenotypic variation for any character is the sum of the genetic and environmental effects and can be determined by the methods given by Kempthorne (1957).

$$V_{(P)} = V_{(G)} + 2 \text{ Cov } (G,E)$$

where $V_{(P)} = \sigma^2 p_{(x)}$ = Variance due to phenotype

$V_{(G)} = \sigma^2 g(x)$ = Variance due to genotype

$V_{(E)} = \sigma^2 e(x)$ = Variance due to environment

Cov(G,E) = Covariance between genotype and environment

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

$$V_{(P)} = V(G) + V(E)$$

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

If there are observations on two characters x and y on each individual, the extent of covariance between x and y due to the genotype and environment can be estimated as suggested by Kempthorne (1957) as follows

$$Cov_P(x, y) = Cov_G(x, y) + Cov_E(x, y)$$

$$\text{or} \quad \sigma p(x, y) = \sigma g(x, y) + \sigma e(x, y)$$

where $\sigma p(x, y)$ = Phenotypic covariance between x and y

$\sigma g(x, y)$ = Genotypic covariance between x and y

$\sigma e(x, y)$ = Environmental covariance between x and y

If the experiment is designed in a Randomised Complete Block Design with 'v' treatments and 'r' replications, the estimates of $\sigma^2 p(x)$, $\sigma^2 p(y)$, $\sigma^2 g(x)$, $\sigma^2 g(y)$, $\sigma^2 e(x)$, $\sigma^2 e(y)$, $\sigma p(x,y)$, $\sigma g(x,y)$ and $\sigma e(x,y)$ can be obtained from the analysis of variance/covariance (Table 1).

2. Coefficient of variation

The coefficient of variation is a unitless measurement and is used for comparing the extent of variation between different characters measured in different scales. Phenotypic coefficient of variation (PCV) for character

$$x = \frac{\sigma p(x)}{\bar{x}} \times 100$$

Genotypic coefficient of variation (GCV) for character

$$x = \frac{\sigma g(x)}{\bar{x}} \times 100$$

where $\sigma p(x)$ and $\sigma g(x)$ are the phenotypic and genotypic standard deviation respectively, and $\bar{x}$ is the mean of the character x.

Table 1. Analysis of variance/covariance

Source	df	MSxx	Expectation of MSxx	MSP (x,y)	Expectation of MSP(x,y)	MS (yy)	Expectation MSyy
Block	(r-1)	Bxx		Bx,y		Byy	
Treatment	(v-1)	Vxx	$\sigma^2 e(x) + r\sigma^2 g(x)$	Vx,y	$\sigma^2 e(x,y) + r\sigma g(x,y)$	Vyy	$\sigma^2 e(y) + r\sigma^2 g(y)$
Error	(r-1)(v-1)	Exx	$\sigma^2 e(x)$	Ex,y	$\sigma e(x,y)$	Eyy	$\sigma^2 e(y)$
Total	rv-1	Txx		Tx,y		Tyy	

Hence we have the following estimates

$\sigma^2 g(x) = 1/r(Vxx-Exx)$ $\quad\sigma g(x,y) = 1/r(Vx,y-Ex,y)$ $\quad\sigma^2 e(y) = Eyy$

$\sigma^2 g(y) = 1/r(Vyy-Eyy)$ $\quad\sigma^2 e(x) = Exx$ $\quad\sigma e(x,y) = Ex,y$

3. 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 (1982) as

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

where $\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

4. Genetic advance under selection (GA)

Genetic advance is a measure of the change in the mean phenotypic level of the population produced by selection and depends upon heritability of the character and selection differential.

$$\text{GA as percentage of mean} = \frac{KH^2 \sigma p}{\bar{x}} \times 100$$

where $\bar{x}$ is the mean of the character x and k is the selection differential, which is 2.06 at 5 per cent intensity of selection in large samples (Allard, 1960).

5. Correlations

The phenotypic correlation coefficient between x and y was estimated as

$$rp\,(x,y) = \frac{\sigma p(x,y)}{\sigma p(x)\ \sigma p(y)}$$

where $\sigma p(x,y)$ is the phenotypic covariance between x and y $\sigma p(x)$ is the standard deviation of the character x and $\sigma p(y)$ is the standard deviation of the character y.

The genotypic correlation coefficient between x and y was estimated as

$$rg(x,y) = \frac{\sigma g(x,y)}{\sigma g(x)\ \sigma g(y)}$$

where $\sigma g(x,y)$ is the genotypic covariance between x and y

$\sigma g(x)$ is the standard deviation of the character x, and

$\sigma g(y)$ is the standard deviation of the character y

Critical value of 'r' corresponding to 62 degrees of freedon at 5 per cent and 1 per cent level of significance was used for the test of significance for phenotypic and genotypic correlation coefficients (Fisher and Yates, 1957).

Results

RESULTS

The data collected from the experiments were tabulated, analysed and the results obtained are presented.

4.1 Analysis of variance

Analysis of variance on 13 characters (Table 3) revealed significant treatment effects for all the characters except number of pods, number of seeds per pod and harvest index. The mean values of 13 characters are presented in Table 4.

4.1.1 Variability

The length of primary root ranged between 9.8 to 18.5 cm with a mean value of 12.1 cm. The variety WBG-13 recorded maximum value and the minimum value was recorded by UG-218. None of the varieties were found to be on par with the variety WBG-13.

The number of secondary roots ranged from 5.8 (PDU-17) to 16.8 (UPU-85-4) with a mean value of 10.14. The variety Co-5 was found to be on par with UPU-85-4.

The shoot-root ratio ranged from 4.8 (UPU-89-67) to 68.3 (UH-82-11) with a mean value of 23.6. None of the varieties were found to be on par with the variety UH-82-11.

Table 3. Analysis of variance for thirteen characters in blackgram

Sl. No.	Characters	Mean square			
		Replication	Treatment	Error	F value
1	Length of primary root	0.339	0.163	0.058	2.82**
2	Number of secondary roots	0.772	0.323	0.065	4.97**
3	Shoot/root ratio	1.877	2.820	1.329	2.12*
4	Weight of nodules in the secondary root	0.659	46.219	6.175	7.48**
5	Dry weight of plants	3.725	0.838	0.477	1.76*
6	Nitrogen content in the plant at 50% flowering	0.011	0.619	0.171	3.62**
7	Number of days to 50% flowering	0.015	1.045	0.140	7.46**
8	Plant height at maturity	1.061	0.941	0.288	3.27**
9	Number of pods	9.930	1.169	0.740	1.58
10	Number of seeds per pod	1.952	1.052	0.849	1.24
11	Biological yield	3.715	0.827	0.469	1.76*
12	Harvest index	0.00063	0.0000813	0.0000334	1.45
13	Grain yield	1.590	0.361	0.202	1.78*

* Indicates 'F' values significant at 5% level
** Indicates 'F' values significant at 1% level

Table 4. Mean value of thirteen characters in blackgram

Genotypes	Length of primary root (cm)	No. of secondary roots	Shoot/ root ratio	Weight of nodules in the secondary roots(mg)	Dry weight of plants (g)	N_2 content in the plant at 50% flowering (%)	No. of days to 50% flowering	Plant height (cm)	No. of pods	No. of seeds per pod	Biological yield (g)	Harvest index	Grain yield per plant (g)
LBG-639	10.8	13.3	26.5	54.9	5.5	4.1	38	24.9	9.9	6.3	5.2	0.42	2.2
LBG-622	10.4	9.2	18.7	113.5	6.6	5.4	37	32.2	14.4	6.1	6.3	0.42	2.7
LBG-683	11.5	10.0	25.3	11.2	2.9	5.2	38	26.2	5.2	5.6	2.7	0.42	1.1
Co-5	16.3	16.3	13.4	43.2	7.9	3.6	38	38.1	5.7	6.0	7.3	0.42	3.2
LBG-648	10.4	17.5	20.0	49.2	4.8	4.2	38	38.1	7.7	5.9	4.6	0.42	1.9
LBG-17	12.9	12.3	19.2	14.2	8.7	3.4	38	33.4	11.6	6.2	8.3	0.42	3.5
VB-3	11.9	8.7	23.9	18.8	7.2	4.8	38	24.4	22.0	6.0	6.9	0.42	2.9
LBG-402	12.3	9.1	10.3	53.9	4.1	5.0	38	30.1	5.8	5.8	3.7	0.42	1.6
LBG-623	11.5	8.5	24.7	35.7	1.6	4.8	37	20.9	3.7	4.9	1.5	0.42	0.6
WBG-13	18.5	12.9	17.4	54.6	10.8	4.0	38	47.3	12.7	6.8	10.3	0.42	4.3
WBU-108	15.0	7.2	27.9	18.6	5.6	4.3	38	21.6	11.7	4.9	5.4	0.42	2.3
PUSA-2	10.5	9.0	18.2	26.6	5.7	3.1	38	23.7	15.5	6.1	5.4	0.42	2.3
TAU-12	14.7	9.6	14.6	128.6	2.6	4.8	37	20.7	9.4	5.7	2.5	0.42	1.0
LBG-685	16.4	10.2	10.8	39.2	5.9	4.5	37	37.0	9.0	6.0	5.4	0.42	2.3
TAU-5	10.6	7.0	21.2	84.9	2.3	3.4	38	19.2	9.5	6.0	2.2	0.43	1.0

The weight of nodules in the secondary roots ranged from 11.2 mg (LBG-683) to 700.0 mg (UPU-85-4) with a mean value of 109.0 mg. None of the varieties were on par with UPU-85-4.

Plant dry weight ranged from 1.6 g (LBG-623) to 16.7 g (AKU-4) with an average value of 5.7 g. None of the varieties were found to be on par with the variety having maximum value.

The nitrogen content in the plant at 50 per cent flowering ranged from 3.1 per cent (PUSA-2) to 5.4 per cent (UPU-82-2 and LBG-622) with a mean value of 4.4 per cent. The varieties found to be on par with the maximum value were LBG-683, VB-3, LBG-402, LBG-623, TAU-12, PANT-4-19, UPU-89-67, AKU-3, UPU-85-4 and UG-218.

The number of days to 50 per cent flowering ranged from 36 to 38 days with a mean value of 37.4 days. The varieties found to be on par with the maximum value were LBG-639, LBG-683, Co-5, LBG-648, LBG-17, VB-3, LBG-402, WBG-13, WBU-108, PUSA-2, TAU-5, T-9, UPU-89-67, AKU-3 and NGG-13.

Plant height at maturity ranged from 17.4 cm (UG-218) to 47.3 cm (WBG-13) with an average value of 26.2 cm. None of the varieties were found to be on par with the variety WBG-13.

The number of pods per plant ranged from 3.7 (LBG-623) to 25.4 (T-9) with a mean value of 12.0. None of othe varieties were found to be on par with T-9.

The number of seeds per pod ranged from 3.7 (UPU-89-67) to 6.8 (WBG-13) with a mean value of 5.7. All the varieties except UPU-89-67, PDU-17, LBG-623 and WBU-108 were found to be on par with WBG-13.

The biological yield per plant ranged from 1.3 g (PDU-17) to 16.1 g (AKU-4) with a mean value of 5.5 g. None of the varieties were found to be on par with the variety AKU-4.

Harvest index ranged from 0.42 to 0.44 with a mean value of 0.43. Three varieties viz. AKU-4, UPU-85-4, and UG-218 recorded the maximum harvest index of 0.44.

The grain yield per plant ranged from 0.6 g (PDU-17) to 7.1 g (AKU-4) with a mean value of 2.37 g. None of the varieties were found to be on par with AKU-4.

4.1.2 Genetic parameters

Phenotypic and genotypic variances and coefficients of variation and heritability and genetic advance estimated for 13 traits are presented respectively in Table 5 and Table 6 and graphically presented respectively in Figures 1 and 2.

4.1.2.1 Phenotypic and genotypic coefficients of variatiation

The maximum phenotypic coefficient of variation was recorded by weight of nodules in the secondary root (55.96) followed by grain yield per plant (36.98), biological yield (36.82) and dry weight of plant (36.12). The minimum

Table 5. Phenotypic and genotypic variances and coefficient of variation for thirteen characters

Sl. No.	Characters	Variance		Coefficient of variation	
		Phenotypic	Genotypic	Phenotypic	Genotypic
1	Length of primary root	0.110	0.530	9.59	21.05
2	Number of secondary roots	0.194	0.130	14.08	11.53
3	Shoot/root ratio	2.070	0.746	30.98	18.60
4	Weight of nodules in the secondary root	26.197	20.020	55.96	48.92
5	Dry weight of plants	0.658	0.181	36.12	18.94
6	Nitrogen content in the plant at 50% flowering	0.395	0.224	8.91	5.05
7	No. of days to 50% flowering	0.593	0.453	1.58	1.21
8	Plant height at maturity	0.615	0.377	15.50	12.13
9	Number of pods	0.955	0.215	29.54	14.02
10	Number of seeds/pod	0.950	0.102	16.54	1.77
11	Biological yield	0.648	0.179	36.82	19.35
12	Harvest index	0.000057	0.000024	1.76	1.14
13	Grain yield	0.282	0.080	36.98	19.70

Table 6. Heritability and Genetic advance for thirteen characters

Sl. No.	Characters	Heritability percentage (H^2) (%)	Genetic advance (GA) (%)
1	Length of primary root	48.0	9.0
2	Number of secondary roots	67.0	18.5
3	Shoot/root ratio	36.0	21.8
4	Weight of nodules in the secondary root	76.4	83.4
5	Dry weight of plants	27.5	19.5
6	Nitrogen content in the plant at 50% flowering	56.6	15.8
7	Number of days to 50% flowering	76.3	3.1
8	Plant height at maturity	57.0	17.3
9	Number of pods	22.0	12.7
10	Number of seeds per pod	10.7	3.6
11	Biological yield	27.0	19.5
12	Harvest index	41.0	1.4
13	Grain yield	28.0	20.3

X_1 - Length of primary root

X_2 - Number of secondary roots

X_3 - Shoot/root ratio

X_4 - Weight of nodules in the secondary roots

X_5 - Dry weight of plants

X_6 - Nitrogen content in the plant at 50 per cent flowering

X_7 - Number of days to 50 per cent flowering

X_8 - Plant height at maturity

X_9 - Number of pods

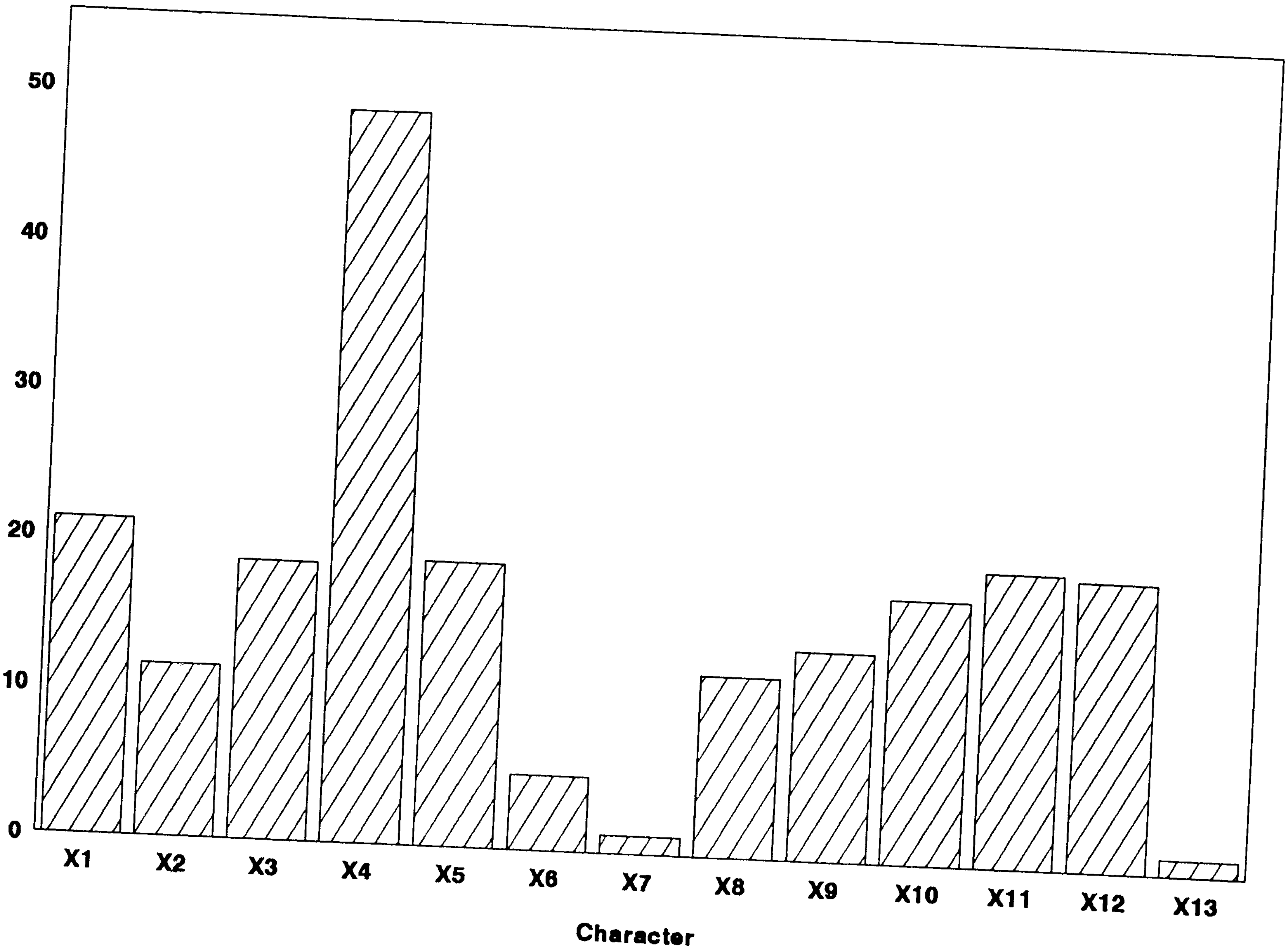
X_{10} - Number of seeds per pod

X_{11} - Biological yield

X_{12} - Harvest index

X_{13} - Grain yield

Fig. 1 Genotypic coefficient of variation for 13 characters



X_1 - Length of primary root

X_2 - Number of secondary roots

X_3 - Shoot/root ratio

X_4 - Weight of nodules in the secondary roots

X_5 - Dry weight of plants

X_6 - Nitrogen content in the plant at 50 per cent flowering

X_7 - Number of days to 50 per cent flowering

X_8 - Plant height at maturity

X_9 - Number of pods

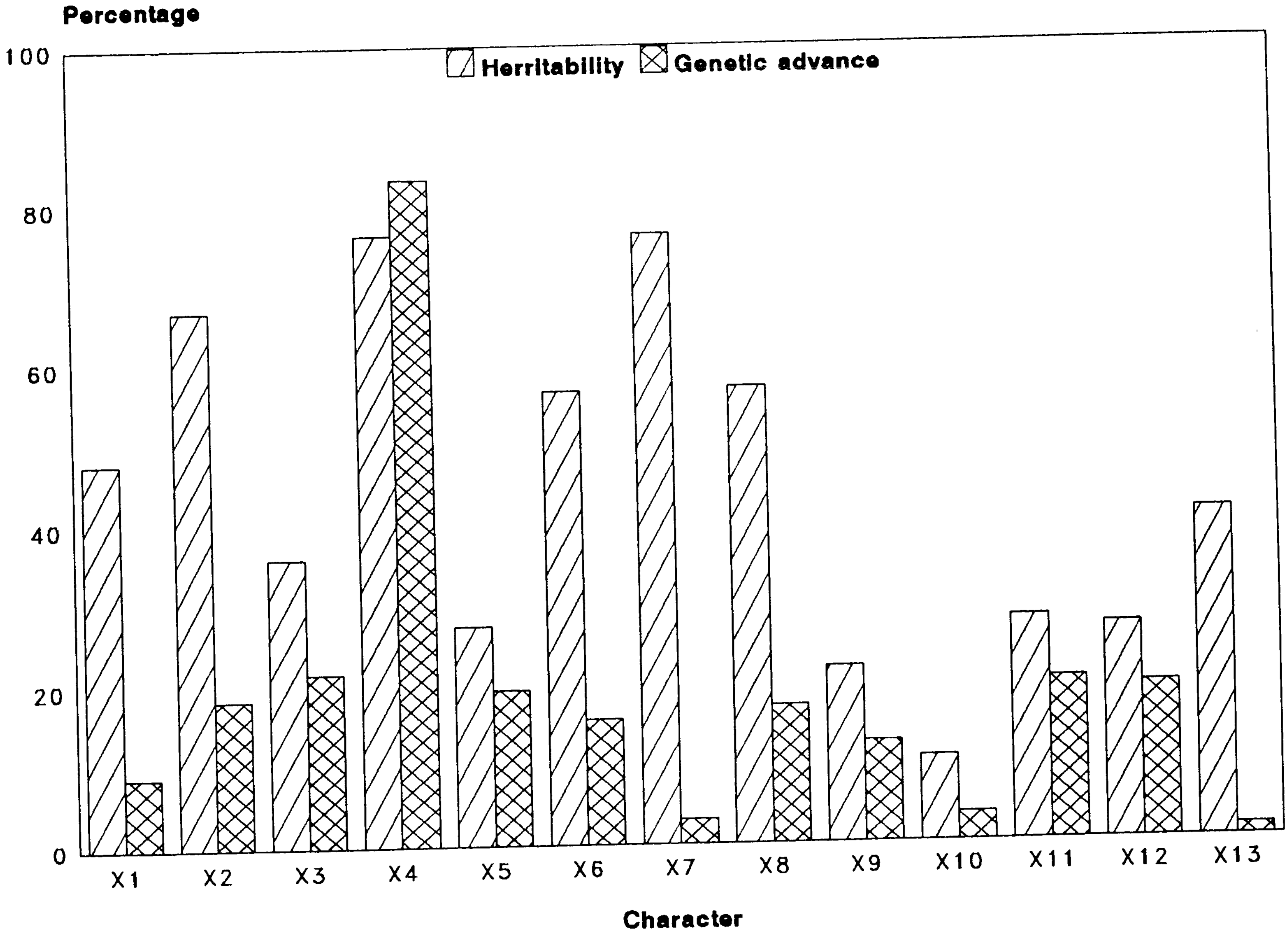
X_{10} - Number of seeds per pod

X_{11} - Biological yield

X_{12} - Harvest index

X_{13} - Grain yield

Fig. 2 Heritability and genetic advance for 13 characters



value was recorded by the character number of days to 50 per cent flowering (1.58) followed by harvest index (1.76).

The genotypic coefficient of variation was maximum in weight of nodules in the secondary root (48.92) followed by length of primary roots (21.05). The minimum value was recorded by Harvest index (1.14) followed by number of days to 50 per cent flowering (1.21).

4.1.2.2 Heritability and genetic advance

High heritability estimates were recorded by number of secondary roots (67.0%), weight of nodules in the secondary root (76.4%) and number of days to fifty per cent flowering (76.3%). Heritability estimates were medium for the characters such as length of primary root (48.0%), shoot-root ratio (36.0%), nitrogen content in the plant at 50 per cent flowering (56.6%), plant height at maturity (57.0%) and harvest index (41.0%). Heritability estimates were comparatively low for plant dry weight (27.5%), number of pods per plant (22.0%), number of seeds per pod (10.7%), grain yield per plant (28.0%) and biological yield per plant (27.0%).

The genetic advance, as percentage of mean was maximum for weight of nodules in the secondary roots (83.4%) and minimum for harvest index (1.41%). Shoot/root ratio (21.8%), plant dry weight (19.5%), grain yield per plant (20.3%) and biological yield (19.5%) recorded comparatively higher values. The characters length of primary root (9.0%), nitrogen content in the plants at 50 per cent flowering (15.8%), number of days to 50 per cent flowering (3.1%), plant height at maturity (17.3%), number of pods per plant (12.7%) and number of seeds per plot (3.6%)

recorded comparatively lower values for genetic advance. Considering traits heritability and genetic advance as percentage of mean, the weight of nodules in the secondary root was the only character having high heritability along with high genetic advance. Shoot/root ratio, recorded moderate heritability alongwith high genetic advance.

4.1.3 Correlations

Phenotypic and genotypic correlations between yield and 12 other characters and their inter-se associations were estimated and presented in Table 7 and graphically represented in Figure 3.

Phenotypic correlation between yield and 12 other characters

Grain yield recorded significant positive phenotypic correlation with all the characters except weight of nodules in the secondary roots, nitrogen content in the plant at 50 per cent flowering and number of days to 50 per cent flowering. The maximum phenotypic correlation with grain yield was recorded by dry weight of plants and biological yield (0.999). Nitrogen content in the plant at 50 per cent flowering (-0.216) had negative non-significant phenotypic correlation with grain yield per plant. Weight of nodules in the secondary roots (0.053) and number of days to 50 per cent flowering (0.070) showed low positive correlation with grain yield per plant.

Inter-se phenotypic correlation between characters

Length of primary root recorded significant positive correlation with

Table 7. Phenotypic and Genotypic correlation coefficients of grain yield and twelve characters in blackgram

		Length of primary root	No. of secondary roots	Shoot/ root ratio	Weight of nodules in the secondary roots	Dry weight of plants	N_2 content in the plant at 50% flowering	No. of days to 50% flowering	Plant height at maturity (cm)	No. of pods	No. of seeds per pod	Biological yield (g)	Harvest index	Grain yield (g)
Length of primary root	P	1.000	0.372*	0.002	-0.063	0.440**	-0.138	0.234	0.519**	0.187	0.147	0.432**	-0.254*	0.422**
	G	1.000	1.411*	-0.383**	-0.172	0.277*	-0.327*	0.409**	0.640**	-0.334*	0.533**	0.253*	-0.639**	0.242*
No. of secondary roots	P		1.000	0.226	0.214	0.392**	-0.116	0.031	0.269*	0.275*	0.355*	0.389**	-0.012	0.385**
	G		1.000	1.195*	0.330*	0.534**	-0.193	0.083	0.446**	0.132	0.738**	0.522**	-0.024	0.505**
Shoot/root ratio	P			1.000	0.442**	0.281*	0.007	-0.385**	-0.129	0.481**	0.212	0.307*	0.185	0.309*
	G			1.000	0.609**	0.199	0.131	-0.500**	-0.515**	0.561**	-0.071	0.243*	0.667**	0.250*
Weight of nodules in the secondary roots	P				1.000	0.027	0.217	-0.551**	-0.257*	0.236	-0.022	0.430	0.437**	0.053
	G				1.000	-0.122	0.281*	-0.769**	-0.475**	0.349*	-0.118	-0.094	0.845**	-0.075
Dry weight of plants	P					1.000	-0.223	0.060	0.689**	0.743**	0.471**	0.999**	0.228	0.999**
	G					1.000	-0.495**	0.124	0.592**	0.347*	0.955**	0.999**	0.339*	0.998**
N_2 content in the plant at 50% flowering	P						1.000	-0.267*	-0.199	-0.083	-0.224	0.221	-0.013	-0.216
	G						1.000	-0.323*	-0.427**	-0.171	-0.646**	-0.487**	0.225	-0.465**
No. of days to 50% flowering	P							1.000	0.359*	-0.074	0.185	0.081	-0.389**	0.070
	G							1.000	0.537**	-0.139	0.672**	0.096	-1.344**	0.071
Plant height at maturity	P								1.000	0.198	0.430**	0.676**	-0.099	0.668**
	G								1.000	-0.386**	1.159**	0.560**	-0.809**	0.542**
No. of pods	P									1.000	0.396**	0.752**	0.281*	0.752**
	G									1.000	0.050	0.383**	0.854**	0.397**
No. of seeds per pod	P										1.000	0.468**	0.003	0.464**
	G										1.000	0.958**	-0.253*	0.916**
Biological yield	P											1.000	0.233	0.999**
	G											1.000	0.378*	0.999**
Harvest index	P												1.000	0.254*
	G												1.000	0.411**
Grain yield	P													1.000
	G													1.000

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

X_1 - Length of primary root

X_2 - Number of secondary roots

X_3 - Shoot/root ratio

X_4 - Weight of nodules in the secondary roots

X_5 - Dry weight of plants

X_6 - Nitrogen content in the plant at 50 per cent flowering

X_7 - Number of days to 50 per cent flowering

X_8 - Plant height at maturity

X_9 - Number of pods

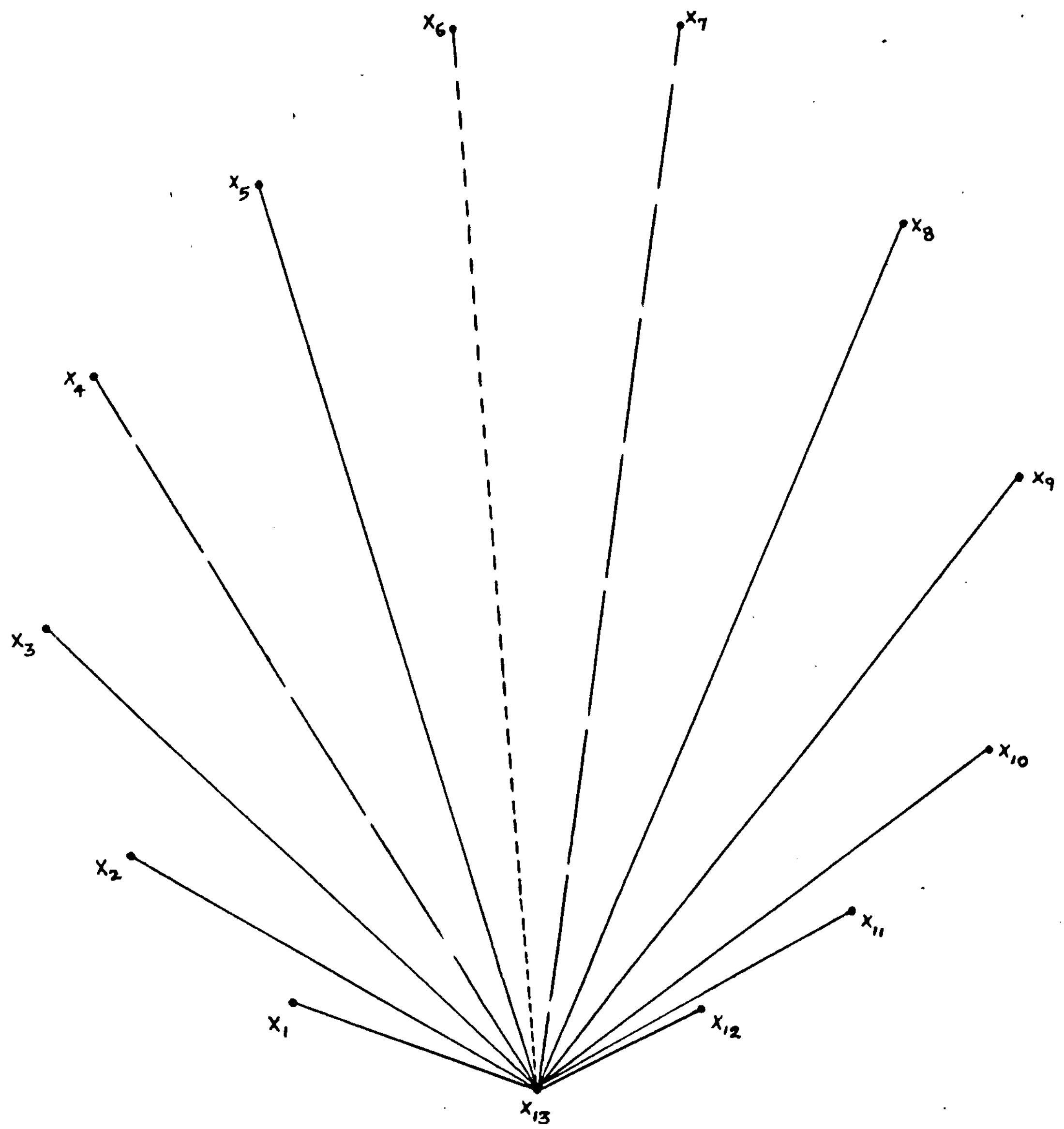
X_{10} - Number of seeds per pod

X_{11} - Biological yield

X_{12} - Harvest index

X_{13} - Grain yield

Fig. 3. Genotypic correlation diagram of yield and twelve other characters in blackgram



—— Significant positive
- - - - Significant negative
— — Non-significant

number of secondary roots (0.372), dry weight of plants (0.440), plant height at maturity (0.519) and biological yield (0.432). The characters such as shoot/root ratio (0.002), number of days to 50 per cent flowering (0.234), number of pods (0.187) and number of seeds per pod (0.147) had positive but non-significant correlations. Weight of nodules in the secondary roots (-0.063) and nitrogen content in the plant at 50 per cent flowering (-0.138) recorded non-significant negative correlation, and harvest index (-0.254) recorded significant negative correlation with length of primary root.

Number of secondary roots recorded significant positive correlation with dry weight of plants (0.392), plant height at maturity (0.269), number of pods (0.275), number of seeds per pod (0.355) and biological yield (0.389); whereas shoot/root ratio (0.226), weight of nodules in the secondary root (0.214), number of days to 50 per cent flowering (0.031) had positive but non-significant correlations. The nitrogen content in the plant at 50 per cent flowering (-0.116) and harvest index (-0.012) had non-significant negative correlation with number of secondary roots.

Shoot-root ratio had significant positive correlation with weight of nodules in the secondary roots (0.442), dry weight of plants (0.392), number of pods (0.481) and biological yield (0.307). The characters nitrogen content in the plant at 50 per cent flowering (0.007), number of seeds per pod (0.212) and harvest index (0.185) recorded positive but non-significant correlations. Number of days to 50 per cent flowering (-0.385) recorded significant negative correlation and plant height at maturity (-0.129) had negative non-significant correlation.

Weight of nodules in the secondary roots recorded significant positive correlation with harvest index (0.437) and non-significant positive correlation with dry weight of plants (0.027), nitrogen content in the plant at 50 per cent flowering (0.217), number of pods (0.236) and biological yield (0.043). This character recorded significant negative correlation with number of days to 50 per cent flowering (-0.551) and plant height at maturity (-0.257), and non-significant negative correlation with number of seeds per pod (-0.022)

Dry weight of plants showed significant positive correlation with plant height (0.689), number of pods (0.743), number of seeds per pod (0.471) and biological yield (0.999), and non-significant positive correlation with number of days to 50 per cent flowering (0.096) and harvest index (0.228). The correlation between this character and nitrogen content in the plant at 50 per cent flowering (-0.223) was non-significant and negative.

Nitrogen content in the plant at 50 per cent flowering showed significant negative correlation with number of days to 50 per cent flowering (-0.267), and non-significant negative correlation with plant height at maturity (-0.199), number of pods (-0.083), number of seeds per pod (-0.224), biological yield (-0.221) and harvest index (-0.013).

Number of days to 50 per cent flowering recorded significant positive correlation with plant height at maturity (0.359), and non-significant positive correlation with number of seeds per pod (0.185) and biological yield (0.081). The correlation between this character and harvest index (-0.389) was significant but negative.

Number of pods (-0.074) showed non-significant negative correlation with number of days to 50 per cent flowering.

Plant height at maturity had significant positive correlation with number of seeds per pod (0.430) and biological yield (0.676), and non-significant positive correlation with number of pods (0.198). The correlation between this character and harvest index (-0.099) was non-significant and negative.

Number of pods showed significant positive correlation with number of seeds per pod (0.396), biological yield (0.752) and harvest index (0.281).

Number of seeds per pod recorded significant positive correlation with biological yield (0.468), and non-significant positive correlation with harvest index (0.003).

Phenotypic correlation between biological yield and harvest index (0.233) was found to be non-significant positive.

Genotypic correlation between yield and 12 other characters

Grain yield recorded significant positive genotypic correlation with all the characters except number of days to 50 per cent flowering, weight of nodules in the secondary roots and nitrogen content in the plant at 50 per cent flowering. The maximum genotypic correlation with grain yield was recorded by biological yield (0.999), followed by dry weight of plants (0.998). Nitrogen content in the plant at 50 per cent flowering (-0.465) had negative significant genotypic correlation with grain yield, and weight of nodules in the secondary root (-0.075) recorded negative non-significant genotypic correlation. Number of days to 50 per cent flowering (0.071) showed low positive correlation with grain yield per plot.

Inter-se genotypic correlation between characters

Length of primary root recorded significant positive correlation with number of secondary roots (0.411), dry weight of plants (0.277), number of days to 50 per cent flowering (0.409), plant height at maturity (0.640), number of seeds per pod (0.533) and biological yield (0.253). Shoot-root ratio (-0.383), nitrogen content in the plant at 50 per cent flowering (-0.327), number of pods (-0.334) and harvest index (-0.639) recorded significant negative correlation, and weight of nodules in the secondary root (-0.172) recorded non-significant negative correlation with length of primary root.

Number of seconday roots recorded significant positive genotypic correlations with shoot-root ratio (1.195), weight of nodules in the secondary root (0.330), dry weight of plants (0.534), plant height at maturity (0.446), number of seeds per pod (0.738) and biological yield (0.522); whereas number of days to 50 per cent flowering (0.083) and number of pods (0.132) had positive but non-significant correlations. Nitrogen content in the plant at 50 per cent flowering (-0.193) and harvest index (-0.024) had non-significant negative correlation with number of secondary roots.

Shoot/root ratio had significant positive correlations with weight of nodules in the secondary root (0.609), number of pods (0.561), biological yield (0.243) and harvest index (0.667). The characters dry weight of plants (0.199) and nitrogen content in the plant at 50 per cent flowering (0.131) recorded positive but non-significant correlations. Number of days to 50 per cent flowering (-0.500) and plant height at maturity (-0.515) recorded significant negative correlations, and number of seeds per pod (-0.071) had negative non-significant correlation.

Weight of nodules in the secondary roots recorded significant positive correlation with nitrogen content in the plant at 50 per cent flowering (0.281), number of pods (0.349) and harvest index (0.845). This character recorded significant negative correlation with number of days to 50 per cent flowering (-0.769) and plant height at maturity (-0.475), and non-significant negative correlation with dry weight of plants (-0.122), number of seeds per pod (-0.118) and biological yield (-0.094).

Dry weight of plants showed significant positive correlation with plant height at maturity (0.592), number of pods (0.347), number of seeds per pod (0.955), biological yield (0.999) and harvest index (0.339), and non-significant positive correlation with number of days to 50 per cent flowering (0.124). The correlation between this character and nitrogen content in the plant at 50 per cent flowering (-0.495) was significant and negative.

Nitrogen content in the plant at 50 per cent flowering showed significant negative correlation with number of days to 50 per cent flowering (-0.323), plant height at maturity (-0.427), number of seeds per pod (-0.646) and biological yield (-0.487); and non-significant negative correlation with number of pods (-0.171). The correlation between this character and harvest index (0.225) was non-significant and positive.

Number of days to 50 per cent flowering recorded significant positive correlation with plant height at maturity (0.537) and number of seeds per pod (0.672), and non-significant positive correlation with biological yield (0.096). The correlation between this character and harvest index (-1.344) was significant but negative. Number of pods (-0.139) showed non-significant negative genotypic correlation.

Plant height at maturity had significant positive correlation with number of seeds per pod (1.159) and biological yield (0.560). The correlation between this character with number of pods (-0.386) and harvest index (-0.809) was significant but negative.

Number of pods showed significant positive correlation with biological yield (0.383) and harvest index (0.854), and non-significant positive correlation with number of seeds per pod (0.050).

Number of seeds per pod showed significant positive correlation with biological yield (0.958), and significant negative correlation with harvest index (-0.253).

Biological yield recorded significant positive correlation with harvest index (0.378).

Discussion

DISCUSSION

The choice of the most suitable breeding method for the improvement of yield and its components in any crop largely depends on the available genetic variability, heritability, genetic advance under selection and association between characters. Selection is the fundamental process in the development of superior varieties, and it depends on the variability available in the crop. Selection based on yield alone is not very efficient, but based on its components as well could be more efficient (Evans, 1978).

This research project in blackgram was programmed mainly to estimate the genetic variability and correlation for biological nitrogen fixation traits and yield components, as a preliminary step for breeding varieties of blackgram with improved nitrogen fixation capacity and high yield potential.

The results obtained in this study are discussed below:

5.1 Variability

The natural variability for yield and its components and a knowledge of the extent of the genetic variation available for yield and its components is always useful to the breeder for crop improvement through selection. The naturally occuring variation in population of self-pollinated species is the primary basis for improvement of these species (Allard, 1960).

The narrow difference between the phenotypic and genotypic variance was observed for the characters number of secondary roots, weight of nodules in the secondary root, nitrogen content in the plant at fifty per cent flowering, number of days to fifty per cent flowering and harvest index. The narrow difference between the genotypic and phenotypic variances indicates that the variation observed in those characters was mainly due to genetic causes and the environment had only very little influence in the expression of the above characters. The wider difference between the phenotypic and genotypic variances recorded for the characters height of the plants, number of pods per plant and grain yield per plant was in consonance with the results of Philip (1987) and Abraham *et al.* (1992) in blackgram. Philip (1987) and Abraham *et al.* (1992) reported narrow difference between the phenotypic and genotypic variance for the character number of seeds per pod, which is contrary to the present study.

The range of genetic diversity for quantitative characters in a population can be compared and assessed reliably by genotypic coefficient of variation. The phenotypic coefficient of variation measures the extent of total variability. In the present study high values of genotypic coefficients of variation were recorded for weight of nodules in the secondary roots, grain yield and biological yield indicating the presence of high amount of genetic variability for the above characters and the scope for their improvement through selection. A high genotypic coefficient of variation for grain yield had earlier been reported by Soundarapandian *et al.* (1975), Goud *et al.* (1977) and Sandhu *et al.* (1978) in blackgram and Ilhamuddin *et al.*

(1989) in green gram. Contrary to the present study, Singh *et al.* (1975) in blackgram and Rathnaswamy *et al.* (1978) in green gram reported low values for genotypic coefficient of variation.

Comparatively high values of phenotypic coefficient of variation with correspondingly low values of genotypic coefficient of variation were recorded for the characters, viz., number of pods per plant and number of seeds per pod, in accordance with the finding of Pillai (1980), Philip (1987) and Abraham *et al.* (1992) in blackgram. The wide difference between phenotypic and genotypic coefficients of variation observed for the above characters reveals the higher influence of the environment in the expression of these characters. Contrary results have been reported for number of pods per plant in blackgram by Sandhu *et al.* (1978); in green gram by Singh and Malhotra (1970b) and Paramasivan and Rajasekharan (1980) and in cowpea by Radhakrishnan and Jebaraj (1982) and Patil and Baviskar (1987). High genotypic coefficient of variation for harvest index reported by Dharmalingam and Kadambavanasundaram (1984) in cowpea was contrary to the results of this study.

The characters such as nitrogen content in the plant at 50 per cent flowering, number of days to 50 per cent flowering and harvest index, had comparatively low phenotypic and genotypic coefficients of variation, indicating the low amount of variability in these characters and thereby limiting the scope for their improvement by selection. Low genotypic coefficient of variation observed for the characters such as number of days to 50 per cent flowering, number of seeds per pod and harvest index, was in agreement with the results of Philip (1987), Abraham *et al.* (1992) in blackgram. The low genotypic coefficient of variation observed for number of days to 50 per cent flowering was in agreement with the results of Pillai (1980) in blackgram, Sreekumar and Abraham (1979) in greem gram and Sreekumar *et al.* (1979) in cowpea, but contrary to the reports of Sandhu *et al.* (1978) in blackgram. To support this study, high genotypic coefficient of variation for height of the plant in blackgram was reported by Singh *et al.* (1975), Soundarapandian *et al.* (1975) and Patel and Shah (1982).

Low genotypic coefficient of variation recorded in this study for number of seeds per pod was in conformity with the observations of Soundarapandian *et al.* (1975), Goud *et al.* (1977), Sandhu *et al.* (1978), Pillai (1980) and Abraham *et al.* (1992) in black gram. Contrary to the present findings, Patel and Shah (1982) in blackgram and Veeraswamy *et al.* (1973b) in cowpea reported high genotypic coefficient of variation for number of seeds per pod.

5.2 Heritability and genetic advance

The heritable portion of the variation cannot be estimated with the help of genotypic coefficient of variation alone. Burton (1952) had suggested that genotypic coefficient of variation together with heritability estimates would give a better idea regarding the amount of genetic advance to be expected by selection. Selection acts on genetic differences and gains from selection for a particular character depends largely on the heritability of the character (Allard, 1960).

The characters in the order of high heritability were weight of nodules in the secondary roots, number of days to 50 per cent flowering, number of secondary roots, plant height at maturity and nitrogen content in the plant at 50 per cent flowering. The high values of heritability estimates reveal the highly heritable nature and the minimum influence of the environment in the expression of these characters. The high heritability estimates recorded for number of days to 50 per cent flowering was in consonance with the reports of Sandhu *et al.* (1978), Patel and Shah (1982) and Abraham *et al.* (1992) in black gram; Sreekumar and Abraham (1979) and Patil *et al.* (1987) in green gram; Swapna (1993) in horse gram; Sreekumar *et al.* (1979), Apte *et al.* (1987) and Roquib and Patnaik (1990) in cowpea. High heritability reported for weight of nodules in the secondary roots and nitrogen content in the plant in Crimson clover by Smith *et al.* (1982) was in consonance with the present results. High heritability estimate for plant height reported by Singh *et al.* (1975); Soundarapandian *et al.* (1975); Goud *et al.* (1977); Sandhu *et al.* (1978); Patel and Shah (1982) and Patil and Narkhede (1987), in blackgram were in accordance with the present results, but contrary to the findings of Abraham *et al.* (1992) in blackgram.

Moderate heritability estimates were recorded for length of primary root, shoot/root ratio and harvest index. However, high heritability estimates reported by Dharmalingam and Kadambavanasundaram (1984) in cowpea, for harvest index, was contrary to the present findings.

Low heritability estimates were recorded for the characters such as dry weight of plants, number of pods, number of seeds per pod, grain yield and biological yield. The low heritability estimates recorded for the characters number of pods per plant and grain yield per plant was in perfect agreement with the results of

Sandhu *et al.* (1978) and Pillai (1980) in blackgram. Low heritability estimates observed in the study for the grain yield per plant agrees with the results Abraham *et al.* (1992) in blackgram, but contrary to the results of Soundarapandian *et al.* (1975) and Patel and Shah (1982) in blackgram.

Eventhough heritability estimates are useful in the selection of superior genotypes on the basis of phenotypic performance of the characters, it does not give a clear picture on the extent of improvement that can be achieved. Hence Johnson *et al.* (1955) have suggested that along with the heritability estimates, the genetic advance should also be considered for identifying characters during selection programmes. In the present study, comparatively high heritability estimates along with high genetic advance was recorded for the characters - weight of nodules in the secondary roots and number of secondary roots. According to Panse (1957), the characters with high heritability and high genetic advance were controlled by additive gene action and therefore amenable to genetic improvement through selection. Therefore, the above characters may be considered during selection programme for the improvement of the crop. The higher heritability estimates and high genetic advance obtained in this study for weight of nodules in the secondary roots was in confirmity with the findings of Hardarson and Jones (1979) in white clover and Smith *et al.* (1982) in Crimson clover.

High heritability with low genetic advance recorded for the characters number of days to 50 per cent flowering by Pillai (1980) in blackgram; Singh and Malhotra (1970b), Veeraswamy *et al.* (1973c) and Sreekumar and Abraham (1979) in green gram were in conformity with the present findings, but was contrary to the results of Sandhu *et al.* (1978), Patel and Shah (1982) and Abraham *et al.* (1992) in blackgram. High heritability along with high genetic advance reported for number of days to 50 per cent flowering by Singh and Mehndiratta (1969) and Rejendran *et al.* (1979) in cowpea also disagree with the results observed in this study.

Low heritability with low genetic advance were recorded for number of pods per plant and number of seeds per pod. Pillai (1980), Patel and Shah (1982) and Abraham *et al.* (1992) in blackgram; Paramasivan and Rajasekharan (1980) in green gram and Apte *et al.* (1987) in cowpea have also reported low heritability and genetic advance for number of pods per plant, in agreement with the present findings. Low heritability and low genetic advance recorded for number of seeds per pod was in accordance with the findings of Joshi (1973) in red gram; but contrary to the reports of Thiagarajan *et al.* (1989) in cowpea.

Based on the result of the genotypic coefficient of variation, heritability and genetic advance it can be concluded that selection based on the weight of nodules in the secondary roots will be very effective for the improvement of nitrogen fixation in blackgram.

5.3 Correlation

When the breeder applies selection pressure for a trait, the population under selection is not only improved for that trait, but is also improved in respect of other characters associated with it. Correlations provide information on the nature and extent of relationship between characters in a population, thus facilitating effective selection and simultaneous improvement of two or more characters. Therefore, In the present study, the number of days to 50 per cent flowering exhibited a positive genotypic correlation with grain yield per plant. A negative correlation between grain yield per plant and number of days to 50 per cent flowering was reported by Sandhu *et al.* (1978); Sandhu *et al.* (1980) and Abraham *et al.* (1992) in blackgram and Uprety *et al.* (1979) in cowpea, in contrary to the present study; but, reports of positive genotypic correlation between number of days to 50 per cent flowering and grain yield were reported by Pillai (1980) in blackgram; Malhotra *et al.* (1974) in green gram and Rajendran *et al.* (1979) in cowpea; Amaranatha *et al.*. (1990) in soyabean, in accordance with the results of the present study.

Nitrogen content in the plant at 50 per cent flowering, exhibited a significant negative correlation with grain yield per plant in the present study indicating that simultaneous improvement of nitrogen content in the plant and yield is very difficult by selection. Contrary to this, positive significant correlation between grain yield and nitrogen content was reported by Rupela and Dart (1981) in chickpea; Singh and Ghai (1984) in pea and Das *et al.* (1980) in soyabean.

5.3.2 Inter-se correlation between characters

Length of primary root recorded high positive genotypic correlation with number of secondary roots, dry weight of plants, number of days to 50 per cent flowering, plant height at maturity, number of seeds per pod and biological yield. The characters such as shoot/root ratio, nitrogen content in the plant at 50 per cent flowering, number of pods and harvest index recorded negative genotypic correlation with length of primary root. From these associations it can be inferred that as the length of primary root increases plant height, biological yield and number of seeds per pod increases with a decrease in nitrogen content and harvest index.

Positive genotypic correlation existed between number of secondary roots and shoot/root ratio, weight of nodules in the secondary roots, dry weight of plants, plant height at maturity, number of seeds per pod and biological yield; and non-significant negative genotypic correlation with nitrogen content in the plant and harvest index. This indicates that characters such as weight of nodules in the secondary roots, biological yield and number of seeds per pod increase with an increase in the number of secondary roots. Positive genotypic correlations were recorded between weight of nodules in the secondary roots and nitrogen content, number of pods and harvest index.

Number of days to 50 per cent flowering had high positive genotypic correlation with plant height at maturity and number of seeds per pod. The positive genotypic correlation of number of days to 50 per cent flowering, with height of the plants recorded in this study was in perfect agreement with the results of Pillai (1980) and Abraham *et al.* (1992) in blackgram. The positive genotypic correlation between this character and number of seeds per pod, observed in this study was contrary to the results of Abraham *et al.* (1992) in blackgram. Harvest index recorded negative genotypic correlation with number of days to 50 per cent flowering. Similar results of negative genotypic association between number of days to 50 per cent flowering and harvest index in blackgram was reported by Abraham *et al.* (1992).

Height of the plant exhibited positive genotypic correlation with number of seeds per pod and biological yield; while this character had negative genotypic correlation with number of pods and harvest index. However, positive genotypic correlation between height of the plant and harvest index; and negative genotypic correlation between height of the plant and number of seeds per pod, reported in blackgram by Abraham *et al.* (1992) were contrary to the results of this study.

Number of pods per plant recorded positive genotypic correlation with biological yield and harvest index. Uprety *et al.* (1979) in cowpea; and Abraham *et al.* (1992) in blackgram, reported positive genotypic correlation of number of pods per plant with biological yield and harvest index, in conformity to the present results.

The observations in this study revealed that most of the yield components such as number of pods per plant and number of grains per pod, possess low variability, heritability and genetic advance. However these components had a high degree of positive genotypic correlation with grain yield per plant indicating that selection based on one or more of the above components may result in the improvement of grain yield. Biological yield also had the maximum positive genotypic correlation with grain yield. Weight of nodules in the secondary roots, which had high variability, heritability, genetic advance, and genotypic correlations with nitrogen content at 50 per cent flowering and harvest index may be considered during selection programmes for identifying blackgram genotype having high nitrogen fixation capacity.

Summary

SUMMARY

The research programme was carried out at the Department of Agricultural Botany, College of Horticulture, Vellanikkara, Trichur during October-March 1993-94. This study aims to assess the genetic variability for biological nitrogen fixation traits and yield components in blackgram as a preliminary step to develop high yielding varieties with good biological nitrogen fixation capacity.

Thirty three varieties of blackgram were evaluated, adopting a randomised block design with two replications. Data on the following characters viz., length of primary root, number of secondary roots, shoot/root ratio, weight of nodules in the secondary roots, dry weight of plants, nitrogen content in the plant at 50 per cent flowering, number of days to 50 per cent flowering, plant height at maturity, number of pods, number of seeds per pod, biological yield, harvest index and grain yield were collected.

The data were subjected to analysis of variance and covariance. Genotypic and phenotypic coefficients of variation (GCV and PCV respectively), heritability (H^2), genetic advance (GA) and genotypic and phenotypic correlations were estimated.

The summary of salient results obtained in this study are the following:

Analysis of variance for thirteen characters revealed significant differences among the varieties for the characters viz., length of primary root, number of

secondary roots, shoot/root ratio, weight of nodules in the secondary roots, dry weight of plants, nitrogen content in the plant at 50 per cent flowering, number of days to 50 per cent flowering, plant height at maturity, biological yield and grain yield, indicating the presence of high variability for the thirty three varieties utilised in this study.

High genotypic and phenotypic coefficients of variation were observed for the characters such as weight of nodules in the secondary roots, grain yield and biological yield indicating the presence of high amount of genetic variability for the above characters and the scope for their improvement, through selection.

High heritability estimates were recorded for weight of nodules in the secondary roots followed by number of days to 50 per cent flowering and number of secondary roots, revealing the lesser influence of the environment in the expression of these characters.

Genetic advance as percentage of mean was higher for weight of nodules in the secondary roots followed by shoot/root ratio, grain yield, biological yield, dry weight of plants and number of secondary roots.

High heritability coupled with high genetic advance was recorded for weight of nodules in the secondary roots and number of secondary roots suggesting the reliability of these characters during selection programmes for the improvement of the nitrogen content of the plant.

Correlation analysis of grain yield per plant and twelve characters indicated that the characters viz., length of primary root, number of secondary roots, shoot/root ratio, dry weight of plants, plant height at maturity, number of pods, number of seeds per pod, biological yield and harvest index recorded high positive genotypic correlation with grain yield. Biological yield had the maximum positive genotypic correlation with grain yield per plant. Grain yield recorded a negative genotypic correlation with nitrogen content in the plant at 50 per cent flowering indicating that simultaneous improvement of yield and nitrogen content in the plant is very difficult through selection.

High positive genotypic correlation of number of pods per plant and number of seeds per pod with grain yield per plant, indicates that selection based on one or more of the above components may result in the improvement of grain yield. Weight of nodules in the secondary roots, which had high variability, heritability, genetic advance and genotypic correlations with nitrogen content in the plant at 50 per cent flowering and harvest index, may be considered during selection programmes for identifying blackgram genotypes having high nitrogen fixation capacity.

References

REFERENCES

Abraham, S.T., Sreekumar, S.G., Saraswathy, P., Nair, V.G. and Nair, P.M. 1992a. Variability in Blackgram under partially shaded conditions. *Agric. Res. J. Kerala*, 30:71-74

Abraham, S.T., Sreekumar, S.G., Saraswathy, P., Nair, V.G. and Nair, P.M. 1992b. Correlation studies in Blackgram under partially shaded conditions. *Agric. Res. J. Kerala*, 30:122-125

Alexander, M. 1977. Introduction to Soil Microbiology (second edition). John Wiley & Sons, New York.

Allard, R.W. 1960. *Principles of Plant Breeding*. John Wiley and Sons, Inc., New York. pp.485

Amarnatha, K.C.N., Viswanatha, S.R. and Chanakeshava, B.C. 1990. Phenotypic and genotypic correlation coefficients of some quantitative characters in soyabean (Glycine max. L. Merrill.). *Mysore J. agric. Sci.* 24:445-449

Angadi, S.P. 1976. Correlation studies and D^2 analysis in cowpea [*Vigna sinensis* (L.) Savi]. *Madras agric. J.* 60 1359-1360

Apte, U.B., Chavan, S.A. and Jadhav, B.B. 1987. Genetic variability and heritability in cowpea. *Indian J. Agric. Sci.*, 57:596-598

Bainiwal, C.R., Malhotra, N. and Jatasara, D.S. 1981. Studies on variability and correlation of pigeon pea. *Indian J. Agric. Res.*, 15:161-165

Barnes, D.K., Heichel, G.H., Vance, C.P. and Ellis, W.R. 1984. A multiple trait breeding programme for improving the symbiosis for N_2 fixation between *Medicago sativa* and *Rhizobium meliloti*. Plant and Soil 82:303-314

Boomikumaran, P. and Rathinam, M. 1981. Correlation and path analysis in greengram. *Madras Agric. J.*, 68:643-647

* Burton, G.W. 1952. Quantitative inheritance in grasses. *Proc. 6th Int. Grassland Congr.* 1:277-283

Chandrababu, R., Sadasivam, R., Natarajaratnam, N. and Sreerangaswamy, S.R. 1985. Photosynthesis in relation to yield potential in blackgram. *Madras agric. J.*, 72:152-155

* Das, M.L., Rahman, A. and Miah, A.J. 1989. Correlation, path-coefficient and regression studies in soyabean *Bangladesh J. agric. Res.* 14(1):27-29

Dharmalingam, V. and Kadambavanasundaram, M. 1984. Genetic variability in cowpea. *Madras agric. J.*, 71:640-643

Econ. Rev. 1990. *Economic Review*. State Planning Board Thiruvananthapuram, pp.25-27

Evans, L.T. 1978. *Crop Physiology*. Cambridge University Press, Cambridge, London. pp.355

Fisher, R.A. and Yates, F. 1957. *Statistical tables - For biological, agricultural and medicinal research*. Oliver and Boyd, London. pp.59

Ganeshiah, K.N. 1980. Multivariate analysis for yield and its contributing characters in horsegram (*Dolichos biflorus* L.). *Mysore J. agric. Sci.* 14:125

Godawat, S.L. 1980. Genetic parameters, correlation coefficients and path coefficient analysis in pigeon pea [*Cajanus cajan* (L.) Millsp.]. *Madras agric. J.*, 67:14-18

* Goud, J.V., Viraktamath, B.C. and Laxmi, P.V. 1977. Variability and correlation studies in blackgram. *Mysore J. agric. Sci.*, 11:322-325

Hardarson, G. and Jones, D.G. 1979. The inheritance of preference for strains of *Rhizobium trifolii* by white clover (*Trifolium repens*). *Ann. Appl. Biol.* 92:329-333

* Ilhamuddin, Tajammal, M.A. and Ihayatullah, 1989. Genotypic and phenotypic variability in yield and other quantitative characters in mungbean (*Vigna radiata* L.). *Sarhad J. Agric.* 5(1):69-71

Jain, J.P. 1982. *Statistical techniques in Quantitative Genetics.* Tata Mc Graw-Hill Co., New Delhi. pp.281

Johnson, H.W., Robinson, H.F and Comstock, R.E. 1955. Estimation of genetic and environmental variability in soyabean. *Agron. J.*, 47:314-318

Joshi, S.N. 1972. Variability and association of some yield components in gram (*Cicer arietinum* L.). *Indian J. Agric. Sci.*, 42:397-399

Joshi, S.N. 1973. Variability and correlation studies in pigeon pea. *Madras agric J.*, 60:412-414

KAU. 1989. *Package of Practices Recommendations.* Directorate of Extension Education, Kerala Agricultural University, Thrissur, pp.110

Kempthorne, O. 1957. An introduction to Genetic Statistics. John Wiley and Sons, Inc., London, Chapman and Hall Ltd. pp.514

Khan, I.A. 1988. Path coefficient analysis of yield attributes in mungbean (*Vigna radiata* L.). *Legume Res.* 11:41-43

Lakshmiah, K., Babu, P.R., Reddy, D.L. and Babu, A.M. 1989. Heritability and correlation studies in blackgram [*Vigna mungo* (L.) Hepper]. *J. Res. APAU*, 17(1):49-52

Lokesha, R. and Shivasankar, G. 1990. Analysis of genetic variability and character association in cluster bean. *Mysore J. agric. Sci.* 24:316-320

Malhotra, V.V., Singh, S. and Singh, K.B. 1974. Yield components in greengram. *Indian J. Agric. Sci.*, 44:136-141

Miller, J.C., Zary, K.W. and Fernandez, G.C.J. 1986. Inheritance of N_2 fixation efficiency in cowpea. *Euphytica.* 35:551-560

Muthiah, D.R. and Sivasubramanian, V. 1981. Genotypic correlations and path coefficient analysis in blackgram. *Madras agric. J.*, **68**:105-109

Naidu, M.R., Chabra, A., Singh, S. and Singh, V.P. 1985. Analysis of yield components in broad bean. *Indian J. Agric. Sci.*, **55**:236-239

Nair, K.S. 1970. Effect of seed inoculation with rhizobium on yield and nitrogen content of green manure crop. *Madras agric. J.*, **57**:213-216

* Nakaseko, K. 1984. Studies on dry matter production, plant type and productivity in grain legumes. *Memoirs of the Faculty of Agriculture, Hokkaido University*, **14**:103-158

Nambiar, P.T.C., Rupela, O.P. and Rao, J.V.D.K. 1988. Nodulation and nitrogen fixation in groundnut, chickpea and pigeonpea. In: *Biological Nitrogen Fixation, recent developments*. Subba Rao, N.S. (Ed.). Oxford and IBH Publishing Co., New Delhi. pp.21-52

Natarajaratnam, N., Venkateswara Rao, T. and Balakrishnan, K. 1985. Path analysis of yield components in cowpea [*Vigna unguiculata* (L.) Walp.]. *Madras agric. J.*, **72**:259-262

Panse, V.G. 1957. Genetics of quantitative characters in relation to plant breeding. *Indian J. Genet*. **17**:318-328

Paramasivan, J. and Rajasekharan, S. 1980. Genetic variability in greengram [*Vigna radiata* (L.) Wilczek.]. *Madras agric. J.*, **67**:421-424

Patel, S.T. and Shah, R.M. 1982. Genetic parameters, associations and path analysis in blackgram [*Vigna mungo* (L.) Hepper]. *Madras agric. J.*, **69**:535-539

* Patil, H.S., Deshmukh, R.B., Deokar, A.B. 1987. Variability studies in some quantitative characters in mungbean. *J. Res. Maharashtra Agric. Univ.*, 12:132

Patil, H.S. and Narkhede, B.N. 1987. Variability and association and path analysis in blackgram. *J. Maharashtra Agric. Univ.*, 12:289-292

Patil, H.S. and Narkhede, B.N. 1989. Association and path analysis of yield attributes in mungbean. *J. Maharashtra Agric. Univ.*, **14**:240-241

* Patil, R.B. and Baviskar, A.P. 1987. Variability studies in cowpea. *J. Res. Maharashtra Agric. Univ.*, **12**:63-66

Patil, S.J., Venugopal, R., Goud, J.V. and Parameswarappa, R. 1989. Correlation and path analyais in cowpea. *Karnataka J. agric. Sci.* 2:170-175

Patil, V.J. and Deshmukh, R.D. 1982. Genetic variability in horsegram. *J. Maharashtra Agric. Univ.* **7**:139-140

Philip, G. 1987. Model for selecting blackgram (*Phaseolus mungo* Roxb.) varieties for yield and adaptability under partial shade. M.Sc.(Ag) Thesis, Kerala Agricultural University.

* Pillai, K.S. 1980. Quantitative genetic study of yield and its components in blackgram. Ph.D. Thesis, Kerala Agricultural University.

Prasannakumari, K.T. and George, M.K 1982. Correlation and path analysis in greem gram. *Agric. Res. J. Kerala*. **20**:82-85

Radhakrishnan, T. and Jebaraj, S. 1982. Genetic variability in cowpea (*Vigna unguiculata* Walp.). *Madras agric. J.*, **69**:216-219

Rajendran, R., Biswas, S.R., Ramachander, R., Satyanarayana, A., Anand, N. and Srinivasan, K. 1979. Genetic improvement of cowpea [*Vigna unguiculata* (L.) Walp.] seed yield. *Agric. Res. J. Kerala*. **17**:60-66

Ramachandran, C., Peter, K.V. and Gopalakrishnan, P.K. 1980. Variability in selected varieties of cowpea (*Vigna unguiculata* Walp.). *Agric. Res. J. Kerala*. 18:94-97

Ramaswami, P.P. and Oblisami, G. 1984. Influence of duration of blackgram on the harvest index among the different genotypes. *Madras agric. J.* 71(4):246-248

Rashid, M.H. and Islam, M.A. 1982. Coefficient of genetic variability, heritability and correlation of agronomic characters in soybean. *Madras agric. J.*, 69:479-481

Rathnaswamy, R., Krishnaswamy, S., Iyemperumal, S. and Marappan, P.V. 1978. Estimates of variability, correlation coefficients and path coefficient analysis in early maturing greengram [*Vigna radiata* (L.) Wilczek.]. *Madras agric. J.*, **65**:188-190

Rathnaswamy, R., Shanmugam, A.S. and Sree Rangaswamy, S.R. 1986. Variability for nodulating ability in greem gram genotypes under field conditions. *Madras agric. J.* **73**(9):481-484

Rathnaswamy, R., Veeraswamy, R., Regupathy, A. and Palaniswamy, G.A. 1973. Studies on genetic variability of certain quantitative characters in red gram [*Cajanus cajan* (L.) Millsp.]. *Madras agric. J.* **60**:204-206

Raut, S.K., Chaudhari, M.S. and Khorgade, P.W. 1988. Character association and path analysis in green gram (*Vigna radiata*). *Ann. Pl. Physiol.* 2:37-42

* Roquib, M.A. and Patnaik, R.K. 1990. Genetic variability in grain yield and its components in cowpea (*Vigna unguiculata*). *Env. Ecol.* **8**(1A):197-200

Rupela, O.P. and Dart, P.J. 1981. Screening for nodulation characteristics in chick pea and subsequent generation of seeds. In: *Biological Nitrogen Fixation Technology for Tropical Agriculture*. (Eds.) Graham, P.H. and Harris, S.C., CIAT, CALI, Columbia, pp.51-61

Sagar, P., Chandra, S. and Arora, N.D. 1976. Analysis of diversity in some urd bean (*Phaseolus mungo* L.) cultivars. *Indian J. Agric. Res.*, **10**:73-78

Sahu, S.K. 1973. Effect of rhizobium inoculation and phosphate application on blackgram and horsegram. *Madras Agric. J.* **60**:989-993

Sandhu, T.S., Bhullar, B.S., Cheema, H.S. and Brar, J.S. 1978. Grain protein, yield and its components in urd bean. *Indian J. Genet.*, **38**:410-415

Sandhu, T.S., Bhullar, B.S., Cheema, H.S. and Brar, J.S. 1980. Path coefficient analysis in urd bean. *indian J. Agric. Res.* 14:35-41

Saraswathy, P., Sreekumar, S.G. and Thomas, E.J. 1979. Path analysis in greengram. *Agric. Res. J. Kerala*. 17:204-207

Satyan, B.A., Amarnath, K.C.N. and Siddaraju, I.H. 1989. Phenotypic and genotypic correlation coefficient of some quantitative characters in green gram. *Curr. Res. Univ. agric. Sci.* 18(12):170-172

Se·tin, M.W. and Barnes, D.K. 1977. Variation among alfalfa genotypes for rate of acetylene reduction. *Crop Sci.*, 17:783-787

Sharma, P.C., Mishra, S.N., Singh, A. and Verma, J.S. 1988. Genetic variation and correlation in cowpea. *Ann. agric. Res.* 9(1):101-105

Shoram, J. 1983. Studies on genetic variability for some quantitative characters in pigeon pea. *Madras agric. J.*, 70:146-148

Singh, B.D. and Murthy, B.K. 1988. Genetic analysis of nitrogen fixation trials in green gram. *Indian J. Agric. Sci.* 58(3):171-175

Singh, D.N., Nandi, A. and Tripathy, P. 1994. Genetic variability and character association in french bean (*Phaseolus vulgaris*). *Indian J. Agric. Sci.* 64(2):114-116

Singh, G. and Singh, M. 1994. Correlation and path analysis in Blackgram (*Phaseolus mungo*). *Indian J. Agric. Sci.* 64(7):462-464

Singh, J.N., Misra, M.K., Chauhan, G.S. and Khan, H. 1986. Genetic association among yield and its component characters in winter seasons urd (*Vigna mungo* L.). *Farm Sci. J.* 1(1-2):95-96

Singh, K.B. and Malhotra, R.S. 1970a. Inter-relationships between yield and yield components in mungbean. *indian J. Genet.*, 30:244-250

Singh, K.B. and Malhotra, R.S. 1970b. Estimates of genetic and environmental variability in mung (*Phaseolus aureus* Roxb.). *Madras agric. J.*, 57:155;159

Singh, K.B. and Mehndiratta, P.D. 1969. Genetic variability and correlation studies in cowpea. *Indian J. Genet.*, 29:104-109

* Singh, R., Joshi, B.S. and Singh, S. 1982. Correlation studies in cowpea (*Vigna unguiculata*). *Tropical Grain Legume Bulletin*, 26:3-5

Singh, R. and Yadav, H.S. 1991. Variability and association analysis in pigeon-pea. *Curr. Res.* 20(7):137-138

Singh, R.K. and Choudhary, B.D. 1979. *Biometrical methods in Quantitative Genetic Analysis*. Kalyani Publishers, New Delhi. pp.39, 79

Singh, R.P., Singh, H.L., Singh, U. and Singh, I.P. 1977. Path analysis in green-gram. *Madras agric. J.*, 64:596-597

Singh, S. and Ghai, B.S. 1984. Inter-relationship of some plant characters and biological nitrogen fixation in pea. *Indian J. Agric. Sci.* 54(5):378-381

Singh, U.P., Singh, U. and Singh, P. 1975. Estimates of variability, heritability and correlations for yield and its components in Urd (*Phaseolus mungo* L.). *Madras agric. J.*, 62:71-72

Smith, G.R., Knight, G.R. and Peterson, H.L. 1982. The inheritance of N_2 fixation efficiency in Crimson Clover. *Crop Sci.* 22:1091-94

Solanki, S.S., Saxena, P.K. and Pandey, I.C. 1988. Genetic variability studies in pea under agro climatic conditions of Western U.P. *Indian J. Hort.* 45(3-4):300-303

Soundarapandian, G., Nagarajan, R., Mahudeswaran, K. and Marappan, P.G. 1975. Genetic variation and scope of selection for yield attributes in blackgram (*Phaseolus mungo* L.). *Madras agric. J.*, 62:318-320

Soundarapandian, G., Nagarajan, P., Mahudeswaran, K. and Marappan, P.V. 1976. Genotypic and phenotypic correlations and path analysis in blackgram. *Madras agric. J.*, 63:141-147

Sreekumar, K. 1982. Symbiotic nitrogen fixation by antibiotic resistant mutants of *Rhizobium* sp. in pigeon pea. M.Sc.(Agri.) Thesis. Banaras Hindu University, Varanasi.

Sreekumar, S.G. and Abraham, A.T. 1979. Yield attributes and heritability in greengram (*Phaseolus aureus* Roxb.). *Agric. Res. J. Kerala*, **17**:141-142

Sreekumar, S.G., Ramachandran Nair, N., Saraswathy, P., Mary K. George and Thomas, E.J. 1979. Genetic variability and correlations in cowpea (*Vigna sinensis* L. Savi.). *Agric. Res. J. Kerala*, **17**:227-231

Suraiya, D., Mercy, S.T., Chandramony, D. and Nayar, N.K. 1988. Genetic variability of yield and its components in horsegram (*Macrotyloma uniflorum* Verdic.). *Indian J. Agric. Sci.* **58**:798-799

Swapna, M. 1993. Germplasm evaluation in Horsegram (*Dolichos biflorus* L.). M.Sc.(Ag.) Thesis. Kerala Agricultural University, Vellanikkara.

Thiagarajan, K., Natarajan, C. and Rathnaswamy, R. 1989. Variability in Nigerian cowpea. *Madras agric. J.* **72**(12):719-720

Tyagi, P.C. and Koranne, K.D. 1988. Correlation and path analysis in cowpea (*Vigna unguiculata* sp.) cylindrica). *Indian J. Agric. Sci.* **58**:57

Upadhaya, L.P., Singh, R.B. and Agarwal, R.K. 1980. Character associations in greengram populations of different maturity groups. *Indian J. Agric. Sci.* **50**:473-476

Uprety, D.C., Tomar, O.P.S. and Sirohi, G.S. 1979. A note on the yield determining factors in cowpea (*Vigna unguiculata*) varieties. *Indian J. Plant Physiol.* 22:156-159

Usha, R.Y. and Sakharam, R.J. 1981. Path analysis of yield components in blackgram. *Indian J. Agric. Sci.* **51**:378-381

Veeraswamy, R., Palaniswamy, G.A. and Rathnaswamy, R. 1973a. Yield attributes and heritability in some varieties of *Phaseolus mungo* (L.). *Madras agric. J.*, **60**:1834-1835

Veeraswamy, R., Palaniswamy, G.A. and Rathnaswamy, R. 1973b. Genetic variability in some quantitative characters of *Vigna sinesnsis* (L.) Savi. *Madras agric. J.*, 60:1359-1360

Veeraswamy, R., Rathanswamy, R. and Murugesan, M. 1975 Path analysis in red gram. *Madras agric. J.*, 62:166-168

Veeraswamy, R., Rathnaswamy, R. and Palaniswamy, G.A. 1973c. Genetic variability in some quantitative characters of *Phaseolus aureus* Roxb. *Madras agric. J.*, 60:1320-1322

Veeraswamy, R., Rathanaswamy, R., Ragupathy, A. and Palaniswamy, G.A. 1973d. Genotypic and phenotypic correlations in *Cajanus cajan* (L.) Millsp. *Madras agric. J.*, 60:1823-1825

W..nua, T.A.T. and Miller, D.A. 1978. Effect of intercropping on Soyabean nitrogen fixation and plant composition of associated sorghum soyabeans. *Agron. J.*, 70:292-295

Waryari, K.B. 1988. Variability and character association in blackgram (*Vigna mungo* L. Hepper.). *Indian J. Agric. Sci.* 58:48-51

* Originals not seen

VARIABILITY OF BIOLOGICAL NITROGEN FIXATION TRAITS AND YIELD COMPONENTS IN BLACKGRAM (*Vigna mungo* (L.) Hepper)

By

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ABSTRACT OF A THESIS

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ABSTRACT

A research programme was carried out at the Department of Agricultural Botany, College of Horticulture, Vellanikkara, Trichur during October-March 1993-94, with the objectives of assessing the genetic variability for biological nitrogen fixation traits and yield components in blackgram as a preliminary step to develop high yielding varieties with good biological nitrogen fixation capacity. Thirty three varieties of blackgram were evaluated, adopting a randomised block design with two replications. Data on thirteen characters were collected and subjected to analysis of variance. The genotypic and phenotypic coefficients of variation, heritability, genetic advance and genotypic and phenotypic correlations were estimated.

Analysis of variance revealed significant differences among the varieties for all the characters except number of pods, number of seeds per pod and harvest index.

High heritability coupled with high genetic advance was recorded for weight of nodules in the secondary roots and number of secondary roots suggesting the reliability of these characters during selection programmes for the improvement of the nitrogen content of this crop. Grain yield recorded high positive genotypic correlation with most of the yield components, biological yield and harvest index; and negative genotypic correlation with nitrogen content in the plant at 50 per cent flowering.

High positive genotypic correlation of number of pods per plant and number of seeds per pod with grain yield per plant, indicating that selection based on one or more of the above components may result in the improvement of grain yield. Weight of nodules in the secondary roots, which had high variability, heritability, genetic advance and genotypic correlations with nitrogen content in the plant at 50 per cent flowering and harvest index may be considered during selection programmes for identifying blackgram genotypes having high nitrogen fixation capacity.