G x E INTERACTION OF SEMI - ERECT COWPEA GENOTYPES

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"G x E interaction of semi-erect cowpea genotypes"** is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled **"G x E interaction of semi-erect cowpea genotypes"** is a record of research work done independently by **Ms. M. Ampily** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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DEDICATED TO

MY BELOVED

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Introduction

1. INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is one of the important leguminous crops cultivated in India. It is a multipurpose crop grown throughout India for its green pods as vegetable, seeds as pulse and foliage as fodder. The importance of the crop has been realized on account of its drought tolerance and adaptation to wide range of agro-climatic conditions. Further, the quick growth and rapid ground coverage have made cowpea an essential component of sustainable agriculture in marginal lands and other regions of the tropics (Singh *et al.*, 1997).

Cowpea affords enormous scope for genetic improvement due to its wide fluctuations in yielding ability when grown over varied environmental conditions. There is a persistent demand for identifying suitable genotypes, which can withstand climatic variations and ensure reasonably good yield. At present only a few semi-erect cowpea varieties are bred and knowledge on genetic parameters as well as seasonal performance is very limited. Therefore evaluation of different genotypes under diverse conditions forms an integral part of breeding programme aimed at identifying stable genotypes.

In Kerala, major portions of the paddy fields are left fallow during third crop season due to non-availability of water. If a short duration crop like cowpea with minimum water requirement can be raised during these periods, it would be of immense use to the farmers for fetching some earnings, at the same time, improving the soil fertility. The semi erect cowpea can fit well in to a cropping system where comparatively lesser cost is involved in cultivation. Consequently, the semi trailing cowpeas with high yield and tolerance to pests and diseases will have high acceptability by farmers.

Identifying a phenotypically stable variety is particularly important from the point of view of increasing production. It is observed that the relative performance of genotypes varies greatly with the environments. Failure of a genotype to give the same response in different environments is a definite indication of genotype-environment interaction. These differential responses of genotypes in different environments are termed as Genotype x Environment interaction (G x E interaction). G x E interaction reduces association between phenotypic and genotypic values and cause genotypes to perform well in one environment and poorly in another, forcing the plant breeder to examine genotypic adaptation. Hence, the occurrence of G x E interaction has been a major challenge for plant breeders.

In order to have better understanding of G x E interaction many models and methods of analyses have been proposed by different workers from time to time. The most simple and accurate model one can assume is an "Additive Main Effects and Multiplicative Interaction (AMMI)" model, where genotypic and environmental effects are assured to be independent and multiplicative interactions are considered.

Genotypic stability is an important aspect of the analysis of G x E interaction. Its importance to plant breeders is immense. Those genotypes, which regain the state of equilibrium when grown over a wide range of environments and continue to be superior in its performance, are said to be stable. The concept of stability of a genotype is not uniquely defined. It is defined in many ways depending on how a scientist wishes to view the problem. However, a simple definition could be that stability is the consistency in the performance of a genotype in all the environments and over years. However, the breeder is interested in identifying genotypes that are not only stable but also superior in performance. This is difficult to achieve because there may be genotypes that perform to their full potential under certain environments and show up very badly in others, thus increasing the variability across environments. Therefore, the purpose of the analysis of G x E interaction should be two-fold for specific environment. In the first, to identify those genotypes which are stable in their performance across environments and in the second, to look for those highly potential genotypes, adaptable to only certain favourable environments.

It is in this backdrop, the present investigation was undertaken at the Department of Olericulture, College of Horticulture, Vellanikkara during 2004-2005 with the following objectives:

- To identify stable high yielding and dual-purpose semi erect cowpea genotypes

- To identify high yielding genotypes adaptable to certain favorable environments

- To study different aspects of G x E interactions with respect to different characters.

Review of Literature

2. REVIEW OF LITERATURE

Improvement of crop plants is possible through breeding techniques only when the genetic make up of the crop is understood. Biometrical tools serve effectively in this direction. Information on the structural and developmental components of yield, such as that sought to be obtained in the present investigation is a prerequisite to evolve superior plant types through different approaches. Since the literature, on different aspects of the investigation of this kind, exclusively on cowpea is limited, an attempt has been made in this chapter to review all relevant literature on a selective basis under the following broad headings:

1. Variability and performance studies
2. Heritability, Genetic advance and Genetic gain
3. Phenotypic and genotypic correlation
4. Path coefficient analysis
5. Genotype x environment interaction
6. Reaction of genotypes towards pests and diseases

2.1 VARIABILITY AND PERFORMANCE STUDIES

Genetic variability in a crop is the basic requirement for its further genetic improvement. The critical assessment of nature and magnitude of variability is one of the important pre-requisites in formulating effective breeding methods.

Karthikeyan (1963) observed the number of pods per plant and number of fruiting nodes on the main stem as the important components of yield. Angadi *et al.* (1978) evaluated fifty types of cowpea at Coimbatore and found that the genetic coefficients of variation for pod number ranged from

30.48 to 81.58 and other parameters such as number of clusters, seeds per pod and 100 seed weight also recorded high genotypic coefficient of variation.

Ramachandran *et al.* (1980) conducted variability studies in selected varieties of cowpea. The maximum value for genotypic coefficient of variation was obtained in yield per plot followed by pods per plant. The lowest value of genotypic coefficient of variation was observed in pod length. According to Radhakrishnan and Jebaraj (1982), significant difference between 16 cowpea varieties were observed for nine yield related traits and all traits showed high heritability.

Pandita *et al.* (1982) in their genetic variability studies in cowpea under dry farming conditions found that analysis of data on six traits in 40 forms revealed significant differences for all traits except number of pods per cluster. Wide variation occurred for yield per plant, days to flowering and plant height. Pod yield per plant had the highest genotypic and phenotypic coefficients of variation.

Chikkadevaiah (1985) in studies of cowpea on yield per plant and 11 related characters in 207 indigenous and 117 exotic genotypes in 1981 found that variability was the greatest for plant spread in the *Kharif* season and for plant height in summer.

Patil and Baviskar (1987) investigated 49 types of cowpea from diverse geographical origin and the maximum range of variation was observed for grain yield per plant followed by pods per plant, clusters per plant and days to maturity. The genotypic and phenotypic coefficients of variation were higher for clusters per plant, pods per plant grain yield per plant and 100-grain weight.

Genetic variability of pod yield and seven other characters of dolichos bean were accessed by Das *et al.* (1987). They observed maximum variability in number of pods per plant. Genotypic coefficient of variation was found high for the characters such as pod yield per plant, number of pods per plant and breadth of pod.

The analysis of variance, range, means, genotypic and phenotypic coefficients of variability were estimated for eighteen characters in 196 collections of field bean by Reddy *et al.* (1992). Substantial genetic variability was noticed for total length of spike, effective length of spike, plant spread, fodder yield per plant, number of pods per plant, number of productive pods per plant, pod yield per plant and bean yield per plant. They were less vulnerable to environmental influences.

Borah and Hazarika (1995) evaluated 112 exotic genotypes in green gram and reported that high estimates of genotypic variances were recorded only for plant height and number of pods per plant.

Patil and Shinde (1995) evaluated the amount of variability in green gram using 89 genotypes and reported large amount of variability for all the characters except for days to flowering and number of seeds per pod as indicated by the estimates genetic coefficient of variability (GCV) and phenotypic coefficient of variability (PCV). Data on genetic variability studied by Veerabadhiran and Jehangir (1995) in green gram revealed that the seed yield, number of pods, number of clusters and number of seeds per pod showed high genotypic coefficients of variation.

Days to 50 per cent flowering, pod length and seeds per pod recorded low values of PCV and GCV and plant height recorded moderate PCV and GCV, which showed the presence of significant variability for all the characters, studied in green gram (Manivannan *et al.*, 1996).

Rajaravindran and Das (1997) studied the variability in vegetable cowpea and found that the genotypic and phenotypic coefficients of variation for all the characters were very low except for green pod yield. The days to maturity recorded the lowest genotypic and phenotypic coefficient of variation.

Variability studies by Resmi (1998) revealed significant differences among the 30 yard long bean genotypes studied. Pod yield per plant was strongly associated with pod weight, pod length and pods per plant. Genotypes VS-6 and VS-11 recorded the maximum selection index scores. Vardhan and Savithramma (1998) observed high GCV and PCV for plant height, number of primary branches, number of secondary branches, pods per plant and plant height in cowpea.

Variability studied in 15 characters in horse gram by Lad *et al.* (1998) revealed that the magnitude of genotypic variance was greater for almost all the characters except number of branches per plant, pod length, grains per pod and 100-grain weight.

High genotypic coefficient of variation and phenotypic coefficient of variation were observed for plant height, number of pods per plant, seed yield per plant and number of branches per plant during the variability studies conducted in cowpea by Selvam *et al.* (2000).

Pournami (2000) conducted variability studies with 15 vegetable cowpea genotypes and observed maximum GCV for number of pods per plant. Tyagi *et al.* (2000) reported high estimates for genotypic coefficients of variation for days to 50 per cent flowering, plant height, seed yield per plant and days to maturity, including their dependability for effecting selection.

Fifty varieties of yard long bean were evaluated for yield and related characters by Vidya *et al.* (2002) and reported high phenotypic and genotypic coefficients of variation for number of pods per plant and pod weight.

Genotypic and phenotypic variations were analyzed for six quantitative characters in thirty seven cultivars of cowpea by Kohli (2002) and reported that the range of phenotypic variation and estimates of phenotypic and genotypic variances and coefficient of variability were high for fodder yield per plant, length of main branch, plant height and days to 50 per cent flowering whereas these estimates were moderate for leafiness and low for number of branches per plant.

Research on cowpea at Kerala Agricultural University has resulted in the development and release of four semi-erect cowpea varieties *viz.* Kanakamony, Anaswara, Kairali and Varun (Gopalakrishnan and Indira, 2002).

Genetic variations of eight quantitative traits of cowpea conducted by Singh and Verma (2002) revealed that high coefficient of variation (20.0-25.0 %) was recorded for seed yield, plant height, 100 seed weight and number of pods per peduncle. Moderate variation (11.86-13.11 %) was recorded for number of days to flowering and pod length. Minimum variability (8.68-9.72 %) was observed for number of days to 50 per cent maturity and number of seeds per pod. While analyzing the variability in 36 genotypes of mung bean by Reddy *et al.* (2003) high magnitude of variability was observed for pods per plant, grain yield per plant and moderate variability was recorded for pods per cluster, clusters per plant, plant height and days to 50 per cent flowering.

Relatively high genotypic and phenotypic coefficients of variation for plant height, number of primary branches per plant, number of peduncles per plant, number of pods per plant and green pod yield per plant was observed by Pal *et al.* (2003) in 40 diverse genotypes of vegetable cowpea. Variability and character association studies for seed yield in fodder cowpea carried over by Chauhan *et al.* (2003) revealed that the additive gene effects were significant for plant height, pods per plant, plant stand and 100 seed weight.

Variability and correlation studies in chickpea conducted by Jeena *et al.* (2005) revealed that high amount of genetic variability was expressed by pods per plant, hundred seed weight, biological yield per plant and seed yield per plant.

2.2 HERITABILITY, GENETIC ADVANCE AND GENETIC GAIN

The heritability estimates, which involve the breeding value of genotypes, serve as an effective tool in predicting the performance of genotypes in subsequent generations, and to decide appropriate weightage for the improvement of a particular character or breeding method to be followed to achieve the objectives.

Charles and Smith (1934) and Powers (1942) separated genetic variance from total variance using the estimate of environmental variance in non-segregating populations. The heritable variation was further divided into additive and non-additive components and the latter fraction included dominance and interallelic interaction (Fisher *et al.*, 1932; Panse, 1940 and Mathur, 1949). If the heritable variation in controlling a character is purely additive, then that character can be fixed by selection and maximum genetic advance can be accomplished by continuous selection, than if part of the heritable variation is composed of non-additive components (Panse, 1957).

The genetic gain that can be obtained for a particular trait through selection is the product of its heritability, phenotypic standard deviation and selection differential (Burton and Devane, 1953).

Though heritability value of a trait indicates the effectiveness of selection based on phenotypic expression, the genetic advance is more useful in predicting the actual value of selection as shown by Johnson *et al.* (1955 a). The expected genetic advance in a single generation is the variable fraction of the selection differential (Robinson *et al.*, 1951).

Singh and Mehndiratta (1969), Trehan *et al.* (1970), Bordia *et al.* (1973), Veeraswamy *et al.* (1973), Laxmi and Goud (1977) and Tikka *et al.* (1977) reported high heritability and genetic advance for number of pods per plant in cowpea. High genetic advance was recorded with respect to pod number, cluster number, seed yield, pod yield and seed weight. Number of branches and number of seeds per pod exhibited high heritability and low genetic advance reported by Angadi *et al.* (1978) in the variability studies in cowpea.

Dharmalingam and Kadambavanasundaram (1984) observed that pod length, 100 seed weight and harvest index showed highest heritability among the yield related traits from 40 genotypes of cowpea.

Ramachandran *et al.* (1980) reported that the heritability estimate was the highest for number of days to flowering (95.74 %) followed by days to first harvest (95.74 %) in a variability study in selected varieties of cowpea. The genetic advance estimated as per cent of mean was maximum for seeds per pod (100.00 %) followed by yield per plot (99.54 %) and pods per plant (93.37 %).

Genetic variability, heritability in broad sense and expected advance of pod yield and seven other characters were studied by Das *et al.* (1987) in 16 genotypes of dolichos bean. All the characters under study were highly heritable in nature. High heritability estimates associated with greater genetic advance was observed for pod yield per plant, number of pods per plant and breadth of pod, which indicated that these characters had additive gene effect and therefore they are more reliable for effective selection.

Patil and Baviskar (1987) reported that the heritability estimates was the highest for 100-grain weight followed by days to maturity and pod length. The expected genetic advance as per cent of mean was high for cluster per plant, pods per plant, 100-grain weight and grain yield per plant. The estimates of heritability together with genetic advance as per cent of mean was high for 100-grain weight, pods per plant, cluster per plant and grain yield per plant.

Apte *et al.* (1987) reported that when seed yield per plant, harvest index and ten yield components were investigated in ten *Vigna unguiculata* genotypes, high heritability was found for 100 seed weight, seeds per pod and days to maturity. Per cent genetic gain was the greatest for 100 -seed weight, plant height, branches per plant and seeds per pod.

Information on heritability and genetic advance was derived from data on 18 characters for yield and its contributing characters in field bean. High values of heritability as well as high genetic advance were recorded for plant spread, number of pods per plant and number of productive pods per plant indicating additive action of genes controlling them (Reddy *et al.*, 1992).

In a study comprising of 112 exotic genotypes of green gram, high estimates of heritabilty along with high genetic advance and GCV values were observed for the plant height, number of pods per plant, seed yield per plant, number of clusters per plant, number of secondary branches per plant, number of primary branches per plant, days to 50 per cent flowering and days to maturity exhibited the lowest estimates of genetic advance (Borah and Hazarika, 1995).

Veerabadhiran and Jehangir (1995) identified high estimates of heritability for the plant height, days to 50 per cent flowering and number of cluster in green gram. Plant height showed the highest genetic advance followed by days to flowering. Manivannan *et al.* (1996) reported that heritability estimates in broad sense was high and genetic advance as per cent of mean was moderate for 50 per cent flowering in green gram. The characters like plant height, pods per plant and seed yield recorded high heritability as well as high genetic advance as per cent of mean.

Rajaravindran and Das (1997) reported that heritability in broad sense was the lowest for pod length followed by days to 50 per cent flowering, days to maturity and green pod yield .The number of pods per plant recorded the lowest heritability.

Tyagi *et al.* (2000) reported high heritability and genetic advance for days to 50 per cent flowering, plant height, seed yield per plant and days to maturity in cowpea. Selvam *et al.* (2000) reported that heritability and genetic advance were quite high for plant height and days to 50 per cent flowering indicating the ponderance of additive gene effects.

Vidya *et al.* (2002) evaluated fifty varieties of yard long bean and reported high genotypic coefficient of variation, heritability in broad sense and genetic advance for the character *viz.* yield of vegetable, pods per plant, number of pods per plant and pod weight.

Reddy *et al.* (2003) evaluated genetic variability for yield and its components in mung bean and found that high heritability coupled with genetic advance as per cent of mean was observed for pods per plant, grain yield per plant, pods per cluster, cluster per plant, plant height and days to 50 per cent flowering while high heritabilty and moderate genetic advance as per cent of mean was recorded for seeds per pod, 100 seed weight and days to maturity.

Pal *et al.* (2003) reported high heritability accompanied by moderate to high genotypic coefficients of variation and genetic advance for plant height, peduncle length, and number of primary branches per plant, which could be improved by simple selection in early generation. Days to 50 per cent flowering and first green pod picking, pod diameter, number of seeds per plant and 100 seed weight manifested high heritability coupled with low genotypic coefficients of variation and genetic advance.

Malarvizhi *et al.* (2005) reported that the heritability and genetic advance was high for the characters like number of branches per plant, number of leaves per plant, dry weight of leaves, dry weight of stem, green fodder yield, plant height indicating that these traits were controlled by additive genetic effects.

2.3 GENOTYPIC AND PHENOTYPIC CORRELATIONS

Knowledge of phenotypic and genotypic correlations between important characters is of immense help in the selection of suitable plant types. The association of characters may be either due to genetic linkage or pleiotrophy (Hardland, 1939). Besides these two, correlated response may be a result of loci located in different chromosomes and any kind of non-random segregation might cause temporary correlations (Lerner, 1958).

Correlations provide useful information to plant breeders for developing selection schemes as it reveals the strength of relationship among the group of characters. Correlation between various characters helps in simultaneous selection of these characters. Genotypic correlations higher than phenotypic correlations indicate the inherent association between the traits and thereby the importance of these correlations in selection.

Grain yield per plant was reported to be positively associated with pods per plant and seeds per pod in cowpea (Singh and Mehndiratta, 1969; Trehan *et al.*, 1970; Premshekar and Raman, 1972; Bapna and Joshi, 1973; Aryeetey and Laing, 1973; Bordia *et al.*, 1973; Patel, 1973; Hanchinal *et al.*, 1979 and Virupakshappa *et al.*, 1980). Another character, which positively correlated with seed yield, was 100 seed weight, as evidenced by the reports of Bliss *et al.* (1973), Singh and Mehndiratta (1969) and Bapna and Joshi (1973) in cowpea.

Number of seeds per pod was observed to be negatively correlated with pods per plant in cowpea by Singh and Mehndiratta (1969) and Aryeetey and Laing (1973). Negative correlation between pods per plant and 100 seed weight in cowpea was reported by Singh and Mehndiratta (1969), Aryeetey and Laing (1973), Patel (1973) and Hanchinal *et al.* (1979) in cowpea.

Kheradnam and Niknejad (1974) observed that the number of seeds per pod, 100 seed weight, number of clusters per plant and number of pods per plant showed positive significant correlation with yield, while number of branches per plant showed negative correlation with seed yield.

In their study to ascertain phenotypic, genotypic and environmental correlation coefficients using varying cowpea populations by Bapna *et al.* (1972) indicated that the magnitude and direction of correlation between yield and yield contributing agronomic characters were largely a function of the number of pods and seeds per plant, pod length and 100 seed weight. Singh *et al.* (1977) studied the strong correlation between yield and number of pods per plant and number of seeds per pod.

Tikka *et al.* (1977) observed positive and significant correlation of seed yield per plant with plant height, primary branches and pods per plant in a collection of 25 cowpea varieties of diverse origin. Dumbre *et al.* (1982) studied the genotypic and phenotypic correlation of six quantitative traits in 24 cultivars of cowpea wherein height and pods per plant were significantly correlated with yield

Jalajakumari (1981) observed that the yield of seeds per plant was highly correlated with number of pods per plant, weight of pod, number of seeds per pod, breadth of seed, thickness of seed and yield of pods per plant.

Jana *et al.* (1983) studied correlations among six characters in 11 varieties of *V. unguiculata* var *sesquipedalis*, in which the genotypic correlation between vegetable pod yield and number of pods per plant was considerably high. A analysis of data on seed yield and nine yield related traits in cowpea by Jindal and Gupta (1984) revealed that plant height, pods per plant, pod length and seeds per pod were significantly and positively associated with seed yield.

Chikkadevaiah (1985) studied that seed yield was positively correlated with number of branches, fruiting bunches, pods per plant and seeds per pod and with 100-seed weight in both *Kharif* and summer seasons in cowpea.

Natarajaratnam *et al.* (1986) investigated the phenotypic correlation coefficients between yield and seven of its components measured in 10 genotypes of cowpea and found that seed yield was strongly associated with pod weight, number of pods per clusters per plant and plant height.

Patil and Bhapkar (1987) studied the interrelationship between grain yield, pods per plant and their component traits in 49 cultivars of cowpea. Grain yield was positively and significantly correlated with pods per plant and grains per pod but these two characters exhibited negative association among them. Pods per plant with clusters per plant and grains per pod, pod length and 100 seed weight showed positive and significant correlation. Negative correlation was found between pods per plant and 100-grain weight, which was highly significant. Positive and significant association was found between pod length and 100-grain weight and cluster per plant with number of primary and secondary branches. However, clusters per plant had negative and highly significant correlation with 100-grain weight. Similar significant negative association was also evident among the traits, pod length and clusters per plant. Days to flowering and maturity had positive correlation, which was significant at genotypic level. Positive and significant correlation was showed by days to flower with number of primary branches and days to maturity with number of secondary branches.

Henry and Krishna (1990) reported that seed yield per plant in pigeon pea showed significant positive correlation with plant height, number of cluster and number of seeds per pod. Kumar *et al.* (1995) reported that pods per plant and 100 seed weight had significant and positive correlation with seed yield.

Venkatesan *et al.* (2003) evaluated 20 diversified genotypes of cowpea for 12 component characters among which braches per plant, clusters per plant and pod yield had positive correlation with seed yield both at genotypic and phenotypic level.

2.4 PATH COEFFICIENT ANALYSIS

Path coefficient is a standardized partial regression coefficient and as such measures the direct influence of one variable upon another and permits the separation of correlation coefficient into components of direct and indirect effects (Dewey and Lu, 1959).

Singh and Mehdiratta (1969) studied 40 lines for path analysis of yield attributing characters and found that the pods per plant, grains per pod and 100 seed weight had appreciable direct effect on grain yield.

Hanichal *et al.* (1979) reported that the path analysis on plant height, number of branches and number of seeds should be considered as one of the important characters in deciding the yield although the apparent correlation was negative. Further, it is suggested that rather than the direct effects of number of seeds and plant height, it is the direct effect of seeds through branches which is more important in deciding the yield.

Jana *et al.* (1983) studied the path coefficient analysis of pod yield in vegetable cowpea (*V. unguiculata var.sesquipedalis*) with emphasis on six characters and found that number of pods per plant exhibited the highest magnitude of direct effects towards yield. The maximum indirect effect came from number of primary branches via number of pods per plant. In negative direction, maximum indirect effects were exerted by days to flower via the number of pods per plant.

On path analysis of 24 genotypes of cowpea by Padhye *et al.* (1984) found that pods per plant and seeds per pod showed the highest positive direct phenotypic and genotypic effects on yield.

Chikkadevaiah (1985) obtained direct positive effect of plant spread, pods per plant and seeds per pod on seed yield in cowpea.

Natarajaratnam *et al.* (1986) indicated that pod weight per plant had the greatest direct effect on seed yield of cowpea. In a study, involving correlation and path coefficient analysis in pigeon pea, by Henry and Krishna (1990) indicated the importance of number of pods per plant, which had maximum direct effect on seed yield.

Nirmalakumari and Subramanian (1993) reported that biological yield per plant, harvest index and pod length showed high positive direct effect on yield and inferred these characters as the most important yield components.

Kumar *et al.* (1995) revealed that positive direct effects were observed for pods per plant, plant height and 100 seed weight in the path coefficient analysis in green gram. Bastin *et al.* (2001) reported that dry matter production had the highest positive direct effect (0.89) on seed yield followed by pod length (0.78) and harvest index (0.63). Path analysis in bush type vegetable cowpea by Ajith (2001) revealed that number of pods per plant and pod weight was the main yield contributing characters.

Twenty diversified genotypes of cowpea were evaluated by Venkatesan *et al.* (2003) and reported high positive direct effects of number of pods per plant, pod length, cluster per plant, seeds per pod and 100 seed weight on seed yield.

Kumar *et al.* (2003) reported that 100 seed weight exhibited maximum positive direct effect followed by number of pods per plant. Days to first flower showed negative direct effects on yield in black gram.

Correlation and path analysis in vegetable cowpea for 12 traits were done by Kutty *et al.* (2004). Path analysis indicated that the number of pods per plant followed by average weight of pods and number of pickings had the greatest positive direct effects on yield. The direct effects of pod length and number of days to first picking were low, mainly due to high indirect effects via average weight of pods and number of pods per plant.

2.5 GENOTYPE X ENVIRONMENT INTERACTION

One of the major objectives in any plant breeding programme is the selection of genotypes that are consistently high yielding over a range of environments. This selection is often inefficient due to Genotype x Environment interactions and the failure of genotypes to have the same relative performance in different environments. Therefore the interrelationship of inherent effect and environmental influence has been studied.

Phenotype is defined formally as the linear function of genotype, environment and genotype-environment interactions. This interplay between genetic and non-genetic effects, genotype and environment interaction, reduces the magnitude of association between genotype and environment. For the first time Fisher and Mackenzi (1923) reported the existence of GE interaction from the results of a varietal trial of potatoes. While Neyman *et al.* (1935) analyzing the data of manurial trial conducted on a large number of sites suggested the use of regression of yield differences among the treatments on the environmental variables as a measure of GE interaction. Subsequently these simple experiments gave rise to more informative methods. Yates and Cochran (1938) examined application of regression method to the analysis of groups of varietal trials by introducing breaking up of interaction sum of squares into two components. One to examine existence of heterogeneity and another to examine 'lack of linear fit'. Since then, because of their practical utilities in the analysis of genotype-environment interaction, these methods have been used frequently.

At present a number of methods improved over this has been employed to know G x E interaction and stability analysis. Recently Additive Main Effect and Multiplicative Interaction (AMMI) analysis has been shown to be more effective than the conventional two-way fixed models with interaction, because it achieves several important goals including parsimony (contains relatively few of the interaction degrees of freedom), effectiveness (contains most of interaction degrees of freedom) and mega environment analysis (Zobel *et al.*, 1988 and Gauch, 1992). One of the main reasons for growing genotypes in wide range of environments is to know about their performance stability. An important aspect of measuring stability is the proper choice of environments. Evaluation of stability parameters done by different ways different workers are discussed here.

Thiyagarajan and Rajasekharan (1987) evaluated cowpea for stability parameters with respect to grain yield in six environments and revealed that genotypes and environmental effects were significant for grain yield.

Twenty-one promising genotypes of black gram were evaluated in summer, *Kharif* and *Rabi* seasons by Mishra (1990) and found that there existed significant differences among the genotypes and the environment.

Stability analysis for yield and its contributing traits in forty genotypes of pea by Gautam and Chaturvedi (1990) revealed that the G x E interaction were significant for the number of pods per plant, pod length, number of seeds per pod and green pod yield per plant.

The G x E interactions of 50 cowpea cultivars from different geographical regions was studied under six environments by Singh *et al.* (1990) for nine quantitative characters. Highly significant differences amongst genotypes, environments and G x E interactions were observed for all the traits.

A majority of the G x E interactions among genotypes and environment were a linear function of the additive environmental component with a significant non-linear residual variation.

Thirteen varieties of cowpea were evaluated in three environments and stability parameters were studied for yield by Vishwanathan and Nadarajan (1996). The varieties IT 86-D-1056 and CO-4 had average response to changes in environmental conditions with higher mean yield as against the population mean yield.

The effect of years, genotypes and genotype x year interaction of cowpea for 14 growth and yield parameters were investigated during the summer seasons of 2000 and 2002 by Khalf *et al.* (2003). The effects of year on the different characters were not significant. The effects of genotypes were highly significant for three characters and non significant for one character. The effects of genotype x year interactions were not significant for all the characters, with only one exception.

Phenotypic stability for grain yield in cowpea by Sangwan *et al.* (2003) reported tha. pooled analysis of variance showed that the mean squares due to genotypes TC-99-1, CPD 15, GC-3, RC-19, HC 98-33 and CAZC 98-9 had average seed y:eld, almost average response to environmental change and were stable.

Stability analysis for test weight in 21 diverse genotypes of cowpea by Khatri *et al.* (2003) found that both linear as well as non-linear component of Genotype x Environment interaction were equally important for seed test weight. Kavitha *et al.* (2003) evaluated 21 genotypes of cowpea for stability of grain yield per plant. They reported that the linear component (59.96 %) of G x E interaction was higher than the non-linear component.

Fifty genotypes of cowpea were evaluated by Singh *et al.* (2003) for seed yield per plot, days to maturity, plant height, and number of pods per plant and test weight. The interaction sum of squares of genotype x year was highly significant, indicating the effect of environment on character expression. A comparison of yield data over the years with weather parameters indicated that the amount of rain and its distribution affected the relative ranking of genotypes.

G x E interactions for seed yield was studied in cowpea by Henry *et al.* (2003). They found that the analysis of variance indicated significant variation for genotypes and G x E interactions for seed yield.

Stability analysis of yield and yield components in early maturing lines of mung bean by Abdulla and Singh (2004) revealed that variance due to genotypes was significant for all the characters, except seed yield per plant. The variance due to G X E interaction was significant for all the characters, except pod length, seeds per pod and seed yield per plant. Days to maturity, 100 seed weight and seed yield per plant recorded significant pooled deviation.

2.6 REACTION OF GENOTYPES TOWARDS PEST AND DISEASES

2.6.1 Aphids

Screening of aphid tolerance by Joseph (1990) resulted in the identification of three resistant lines viz., VS 350, VS 438, VS 452 and reported that non-preference and antibiosis mechanism were the causes for resistance. Average number of rainy days and relative humidity had negative relationship with aphid population. Inheritance of aphid resistance in cowpea studied by Joseph and Peter (2003) indicated that a single dominant gene governed the resistance to aphids.

Joseph and Peter (2003) reported that there was a positive correlation between the level of aphid resistance expressed and the per cent obstruction created through physical blending of the genotypes.

2.6.2 Pod borer

Jagginavar *et al.* (1990) reported that the lowest incidence of the cowpea pod borer was recorded when the crop was sown in the first week of October. The per cent of seed and pod damage was also lowest in early October sowing.

None of the varieties screened for resistance to pod borer (*Maruca testulalis)* were resistant (Anithakumari, 1992). The pod wall thickness and pubescence of the pods did not show any correlation with the level of borer infestation.

Veeranna and Hussain (1997) reported that trichomes are important in reducing attack by *Maruca testulalis.*

Panikar (2000) reported that the pod width was found to be positively correlated with Plant Resistance Index, pod damage severity and per cent pod infestation. Non-glandular trichome density on pods recorded significant negative correlation with Plant Resistance Index and pod damage indicating that plant resistance increases with increase in non-glandular trichome density on pods. Another study by Vidya (2000) on pod borer resistance in yard long bean resulted in the identification of the cultivar VS- 42, suitable for cultivation in legume pod borer endemic areas.

Yucheng *et al.* (2003) reported that there was a distinct correlation between pod borer infestation and trichome density.

2.6.3 Coreid bug

Koona *et al.* (2002) in their laboratory and screen house experiment revealed that the wild cowpea accessions showed antibiosis resistance causing more than 50 per cent mortality of the coreid bug nymphs within three days of placing them on pods.

2.6.4 Anthracnose

Anthracnose is the main disease of yard long bean in Kerala and the pathogen was found to be seed borne (Praveenkumar, 1999). He reported that Kanakamony was found immune to the disease and summer season was found to be best season for cowpea cultivation in areas where anthracnose is a problem.

2.6.5 Mosaic

Studies conducted on the cowpea mosaic virus disease identified the major symptoms as vein banding, interveinal chlorosis, mosaic mottling and general stunting of the plants. Transmission studies showed that the virus could be transmitted through mechanical means, grafting, through seeds and by means of aphid vectors.

Screening of cowpea for resistance to Aphid Borne Mosaic Virus disease (CAMV) showed that out of 59, two cultivars *viz.* V-317 and V-276 were found highly resistant under field conditions (Sudhakumari, 1993). Sindhu (2001) reported that chlorophyll content decreased in susceptible variety due to virus infestation and also a lower level of phenol content was observed in resistant variety.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation on "G x E interaction of semi-erect cowpea genotypes" was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara during the period 2004-2005.

The experimental site was located at an altitude of 22.5m above M.S.L between 10^0 32' N latitude and 75^0 16' longitude. The location experiences a warm humid tropical climate. The soil for the experimental site comes under the textural class of sandy clay loam and is acidic in reaction. The average monthly values of the meteorological parameters like rainfall, maximum and minimum temperatures and relative humidity were collected from the observatory attached to College of Horticulture and are presented in Appendix-1

3.1 MATERIALS

Fifty semi-erect cowpea accessions (including released varieties) constituted the materials for study. The sources of the accessions are given in table 1.

3.2 METHODS

All the cowpea genotypes were evaluated for three seasons (*Kharif, Rabi* and summer) during the year 2004-2005.

3.2.1 Experiment 1

Fifty semi-erect cowpea accessions (including released varieties) were evaluated in the Department of Olericulture during three season's *viz.*

Table 1. Source of semi-erect cowpea accessions

Sl.No.	Accessions	Source
1	VS1015	Kottayam
2	VS 1025	Wayanad
3	VS 1026	Wayanad
4	VS 1028	Kottayam
5	VS 1030	Kottayam
6	VS 1032	Alappuzha
7	VS 1034	Kasaragod
8	VS 1035	Kasaragod
9	VS 1042	Thrissur
10	VS 1047	Alappuzha
11	VS 1053	Thrissur
12	VS 1054	Kottayam
13	VS 1058	Kannur
14	VS 1075	Alappuzha
15	VS 1104	Malappuram
16	VS 1111	Malappuram
17	VS 1133	Malappuram
18	VS 1135	Malappuram
19	VS 1140	Kasaragod
20	VS 1151	Kozhikode
21	VS 1153	Kozhikode
22	VS 1156	Kozhikode
23	VS 1160	Kottayam
24	VS 1166	Kottayam
25	VS 1168	Wayanad
26	VS 1170	Wayanad
27	VS 1171	Wayanad
28	VS 1172	Wayanad
29	VS 1173	Wayanad
30	VS 1174	Wayanad
31	VS 1175	Wayanad
32	VS 1177	Wayanad
33	VS 1179	Wayanad
34	VS 1180	Wayanad
35	VS 1185	Wayanad
36	VS 1213	Kannur
37	VS 1215	Malappuram
38	VS 1220*	KAU,Thrissur
39	VS 1221	Kannur
40	VS 1230	Wayanad
41	VS 1231	Thiruvanathapuram
42	VS 1235	Kottayam
43	VS 1248	Thiruvanathapuram
44	VS 1263	Kannur
45	VS 1276****	KAU,Thrissur
46	VS 1277	Idukki
47	VS 1282	Kozhikode
48	VS 1294	Palakkad
49	VS1266**	KAU,Thrissur
50	VS1286***	KAU,Thrissur

VS-1220* Anaswara,VS-1286***Varun,VS-1266**Kairali, VS-1276****-Kanakamony

Plate 1 Field view of cowpea accessions

Kharif (June 2004 - September 2004), *Rabi* (October 2004 - February 2005) and summer (February - May 2005).

The accessions were raised in randomized block design with two replications. Plot size was 3.30 x 1.20 m^2 and the spacing was 45 x 30 cm, as per the package of practices recommendations (KAU, 2003). There were 20 plants per plot (Plate 1). The following observations were recorded.

Qualitative characters

1. Plant growth habit

   Recorded at completion of vegetative stage.

   Erect / Semi erect / Bushy / Viny / Spreading

2. Immature and Mature pod colour

   Light Green / Green /Dark Green / Dark Green with purple splashes / Light purple with green splashes / Purple with green splashes

3. Seed crowding

   Not crowded (no compressing of seed ends) / Semi-crowding (slight flattening of seed ends) / Crowded (marked compression of seed ends) / Extremely crowded (seed width is greater than seed length)

4. Seed coat colour of mature seed

   White / Apricot buff / Red/ Deep Red /Brown/ Black/ Capusine buff /Mottled brown / Buff/ Mottled grey / Mottled Red

The following quantitative characters were recorded from five observational plants selected at random from in each plot.

5. Days to first flowering

Number of days from date of germination to first flowering stage within a plot.

6. Days to 50 per cent flowering

Number of days taken from date of germination to 50 per cent of the plants to flower within a plot.

7. Number of primary branches

The number of primary branches emerging from the main vine.

8. Length of main branch (at 60 DAS) (cm)

The length of the main vine was recorded from ground region to tip of the vine at 60 days after sowing.

9. Number of clusters per plant

The number of clusters produced per plant was recorded and the mean was computed.

10. Number of pods per plant

The number of pods produced at each harvest was recorded and the mean was computed.

11. Green pod yield per plant (g)

The number of fully matured pods produced on the observational plants was recorded and the mean was computed to arrive at the pod yield per plant.

12. Green pod yield per plot (kg)

Total weight of the pods harvested from each plot was recorded.

13. Peduncle length (cm)

Length of the peduncle from the stalk end to the tip was recorded in the first fruit cluster.

14. Pod length (cm)

Length of the pods was recorded and the mean was computed.

15. Green biomass per plant (at 60 DAS) (g)

At 60 days after sowing, the plants were uprooted and biomass was taken.

16. Days to 80 per cent maturity

Counted the number of days from planting to the day when 80 per cent of the pods matured for vegetable purpose.

17. Number of seeds per pod

Average number of seeds in fully mature pods was computed.

18. Seed yield per plant (g)

Total weight of the seeds collected from individual plant.

19. Hundred seed weight (g)

Weight of hundred bold seeds extracted from the dry pods were recorded.

21. Incidence of following pests and diseases

a. Pod borer

Pods affected by pod borer were counted at each harvest and per cent incidence was calculated.

b. Coreid bug

Pods affected by coreid bug were counted and the per cent incidence was calculated.

c. Aphids

Number of plants affected by aphids were counted and per cent infestation was recorded.

d. Anthracnose

Number of plants affected by anthracnose was recorded and per cent infestation was calculated.

e. Collar rot

Number of plants affected by collar rot was counted and per cent was worked out.

f. Mosaic

Number of plants affected by mosaic was counted and per cent was worked out.

3.3 STATISTICAL ANALYSIS

The data obtained from three seasons viz. *Kharif, Rabi* and summer were subjected to statistical analysis for estimation of variance and stability.

3.3.1 Estimation of genetic parameters

The variance components were estimated as suggested by Singh and Chaudhary (1985).

3.3.1(a) Phenotypic variance

Phenotypic variance (Vp) = Vg + Ve

where,

(Vg) = Genotypic variance

(Ve) = Environmental variance

3.3.1(b) Genotypic variance

$$\text{Genotypic variance (Vg)} = \frac{VT - VE}{N}$$

where,

VT = Mean sum of squares due to treatments

VE = Mean sum of squares due to error

N = Number of replications

Environmental variance (Ve) = VE

where,

VE = Mean sum of squares due to error

3.3.1(c) Phenotypic and genotypic coefficients of variation

The phenotypic and genotypic coefficients of variation were calculated by the formula suggested by Burton and Devane (1953).

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\sqrt{Vp}}{\bar{X}} \times 100$$

where,

Vp = Phenotypic variance

$\bar{X}$ = Mean of the character under study

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sqrt{Vg}}{\bar{X}} \times 100$$

where,

Vg = Genotypic variance

$\bar{X}$ = Mean of the character under study

The estimates of PCV and GCV were classified as

High	-	>20 per cent
Low	-	<10 per cent
Moderate	-	10-20 per cent

3.3.1(d) Heritability

Heritability in the broad sense was estimated by following the formula suggested by Burton and Devane (1953).

$$\text{Heritability (H)} = \frac{Vg}{Vp} \times 100$$

where,

Vg = Genotypic variance

Vp = Phenotypic variance

The heritability was categorised as

High	-	60-100 per cent
Moderate	-	30-60 per cent
Low	-	< 30 per cent

3.3.1(e) Expected genetic advance

The expected genetic advance of the cultures was measured by the formula suggested by Lush (1949), Johnson *et al.* (1955a) at five per cent selection intensity using the constant K as 2.06 given by Allard (1960).

$$\text{Expected genetic advance (GA)} = \frac{Vg}{\sqrt{Vp}} \times K$$

where,

Vg = Genotypic variance

Vp = Phenotypic variance

K = Selection differential

3.3.1(f) Phenotypic and genotypic correlation coefficients

The phenotypic and genotypic covariances were worked out in the same way as the variances were calculated. Mean product expectations of the covariance analyses are analogous to the mean square expectation of the analyses of variance. The different covariance estimates were calculated by the method suggested by Fisher (1954) using the statistical package SPAR 1.

Phenotypic covariance between two characters 1 and 2 (CoVp12) = CoVg12 + CoVe12

where,

CoVg12 = Genotypic covariance between characters 1 and 2 and

CoVe12 = Environmental covariance between characters 1 and 2

Genotypic covariance between two characters 1 and 2 is as follows,

$$CoVg12 = \frac{Mt12 - Me12}{N}$$

where,

Mt12 = Mean sum of product due to treatment between characters 1 and 2

Me12 = Mean sum of product due to error between characters 1 and 2

N = Number of replications

The phenotypic and genotypic correlation coefficients among the various characters were worked out in all possible combinations according to the formula suggested by Johnson *et al.* (1955b).

Phenotypic correlation coefficient between two characters 1 and 2.

$$(r_p12) = \frac{CoVp12}{\sqrt{Vp1\ Vp2}}$$

where,

CoVp12 = phenotypic covariance between characters 1 and 2

Vp1 = Phenotypic variance of character 1

Vp2 = Phenotypic variance of character 2

Genotypic correlation coefficient between two characters 1 and 2.

$$(r_g12) = \frac{CoVg12}{\sqrt{Vg1\ Vg2}}$$

where,

CoVg12 = Genotypic covariance between characters 1 and 2

Vg1 = Genotypic variance of character 1

Vg2 = Genotypic variance of character 2

3.3.1 (g) Path analysis

Path analysis was carried out by methods by Singh and Chaudhary (1985). For carrying out various statistical analyses the software package SPAR 1 was used.

3.3.1 (h) Mean performance

Mean performance of the accessions for individual seasons was used to analyse the performance with respect to each quantitative character.

3.3.1(i) G x E interaction using AMMI model and its evaluation for a balanced data

Non-genetic parameters like eigen value and eigen vectors as well as principal components are computed to predict Genotype x environment interaction (GEI) using AMMI model (Additive main effects and multiplicative interaction). This technique is useful to capture non-linear interactions, when Joint Regression technique fails to perceive important effects in studies of G x E interaction.

In AMMI model the interaction is described in terms of differential sensitivity to the most discriminating environmental variables that can be constructed. These environmental variables are hypothetical and obtained from the data themselves. No explicitly measured environmental variables enter the model. Because both environmental variables and genotypic sensitivities are estimated from the data table itself, the AMMI model is called a bilinear model. Given the column parameters the model is linear in the row parameters (Zobel *et al.*, 1988).

The AMMI model for a two-way table of genotype X environments may be written as

$$y_{ij} = \mu + \alpha_i + \beta_j + \sum_{m=1}^{m'} \lambda_m \gamma_{mi} \delta_{mj} + \theta_{ij}, \quad i = 1,\dots,K \text{ and } j = 1,\dots,N \qquad (1)$$

where,

y_{ij} is the mean yield of i th genotype in j th environment

μ is the grand mean

α_i is the i–th genotype mean deviation

β_j is the j–th environment mean deviation

m' is the number of PCA axes retained in the model

λ_m is the singular value for the PCA axis, m

λ_{mi} is the i-th genotype PCA score for the axis, m

δ_{mj} is th j-th environment PCA score for the axis, m

θ_{ij} is the residual

The basic model is essentially a two way ANOVA model, which requires that the matrix of interaction parameters be decomposed by using factor analytic techniques.

Let us reparameterize the equation (1) to obtain the matrix of interaction parameters as

$$y_{ij} = \mu + \alpha_i + \beta_j + V_{ij} \qquad (2)$$

m′

where,

$$V_{ij} = \sum_{m=1} \lambda_m \gamma_{mi} \delta_{mj} + \theta_{ij}$$ of the equation (1)

Now the estimates of V_{ij} may be obtained as

$$V_{ij} = yij - \mu - \alpha_i - \beta_j \qquad (3)$$

From the matrix X of interaction estimates from V_{ij} 's such that each row of X denotes the interactions of a variety over N environments. Using factor analytic decomposition, the matrix X may be written as

$$X = ADB' \qquad (4)$$

Where

X is Kx N matrix with V_{ij} as elements

A is Kx M orthogonal matrix

D is M xM diagonal matrix with elements $d_1 \geq d_2 \geq \ldots$

B is N x M orthogonal matrix

M is the rank of X

The matrices A, D and B of equation (4) may be obtained from the characteristic vectors and characteristic roots of K x K matrix XX'. The K x M matrix A then consists of the characteristic vectors and the M x M diagonal matrix D consists of the square roots of the characteristic roots of XX'. The N x M matrix can then obtained by solving

$$B = X' AD^{-1} \qquad (5)$$

The above solution specifies that the matrices D and A found by solving the eigen values and eigen vectors of the matrix XX' and then the matrix B be obtained from (5). It is also possible to solve for the matrices D and B by finding the eignvalues and eigenvectors of the matrix X'X and then obtaining A from X BD^{-1}.For ease of calculation it is convenient to solve for the eigen values and eigen vectors of either X'X or XX' whichever has smaller dimension.

The environmental eigen vector corresponding to λ_1 (first column of B) represents the hypothetical environmental variable that describes the largest amount of interaction and thus best discriminates between genotypes, the second axis the second largest amount and so on (Bajpai, 1998).

Graphical display of interaction with AMMI interaction parameters is known as Biplot.

Let us redistribute the singular values, λ_m over the genotypic scores, $\gamma^*_{mi} = \gamma_{mi} \lambda_m^c$ and the environmental scores $\delta_{mj}\lambda_m^{(1-c)}$; where c is a scaling constant ,varies from 0 to 1.The features of the biplot, however are not too critically dependent on c , and c = 0.5 may suit well for most problems.

The statistical analysis was carried out using the software IRRISTAT package.

Results and Discussion

4. RESULTS

The experiments on genotype x environment interaction in fifty accessions of semi-erect cowpea was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara during 2004-2005 in three seasons *viz.*, *Kharif* (June 2004 - September 2004), *Rabi* (October 2004 - February 2005) and summer (February - May 2005). The results obtained from mean performance, stability and variability of the present study are presented here.

4.1 QUALITATIVE CHARACTERS

The 50 cowpea accessions selected for the study behaved uniformly and were semi-erect in nature during all the seasons (Table 2). However, it showed wide variation for the remaining qualitative characters. Pod colour both at immature and mature stage varied widely from all the shades of green to purple (Plate 2). Out of the 50, the colour of pod at immature and mature stages were light green in eleven accessions; light green with purple tip in two accessions; purple in three accessions and purple with dark green tip in one accession. The remaining accessions had more or less uniform dark green colour.

When the accessions were characterized based on the arrangement of seeds 26 accessions had crowded seeds, five had non crowded and 19 accessions had semi crowded arrangement.

The observations on seed coat colour also revealed significant variability among the accessions (Table 2). Different colours like buff, dirty

Table 2. Qualitative characters of 50 semi-erect cowpea over all the seasons

Accessions.	Plant growth habit	Immature pod colour	Mature pod colour	Seed crowding	Seed coat colour
VS-1015	Semi-erect	Light green	Light green	Crowded	Buff
VS-1025	Semi-erect	Light green with purple tip	Light green with purple tip	Crowded	Dirty black
VS-1026	Semi-erect	Dark green	Dark green	Crowded	Brown
VS-1028	Semi-erect	Dark green	Dark green	Semi crowded	Red
VS-1030	Semi-erect	Light green	Light green	Semi crowded	Buff
VS-1032	Semi-erect	Dark green	Dark green	Semi crowded	Red
VS-1034	Semi-erect	Purple	Purple	Crowded	Purplish red
VS-1035	Semi-erect	Dark green	Dark green	Semi crowded	Deep red
VS-1042	Semi-erect	Dark green	Dark green	Crowded	Red
VS-1047	Semi-erect	Light green	Light green	Not crowded	Brown
VS-1053	Semi-erect	Dark green	Dark green	Semi crowded	Buff
VS-1054	Semi-erect	Dark green	Dark green	Semi crowded	Brown
VS-1058	Semi-erect	Dark green	Dark green	Semi crowded	Deep red
VS-1075	Semi-erect	Dark green	Dark green	Semi crowded	Deep red
VS-1104	Semi-erect	Light green	Light green	Semi crowded	Buff
VS-1111	Semi-erect	Dark green	Dark green	Semi crowded	Buff
VS-1133	Semi-erect	Dark green	Dark green	Semi crowded	Buff
VS-1135	Semi-erect	Dark green	Dark green	Semi crowded	Buff
VS-1140	Semi-erect	Dark green	Dark green	Crowded	Brown
VS-1151	Semi-erect	Light green	Light green	Crowded	Mottled
VS-1153	Semi-erect	Dark green	Dark green	Semi crowded	Red
VS-1156	Semi-erect	Light green	Light green	Semi crowded	Buff
VS-1160	Semi-erect	Dark green	Dark green	Crowded	Red
VS-1166	Semi-erect	Dark green with purlish tip	Dark green with purlish tip	Crowded	Buff
VS-1168	Semi-erect	Dark green	Dark green	Crowded	Red
VS-1170	Semi-erect	Light green	Light green	Crowded	Dirty black
VS-1171	Semi-erect	Light green with purple tip	Light green with purple tip	Crowded	Red
VS-1172	Semi-erect	Light green	Light green	Crowded	Red

Table 2. Qualitative characters of 50 semi-erect cowpea over all the seasons (cont…)

VS-1173	Semi-erect	Dark green	Dark green	Crowded	Black
VS-1174	Semi-erect	Dark green	Dark green	Crowded	Purple
VS-1175	Semi-erect	Light green with purple tip	Light green with purple tip	Crowded	Black
VS-1177	Semi-erect	Light green	Light green	Crowded	Buff
VS-1179	Semi-erect	Light green	Light green	Crowded	Buff
VS-1180	Semi-erect	Dark green with purplish tinch	Dark green with purplish tinch	Crowded	Black
VS-1185	Semi-erect	Dark green	Dark green	Semi crowded	Red
VS-1213	Semi-erect	Dark green	Dark green	Semi crowded	Red
VS-1215	Semi-erect	Light green	Light green	Not crowded	Buff
VS-1220	Semi-erect	Light green	Light green	Semi crowded	Buff
VS-1221	Semi-erect	Dark green	Dark green	Crowded	Creamish white
VS-1230	Semi-erect	Dark green	Dark green	Crowded	Purplish red
VS-1231	Semi-erect	Purple with dark green tip	Purple with dark green tip	Crowded	Black
VS-1235	Semi-erect	Purple tinched	Purple tinched	Not crowded	Buff
VS-1248	Semi-erect	Dark green	Dark green	Crowded	Buff
VS-1263	Semi-erect	Dark green	Dark green	Semi crowded	Red
VS-1276	Semi-erect	Dark green	Dark green	Crowded	Red
VS-1277	Semi-erect	Dark green	Dark green	Crowded	Red
VS-1282	Semi-erect	Dark green	Dark green	Semi crowded	Dirty black
VS-1294	Semi-erect	Dark green	Dark green	Crowded	Buff
VS-1266	Semi-erect	Purple	Purple	Not crowded	Purplish red
VS-1286	Semi-erect	Purple	Purple	Not crowded	Purplish red

Plate 2 Variability of pods in cowpea

black, brown, red, purplish red, deep red, black, creamish white and mottled (cream with brown) were recorded among the 50 accessions.

4.2 MEAN PERFORMANCE AND STABILITY OF COWPEA ACCESSIONS

The 50 semi-erect cowpea accessions showed significant differences with respect to all the quantitative characters studied when subjected to AMMI-1 PCA model.

4.2.1 Days to first flowering

The mean performance of 50 semi erect cowpea accessions for days to first flowering in each season are given in table 3. The accessions VS-1248 (31.00), VS-1025 (36.00), VS-1185 (37.00), VS-1034 (37.00) and VS-1174 (37.00) recorded the lowest number of days to flowering in summer. The accessions VS-1266 (Kairali) (33.00), VS-1248 (36.50), VS-1231 (39.00) and VS-1025 (39.50) recorded the lowest mean values in *Rabi* while during *Kharif,* the accessions VS-1177 (35.00), VS-1248 (38.50), VS-1042 (39.00), VS-1180 (39.50) and VS-1263 (39.50) were found to take the lowest number of days for first flowering.

However, the accession VS-1248 took minimum (35.33) number of days for first flowering followed by accessions VS-1025 (39.00), VS-1231 (39.17), VS-1177 (349.33), VS-1180 (39.50), VS-1266 (Kairali) (39.67), VS-1032 (40.00) and VS-1028 (40.00) when all the seasons were considered. All these accessions were found suitable for all environments in general.

Table 3. Mean performance of cowpea accessions for days to first flowering

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	61.00	40.50	42.00	47.83
2	VS-1025	41.50	39.50	36.00	39.00
3	VS-1026	41.50	46.00	48.00	45.17
4	VS-1028	40.50	40.50	39.00	40.00
5	VS-1030	42.00	42.50	43.50	42.67
6	VS-1032	39.50	42.00	38.50	40.00
7	VS-1034	47.00	38.00	37.00	40.67
8	VS-1035	42.00	43.50	39.50	41.67
9	VS-1042	39.00	41.00	40.00	40.00
10	VS-1047	50.00	46.00	42.50	46.17
11	VS-1053	51.50	41.00	40.00	44.17
12	VS-1054	39.50	48.50	42.50	43.50
13	VS-1058	41.00	45.00	40.00	42.00
14	VS-1075	45.50	47.00	40.50	44.33
15	VS-1104	44.00	42.00	43.50	43.17
16	VS-1111	43.00	44.50	40.50	42.67
17	VS-1133	51.50	43.50	42.50	45.83
18	VS-1135	42.50	46.00	41.00	43.17
19	VS-1140	52.00	47.50	47.00	48.83
20	VS-1151	42.50	44.00	51.00	45.83
21	VS-1153	44.00	46.50	38.00	42.83
22	VS-1156	42.50	41.50	42.00	42.00
23	VS-1160	41.00	41.50	41.50	41.33
24	VS-1166	52.50	39.50	37.50	43.17
25	VS-1168	46.00	43.00	37.50	42.17
26	VS-1170	47.00	43.00	37.50	42.50
27	VS-1171	46.00	47.00	39.00	44.00
28	VS-1172	44.50	46.00	37.50	42.67
29	VS-1173	43.00	44.00	41.00	42.67
30	VS-1174	39.50	46.50	37.00	41.00
31	VS-1175	43.00	46.50	42.00	43.83
32	VS-1177	35.00	45.00	38.00	39.33
33	VS-1179	42.50	45.50	37.50	41.83
34	VS-1180	39.50	42.50	36.50	39.50
35	VS-1185	40.00	43.00	37.00	40.00
36	VS-1213	41.50	45.00	39.00	41.83
37	VS-1215	41.50	44.00	43.00	42.83
38	VS-1220	47.00	43.00	43.00	44.33
39	VS-1221	46.50	43.50	45.00	45.00
40	VS-1230	40.50	56.00	46.50	47.67
41	VS-1231	40.00	39.00	38.50	39.17
42	VS-1235	61.50	42.00	39.00	47.50
43	VS-1248	38.50	36.50	31.00	35.33
44	VS-1263	39.50	43.00	38.00	40.17
45	VS-1276	42.50	44.00	39.50	42.00
46	VS-1277	47.00	54.50	37.50	46.33
47	VS-1282	52.00	58.00	43.50	51.17
48	VS-1294	60.50	44.00	43.50	49.33
49	VS-1266	48.00	33.00	38.00	39.67
50	VS-1286	43.00	43.50	42.00	42.83
	Mean	44.65	43.97	40.42	-
	SE	0.60	0.60	0.60	-

Among the three environments, summer was found to be best (40.42) for cowpea when days to first flowering are considered. During *Rabi* it took 43.97 days for first flowering while during *Kharif* it took 44.65 days.

4.2.2 Days to 50 per cent flowering

The data on days to 50 per cent flowering are presented in table 4.

The accessions VS-1248 (34.50), VS-1180 (39.00), VS-1025 (40.00), VS-1174 (40.00) and VS-1034 (40.50) flowered early during summer season whereas accessions VS-1266 (Kairali) (39.00), VS-1248 (42.00), VS-1025 (42.50), VS-1034 (42.50), VS-1015 (44.00) were early during *Rabi* and accessions VS-1248 (43.50), VS-1177 (44.50), VS-1174 (48.50), VS-1025 (49.02), VS-1035 (49.50) were early during *Kharif.*

The accession VS-1248 took the lowest number of days to achieve 50 per cent flowering and was early during all the seasons. This was followed by accessions VS-1025 (43.83), VS-1266 (Kairali) (45.00), VS-1034 (45.33), VS-1028 (45.50), VS-1032 (45.83).

The lowest number of days to 50 per cent flowering was recorded during summer (43.50) followed by *Rabi* (49.79) whereas the accessions took the highest number of days to achieve 50 per cent flowering (54.69 days) during *Kharif.*

4.2.3 Number of primary branches

The data on mean number of primary branches of cowpea accessions is presented in table 5.

Table 4. Mean performance of cowpea accessions for days to 50 per cent flowering

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	70.00	44.00	47.00	53.67
2	VS-1025	49.00	42.50	40.00	43.83
3	VS-1026	51.50	49.50	50.00	50.33
4	VS-1028	50.00	44.50	42.00	45.50
5	VS-1030	52.00	48.50	46.00	48.83
6	VS-1032	49.50	46.00	42.00	45.83
7	VS-1034	53.00	42.50	40.50	45.33
8	VS-1035	49.50	48.50	42.00	46.67
9	VS-1042	52.00	45.50	43.00	46.83
10	VS-1047	60.00	49.00	46.00	51.67
11	VS-1053	61.00	45.00	42.50	49.50
12	VS-1054	55.00	53.50	45.50	51.33
13	VS-1058	52.50	50.00	41.50	48.00
14	VS-1075	61.50	54.00	43.00	52.83
15	VS-1104	57.00	48.50	47.00	50.83
16	VS-1111	53.00	49.00	44.50	48.83
17	VS-1133	63.00	49.50	45.00	52.50
18	VS-1135	51.00	51.00	43.50	48.50
19	VS-1140	62.50	52.50	50.50	55.17
20	VS-1151	51.00	50.50	53.00	51.50
21	VS-1153	50.00	51.00	40.50	47.17
22	VS-1156	54.50	48.50	43.50	48.83
23	VS-1160	50.50	48.50	44.50	47.83
24	VS-1166	61.50	45.00	40.50	49.00
25	VS-1168	55.00	46.50	41.00	47.50
26	VS-1170	57.50	50.00	40.50	49.33
27	VS-1171	54.50	52.50	41.00	49.33
28	VS-1172	56.00	54.00	41.00	50.33
29	VS-1173	56.00	50.00	44.50	50.17
30	VS-1174	48.50	52.50	40.00	47.00
31	VS-1175	51.50	54.00	44.00	49.83
32	VS-1177	44.50	56.00	41.00	47.17
33	VS-1179	52.00	50.50	41.00	47.83
34	VS-1180	54.50	53.50	39.00	49.00
35	VS-1185	54.50	52.50	42.00	49.67
36	VS-1213	50.50	51.00	41.50	47.67
37	VS-1215	50.00	51.50	46.50	49.33
38	VS-1220	57.00	49.00	46.50	50.83
39	VS-1221	50.00	51.50	49.00	50.17
40	VS-1230	49.50	64.00	49.00	54.17
41	VS-1231	54.50	45.50	41.50	47.17
42	VS-1235	70.00	49.50	44.50	54.67
43	VS-1248	43.50	42.00	34.50	40.00
44	VS-1263	54.00	48.50	42.00	48.17
45	VS-1276	55.50	49.00	42.50	49.00
46	VS-1277	59.00	58.50	41.50	53.00
47	VS-1282	62.00	62.00	46.00	56.67
48	VS-1294	66.00	49.50	46.00	53.83
49	VS-1266	54.00	39.00	42.00	45.00
50	VS-1286	54.00	50.00	44.50	49.50
	Mean	54.69	49.79	43.50	-
	SE	0.60	0.60	0.60	-

Table 5. Mean performance of cowpea accessions for number of primary branches

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	9.10	4.70	8.10	7.30
2	VS-1025	10.50	5.40	8.30	8.00
3	VS-1026	9.20	4.30	7.40	6.97
4	VS-1028	7.50	3.70	6.40	5.87
5	VS-1030	7.50	5.40	7.10	6.67
6	VS-1032	7.60	5.20	6.80	6.50
7	VS-1034	7.10	4.40	5.30	5.60
8	VS-1035	8.60	5.30	5.60	6.50
9	VS-1042	8.70	4.40	6.30	6.47
10	VS-1047	7.50	4.90	7.60	6.67
11	VS-1053	4.70	4.30	7.00	5.33
12	VS-1054	6.50	4.80	5.40	5.50
13	VS-1058	9.60	5.00	5.80	6.80
14	VS-1075	7.20	3.50	5.00	5.23
15	VS-1104	7.50	4.60	7.00	6.37
16	VS-1111	6.30	4.60	6.60	5.83
17	VS-1133	6.60	4.70	6.50	5.93
18	VS-1135	7.10	4.50	6.50	6.00
19	VS-1140	7.00	5.40	6.4	6.27
20	VS-1151	5.30	5.40	6.10	5.60
21	VS-1153	4.70	5.20	8.70	6.20
22	VS-1156	4.00	4.70	6.50	5.00
23	VS-1160	4.60	4.20	5.60	4.80
24	VS-1166	4.30	5.60	9.00	6.30
25	VS-1168	4.60	5.70	9.20	6.50
26	VS-1170	6.20	5.40	9.40	7.00
27	VS-1171	4.40	6.10	9.60	6.70
28	VS-1172	4.30	5.00	9.00	6.10
29	VS-1173	3.50	7.50	6.90	5.97
30	VS-1174	4.40	6.50	8.10	6.33
31	VS-1175	7.00	5.00	9.40	7.13
32	VS-1177	7.10	5.90	10.00	7.67
33	VS-1179	6.80	6.40	9.90	7.70
34	VS-1180	6.10	5.10	6.20	5.80
35	VS-1185	5.30	7.10	7.90	6.77
36	VS-1213	5.50	4.70	6.00	5.40
37	VS-1215	5.90	5.20	6.50	5.87
38	VS-1220	5.40	5.00	5.50	5.30
39	VS-1221	4.90	5.00	8.90	6.27
40	VS-1230	5.00	5.50	6.90	5.80
41	VS-1231	5.10	5.80	5.80	5.50
42	VS-1235	5.60	5.40	5.90	5.63
43	VS-1248	4.50	6.30	6.20	5.67
44	VS-1263	3.70	4.70	5.60	4.67
45	VS-1276	6.50	6.10	7.10	6.50
46	VS-1277	4.30	5.70	7.30	5.77
47	VS-1282	7.00	6.70	7.00	6.90
48	VS-1294	6.50	5.00	6.50	6.00
49	VS-1266	5.20	5.00	6.60	5.60
50	VS-1286	5.10	4.20	7.2	5.50
	Mean	6.17	5.20	7.11	-
	SE	0.18	0.18	0.18	-

During summer, the accession VS-1177 (10.00) recorded the highest number of primary branches followed by the accessions VS-1179 (9.90), VS-1171 (9.60), VS-1175 and VS-1170 (9.40), VS-1168 (9.20), VS-1166 and VS-1172 (9.00), where as the accessions VS-1025 (10.50), VS-1058 (9.60), VS-1026 (9.20) and VS-1015 (9.10) were superior during *Kharif* . In the low performing environment like *Rabi*, the accessions VS-1173 (7.50) and VS-1185 (7.10) were found to have more number of primary branches.

The accession VS-1025 possessed the maximum (8.07) mean number of primary branches when all the seasons were considered. This was followed by accessions VS-1179 (7.70), VS-1177 (7.67), VS-1015 (7.30), VS-1175 (7.13), VS-1170 (7.00) and so on.

The mean highest number of primary branches was recorded during summer (7.11) followed by *Kharif* (6.17) and *Rabi* (5.20).

4.2.4 Length of main branch

The data on the length of main branch are presented in table 6.

During *Kharif*, the accessions VS-1282 (260.00 cm), VS-1042 (221.50 cm), VS-1179 (202.20 cm), VS-1032 (197.00 cm), VS-1276 (Kanakamony) (193.00 cm) and VS-1172 (192.50 cm) recorded the highest length of main branch where as during summer the accessions VS-1015 (181.80 cm), VS-1026 (179.80 cm), VS-1276 (Kanakamony) (173.50 cm) and VS-1263 (172.50 cm) had highest length. During *Rabi*, the accessions VS-1058 (181.20 cm), VS-1179 (173.50 cm), VS-1286 (Varun) (170.30 cm), VS-1266 (Kairali) (164.90 cm) and VS-1032 (154.40 cm) had the highest mean values.

The accession VS-1282 recorded the highest mean length of main branch (186.00 cm) when all the seasons were considered, followed by VS-1179

Table 6. Mean performance of cowpea accessions for length of main branch (cm)

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	161.70	115.50	181.80	153.00
2	VS-1025	159.00	118.50	165.90	147.80
3	VS-1026	122.00	83.50	179.80	128.40
4	VS-1028	119.50	121.60	158.20	133.10
5	VS-1030	181.00	98.90	130.20	136.70
6	VS-1032	197.00	154.4 0	134.60	162.00
7	VS-1034	167.00	149.10	137.90	151.30
8	VS-1035	121.00	153.2	149.70	141.30
9	VS-1042	221.50	98.50	136.10	152.00
10	VS-1047	181.00	119.60	126.80	142.50
11	VS-1053	107.00	108.50	145.70	120.40
12	VS-1054	183.00	123.00	145.70	150.60
13	VS-1058	120.50	181.20	129.40	143.70
14	VS-1075	182.50	141.00	125.30	149.60
15	VS-1104	136.00	91.30	137.40	121.60
16	VS-1111	138.50	95.50	139.10	124.40
17	VS-1133	108.50	100.00	138.70	115.70
18	VS-1135	128.50	99.00	137.90	121.80
19	VS-1140	143.50	95.00	145.60	128.00
20	VS-1151	155.00	90.50	137.30	127.60
21	VS-1153	155.50	105.80	133.50	131.60
22	VS-1156	138.80	105.30	126.80	123.70
23	VS-1160	138.10	112.10	144.90	131.70
24	VS-1166	134.50	103.00	146.80	128.10
25	VS-1168	164.20	88.00	152.90	135.00
26	VS-1170	105.50	113.80	159.10	126.10
27	VS-1171	158.50	119.30	161.80	146.50
28	VS-1172	192.50	99.10	160.30	150.60
29	VS-1173	146.90	105.70	163.90	138.80
30	VS-1174	179.50	125.40	164.40	156.40
31	VS-1175	135.70	136.50	143.80	138.70
32	VS-1177	146.30	145.70	137.30	143.10
33	VS-1179	202.20	173.50	156.60	177.40
34	VS-1180	177.20	123.50	143.70	148.10
35	VS-1185	188.20	126.80	134.20	149.70
36	VS-1213	138.60	115.50	163.90	139.30
37	VS-1215	141.10	130.00	161.60	144.20
38	VS-1220	118.70	136.10	158.20	137.70
39	VS-1221	114.60	107.20	160.10	127.30
40	VS-1230	159.80	147.00	157.90	154.90
41	VS-1231	153.00	97.00	126.30	125.40
42	VS-1235	118.00	78.80	135.50	110.80
43	VS-1248	152.50	97.30	115.60	121.80
44	VS-1263	187.50	92.10	172.50	150.70
45	VS-1276	193.00	115.50	173.50	160.70
46	VS-1277	157.70	123.50	163.40	148.20
47	VS-1282	260.00	153.70	144.20	186.00
48	VS-1294	181.00	145.50	143.10	156.50
49	VS-1266	159.50	164.90	161.60	162.00
50	VS-1286	151.50	170.30	167.50	163.10
	Mean	155.68	119.91	148.36	-
	SE	3.36	3.36	3.36	-

(177.40 cm), VS-1286 (Varun) (163.10 cm), VS-1032 and VS-1266 (Kairali) (162.00 cm), VS-1276 (Kanakamony) (160.70 cm).

Maximum length of main branch (155.68 cm) was recorded during *Kharif* followed by summer (148.36 cm) and *Rabi* (119.91 cm).

4.2.5 Number of clusters per plant

The data on mean number of clusters per plant is given in table 7.

During summer, the accessions VS-1177 (23.50), VS-1170 (22.00), VS-1172 (21.90), VS-1179 (21.40), VS-1025 (21.10), VS-1294 (20.30) were found to have more clusters, whereas the accessions VS-1177 (23.80), VS-1221 (22.70), VS-1175 (21.00), VS-1179 (20.30), VS-1170 (20.20) were found to be better during *Rabi*. The highest number of clusters was recorded for accessions VS-1177 (22.80), VS-1175 (20.50), VS-1294 (20.30), VS-1025 (19.60) and VS-1042 (19.10) during *Kharif*.

Considering all the seasons the highest mean number of clusters per plant was recorded by the accession VS-1177 (23.37) followed by VS-1025 (20.13), VS-1175 (19.93), VS-1179 (19.80) and VS-1294 (19.33).

High mean number of clusters per plant was recorded during summer (16.19) followed by *Rabi* (15.19) and *Kharif* (13.01).

4.2.6 Number of pods per plant

The data on mean number of pods per plant is presented in table 8.

The mean performance during each season differed significantly for number of pods per plant. During summer, the accessions VS-1177 (38.50), VS-

Table 7. Mean performance of cowpea accessions for number of clusters per plant

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	13.30	12.90	16.80	14.33
2	VS-1025	19.60	19.70	21.10	20.13
3	VS-1026	5.90	17.00	19.00	13.97
4	VS-1028	8.30	13.10	8.70	10.00
5	VS-1030	6.00	16.80	14.30	12.37
6	VS-1032	14.90	12.70	19.80	15.80
7	VS-1034	11.80	17.00	18.50	15.77
8	VS-1035	14.20	14.90	15.20	14.77
9	VS-1042	19.10	12.20	18.50	16.60
10	VS-1047	7.40	10.60	19.80	12.60
11	VS-1053	9.70	12.20	13.50	11.80
12	VS-1054	12.50	8.80	14.80	12.00
13	VS-1058	13.10	10.80	12.00	11.97
14	VS-1075	15.30	10.80	10.60	12.23
15	VS-1104	7.40	19.90	11.80	13.00
16	VS-1111	15.0	19.80	17.50	17.43
17	VS-1133	17.10	19.00	16.50	17.50
18	VS-1135	15.00	18.30	13.60	15.63
19	VS-1140	6.70	10.50	11.60	9.600
20	VS-1151	14.70	16.10	17.20	16.00
21	VS-1153	9.30	14.10	14.60	12.67
22	VS-1156	11.10	14.70	16.50	14.10
23	VS-1160	16.50	14.20	18.20	16.30
24	VS-1166	13.80	17.20	18.30	16.43
25	VS-1168	12.70	13.00	10.70	12.13
26	VS-1170	10.90	20.20	22.00	17.70
27	VS-1171	9.40	17.40	19.90	15.50
28	VS-1172	12.60	16.60	21.90	17.00
29	VS-1173	13.10	17.20	20.00	16.77
30	VS-1174	11.00	19.90	19.30	16.73
31	VS-1175	20.50	21.00	18.30	19.93
32	VS-1177	22.80	23.80	23.50	23.37
33	VS-1179	17.70	20.30	21.40	19.80
34	VS-1180	11.20	13.90	13.70	12.93
35	VS-1185	14.20	15.60	19.30	16.37
36	VS-1213	9.80	10.70	12.10	10.87
37	VS-1215	9.50	12.60	10.30	10.80
38	VS-1220	11.60	15.80	13.80	13.73
39	VS-1221	17.10	22.70	16.80	18.87
40	VS-1230	9.80	10.20	12.10	10.70
41	VS-1231	12.40	12.80	13.60	12.93
42	VS-1235	12.50	12.70	9.80	11.67
43	VS-1248	11.50	16.40	12.70	13.50
44	VS-1263	10.50	9.70	10.20	10.13
45	VS-1276	11.80	13.80	17.80	14.47
46	VS-1277	16.80	9.300	19.10	15.00
47	VS-1282	16.30	14.50	19.20	16.67
48	VS-1294	20.30	17.40	20.30	19.33
49	VS-1266	13.00	14.30	16.90	14.73
50	VS-1286	13.80	14.70	16.60	15.00
	Mean	13.0	15.19	16.19	-
	SE	0.39	0.39	0.39	-

Table 8. Mean performance of cowpea accessions for number of pods per plant

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	8.50	13.50	10.50	10.83
2	VS-1025	20.50	26.50	26.50	24.50
3	VS-1026	8.50	12.00	14.50	11.67
4	VS-1028	10.50	8.50	22.00	13.67
5	VS-1030	11.00	5.00	11.50	9.16
6	VS-1032	15.50	15.00	15.00	15.17
7	VS-1034	14.00	8.50	14.50	12.33
8	VS-1035	15.50	10.50	11.00	12.33
9	VS-1042	18.50	8.50	15.50	14.17
10	VS-1047	18.50	11.50	10.50	13.50
11	VS-1053	13.00	10.50	14.00	12.50
12	VS-1054	10.50	8.00	19.50	12.67
13	VS-1058	7.000	9.500	12.00	9.500
14	VS-1075	8.500	12.50	13.00	11.33
15	VS-1104	11.50	5.00	8.00	8.167
16	VS-1111	17.50	16.50	28.50	20.83
17	VS-1133	20.50	13.50	16.50	16.83
18	VS-1135	18.50	17.00	14.00	16.50
19	VS-1140	9.500	7.50	9.00	8.667
20	VS-1151	15.00	13.50	32.00	20.17
21	VS-1153	7.50	10.50	22.50	13.50
22	VS-1156	9.00	5.50	6.00	6.833
23	VS-1160	15.50	8.50	13.00	12.33
24	VS-1166	15.50	7.50	10.00	11.00
25	VS-1168	14.50	6.00	17.50	12.67
26	VS-1170	14.50	9.50	24.50	16.17
27	VS-1171	15.00	13.50	33.00	20.50
28	VS-1172	16.00	9.50	35.00	20.17
29	VS-1173	15.00	9.00	12.50	12.17
30	VS-1174	26.00	9.50	16.50	17.33
31	VS-1175	18.00	23.00	17.00	19.33
32	VS-1177	31.00	25.50	38.50	31.67
33	VS-1179	21.00	16.00	35.00	24.00
34	VS-1180	9.00	3.50	23.50	12.00
35	VS-1185	18.00	5.00	15.75	12.92
36	VS-1213	12.00	5.00	19.50	12.17
37	VS-1215	6.00	10.50	5.00	7.167
38	VS-1220	6.50	6.00	5.50	6.00
39	VS-1221	18.50	11.50	8.50	12.83
40	VS-1230	6.50	3.50	8.00	6.00
41	VS-1231	21.00	10.00	20.50	17.17
42	VS-1235	15.00	6.00	16.50	12.50
43	VS-1248	20.50	5.00	23.50	16.33
44	VS-1263	10.00	8.00	14.50	10.83
45	VS-1276	16.50	11.50	11.50	13.17
46	VS-1277	12.00	7.00	15.00	11.33
47	VS-1282	28.50	7.00	11.50	15.67
48	VS-1294	19.00	6.50	10.50	12.00
49	VS-1266	7.00	3.50	7.00	5.83
50	VS-1286	14.50	7.50	7.50	9.83
	Mean	10.00	14.63	16.45	-
	SE	0.70	0.70	0.70	-

1179 (35.00), VS-1172 (35.00), VS-1171 (33.00), VS-1151 (32.00) and VS-1111 (28.50) recorded the highest mean number of pods per plant. During *Kharif*, the accessions VS-1177 (31.00), VS-1282 (28.50), VS-1174 (26.00), VS-1179 (21.00) and VS-1133 (20.50) were found highly suitable. However, during *Rabi* the accessions VS-1025 (26.50), VS-1177 (25.50), VS-1175 (23.00), VS-1135 (17.00) and VS-1111 (16.50) were promising.

Out of the 50 accessions evaluated, the accession VS-1177 (31.67) recorded the highest number of pods per plant, followed by VS-1025 (24.50), VS-1179 (24.00), VS-1111 (20.83), VS-1171 (20.50), VS-1151 (20.17) and VS-1172 (20.17).

When all the seasons were considered, it was during summer that the highest number of pods per plant was recorded (16.45). It was followed by *Kharif* (14.63) whereas in *Rabi* it was lowest (10.00).

4.2.7 Green pod yield per plant

The green pod yield per plant during three seasons is furnished in table 9.

During summer 2005, maximum yield was recorded for accessions VS-1177 (206.90 g), VS-1179 (183.90 g), VS-1172 (159.50 g), VS-1025 (147.50 g), VS-1180 (145.00 g) and VS-1170 (138.30 g). During *Kharif*, green pod yield per plant was maximum in the accession VS-1177 (199.00 g) followed by VS-1042 (128.50 g), VS-1025 (120.00 g), VS-1104 (117.00 g) and VS-1174 (115.50 g). During *Rabi*, the accessions VS-1177 (159.50 g), VS-1025 (144.50 g), VS-1175 (126.30 g), VS-1015 (122.70 g) and VS-1032 (104.00 g) were found to be better.

Table 9. Mean performance of cowpea accessions for green pod yield per plant (g)

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	92.50	122.70	94.50	103.20
2	VS-1025	120.00	144.50	147.50	137.30
3	VS-1026	52.50	58.00	75.88	62.12
4	VS-1028	67.00	39.00	80.70	62.23
5	VS-1030	97.00	26.00	87.23	70.00
6	VS-1032	108.00	104.00	94.40	102.10
7	VS-1034	85.00	53.00	90.29	76.10
8	VS-1035	88.60	58.75	63.00	70.12
9	VS-1042	128.50	53.50	93.71	91.90
10	VS-1047	107.50	66.50	59.45	77.82
11	VS-1053	52.50	42.12	55.50	50.00
12	VS-1054	74.00	54.12	136.00	88.00
13	VS-1058	64.00	53.50	76.00	64.50
14	VS-1075	48.00	64.00	70.50	60.83
15	VS-1104	117.00	46.65	78.00	80.50
16	VS-1111	79.50	74.00	130.00	94.50
17	VS-1133	106.00	66.50	83.50	85.33
18	VS-1135	55.00	63.50	41.50	53.36
19	VS-1140	39.16	35.00	35.50	36.50
20	VS-1151	59.50	80.00	123.8	87.78
21	VS-1153	48.50	59.00	107.2	71.50
22	VS-1156	63.50	43.50	40.00	49.00
23	VS-1160	48.50	24.50	50.00	41.00
24	VS-1166	90.50	36.00	42.50	56.33
25	VS-1168	69.50	22.00	87.50	59.67
26	VS-1170	103.00	56.44	138.3	99.24
27	VS-1171	77.00	68.25	136.00	93.75
28	VS-1172	94.00	50.20	159.50	101.20
29	VS-1173	63.50	21.60	49.90	45.00
30	VS-1174	115.50	48.50	77.50	80.50
31	VS-1175	94.50	126.3	79.10	99.98
32	VS-1177	199.00	159.50	206.90	188.50
33	VS-1179	104.00	81.30	183.90	123.10
34	VS-1180	84.00	29.00	145.00	86.00
35	VS-1185	91.50	32.00	105.50	76.33
36	VS-1213	98.00	37.00	95.50	76.83
37	VS-1215	75.00	98.15	48.00	73.72
38	VS-1220	76.50	49.50	50.00	58.67
39	VS-1221	35.00	34.00	17.50	28.83
40	VS-1230	51.00	32.00	47.00	43.33
41	VS-1231	77.50	32.50	67.50	59.17
42	VS-1235	82.00	33.17	81.50	65.50
43	VS-1248	41.00	10.00	37.50	29.50
44	VS-1263	50.00	50.00	68.50	56.17
45	VS-1276	80.50	72.50	69.00	74.00
46	VS-1277	66.00	37.50	82.50	62.00
47	VS-1282	57.25	12.35	30.50	33.37
48	VS-1294	42.50	15.00	21.50	26.33
49	VS-1266	46.50	22.50	39.50	36.17
50	VS-1286	98.35	78.00	33.00	69.78
	Mean	79.29	55.51	82.29	-
	SE	3.33	3.33	3.33	-

The accessions VS-1177 (188.50 g), VS-1025 (137.20 g), VS-1179 (123.10 g), VS-1015 (103.20 g), VS-1032 (102.10 g) and VS-1172 (101.20 g) had the highest mean green pod yield per plant in the pooled analysis. In all the seasons the accession VS-1177 out yielded others.

Maximum green pod yield per plant was recorded during summer (82.29 g) followed by *Kharif* (79.29 g) and *Rabi* (55.51 g).

4.2.8 Peduncle length

The data on the peduncle length are presented in table 10.

During summer the highest peduncle length was noticed for accessions VS-1133 (45.88 cm), VS-1030 (45.31 cm), VS-1160 (44.25 cm), VS-1015 (43.95 cm) and VS-1215 (43.77 cm). During *Kharif*, the accessions VS-1140 (46.60 cm), VS-1266 (Kairali) (42.80 cm), VS-1030 (42.30 cm), VS-1156 (40.20 cm) and VS-1174 (40.10 cm) and during *Rabi* VS-1030 (40.58 cm), VS-1286 (Varun) (33.39 cm), VS-1028 (32.38 cm), VS-1266 (Kairali) (32.20 cm) and VS-1171 (31.93 cm) expressed the maximum mean peduncle length.

The accession VS-1030 recorded the highest overall mean peduncle length of 42.73 cm followed by VS-1266 (Kairali) (36.74 cm), VS-1156 (34.08 cm), VS-1133 (33.99 cm) and VS-1140 (33.98 cm).

The highest mean peduncle length was noticed during summer (32.81 cm) followed by *Kharif* (29.01 cm) and *Rabi* (25.89 cm).

4.2.9 Pod length

The data on mean pod length of the cowpea accessions are presented in table 11.

Table 10. Mean performance of cowpea accessions for peduncle length (cm)

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	26.30	29.00	43.95	33.11
2	VS-1025	28.30	27.50	40.76	32.21
3	VS-1026	24.80	28.50	25.33	26.22
4	VS-1028	27.10	32.38	31.50	30.33
5	VS-1030	42.30	40.50	45.31	42.73
6	VS-1032	26.50	30.63	31.15	29.43
7	VS-1034	30.10	30.00	33.76	31.29
8	VS-1035	29.10	30.96	29.33	29.80
9	VS-1042	27.60	30.50	26.88	28.34
10	VS-1047	31.24	28.44	33.21	30.96
11	VS-1053	29.20	29.00	32.65	30.31
12	VS-1054	32.20	20.93	15.98	23.00
13	VS-1058	30.50	26.96	27.21	28.22
14	VS-1075	35.20	31.87	31.23	32.77
15	VS-1104	34.30	28.82	32.50	31.89
16	VS-1111	27.15	30.50	38.66	32.13
17	VS-1133	26.20	29.87	45.88	33.99
18	VS-1135	32.80	28.33	37.68	32.94
19	VS-1140	46.60	24.50	30.78	33.98
20	VS-1151	27.40	27.50	33.50	29.50
21	VS-1153	35.00	31.72	33.26	33.33
22	VS-1156	40.20	30.00	32.00	34.00
23	VS-1160	22.10	16.36	44.25	27.50
24	VS-1166	28.30	23.66	33.44	28.47
25	VS-1168	21.50	23.32	29.98	24.93
26	VS-1170	22.50	29.99	29.00	27.19
27	VS-1171	26.2	31.93	29.7	29.29
28	VS-1172	20.80	26.73	28.22	25.25
29	VS-1173	37.00	24.39	31.48	30.96
30	VS-1174	40.10	23.25	33.21	32.19
31	VS-1175	30.505	28.005	29.94	29.50
32	VS-1177	36.80	21.50	31.11	29.81
33	VS-1179	18.10	17.64	29.41	21.72
34	VS-1180	23.10	12.85	41.00	25.66
35	VS-1185	25.14	20.25	34.00	26.48
36	VS-1213	25.30	18.29	31.32	24.97
37	VS-1215	26.10	30.25	43.77	33.37
38	VS-1220	20.40	20.45	31.83	24.23
39	VS-1221	29.80	24.35	25.50	26.50
40	VS-1230	31.20	22.88	32.41	28.83
41	VS-1231	18.20	16.19	34.48	22.96
42	VS-1235	17.00	21.82	41.50	26.80
43	VS-1248	24.40	17.20	30.47	24.00
44	VS-1263	31.80	18.76	31.83	27.46
45	VS-1276	31.40	25.50	27.41	28.11
46	VS-1277	25.00	22.50	26.19	24.50
47	VS-1282	37.90	27.50	30.65	32.00
48	VS-1294	15.70	14.25	31.7	20.50
49	VS-1266	42.80	32.20	35.21	36.74
50	VS-1286	31.30	33.39	28.32	31.00
	Mean	29.00	25.89	32.81	-
	SE	0.79	0.79	0.79	-

Table 11. Mean performance of cowpea accessions for pod length (cm)

Sl.No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	28.45	29.64	33.00	30.39
2	VS-1025	17.94	19.42	20.29	19.22
3	VS-1026	17.40	18.97	18.19	18.19
4	VS-1028	16.89	18.72	19.34	18.32
5	VS-1030	27.50	27.72	25.50	26.94
6	VS-1032	16.97	18.17	18.29	17.81
7	VS-1034	16.92	21.00	22.19	20.00
8	VS-1035	16.25	18.00	18.64	17.66
9	VS-1042	18.00	18.35	19.79	18.73
10	VS-1047	18.90	24.41	23.99	22.43
11	VS-1053	14.20	13.93	17.29	15.14
12	VS-1054	21.90	25.82	24.23	23.98
13	VS-1058	19.15	19.45	19.84	19.48
14	VS-1075	18.35	20.22	19.507	19.38
15	VS-1104	31.20	28.35	28.89	29.48
16	VS-1111	17.80	15.50	16.63	16.67
17	VS-1133	13.60	17.24	17.77	16.20
18	VS-1135	15.38	16.49	16.37	16.00
19	VS-1140	16.35	24.40	23.42	21.39
20	VS-1151	17.95	24.77	22.50	21.77
21	VS-1153	18.65	18.50	18.37	18.50
22	VS-1156	20.00	20.94	23.31	21.42
23	VS-1160	18.65	18.501	14.85	17.34
24	VS-1166	16.50	18.40	18.97	17.97
25	VS-1168	16.25	18.00	18.24	17.50
26	VS-1170	14.35	15.50	17.49	15.8
27	VS-1171	16.30	17.72	17.72	17.25
28	VS-1172	15.70	18.50	18.63	17.62
29	VS-1173	11.20	16.49	16.16	14.62
30	VS-1174	14.90	18.10	19.00	17.33
31	VS-1175	16.15	16.50	16.50	16.39
32	VS-1177	16.60	17.24	18.00	17.31
33	VS-1179	15.85	17.63	17.67	17.00
34	VS-1180	18.70	18.72	18.69	18.70
35	VS-1185	17.50	17.41	17.50	17.50
36	VS-1213	17.50	18.46	18.44	18.15
37	VS-1215	24.00	25.43	27.00	25.50
38	VS-1220	29.50	27.29	28.79	28.50
39	VS-1221	13.44	16.60	14.60	14.88
40	VS-1230	17.44	20.34	20.44	19.41
41	VS-1231	11.19	15.00	15.35	13.86
42	VS-1235	14.47	16.94	15.98	15.80
43	VS-1248	10.94	9.800	10.33	10.36
44	VS-1263	18.25	17.00	17.84	17.73
45	VS-1276	17.29	18.92	20.00	18.74
46	VS-1277	16.40	18.29	18.85	17.85
47	VS-1282	12.30	13.80	13.43	13.18
48	VS-1294	10.80	11.72	12.23	11.50
49	VS-1266	22.34	21.91	12.19	18.81
50	VS-1286	25.60	19.74	19.00	21.47
	Mean	17.80	19.21	19.24	-
	SE	0.24	0.24	0.24	-

The highest mean pod length was recorded by the accessions VS-1015 (33.08 cm), VS-1104 (28.89 cm), VS-1220 (Anaswara) (28.79 cm), VS-1215 (27.08 cm) and VS-1030 (25.56 cm) during summer. The accessions VS-1104 (31.20 cm), VS-1220 (Anaswara) (29.50 cm), VS-1286 (Varun) (28.60 cm), VS-1015 (28.45 cm) and VS-1030 (27.54 cm), recorded the highest mean pod length during *Kharif*, while VS-1015 (29.64 cm), VS-1104 (28.35 cm), VS-1030 (27.72 cm), VS-1220 (Anaswara) (27.29 cm), VS-1054 (25.82 cm) recorded the highest pod length during *Rabi*.

The over all mean performance showed that the accession VS-1015 had the highest pod length (30.39 cm) followed by VS-1104 (29.48 cm), VS-1220 (Anaswara) (28.50 cm), VS-1030 (26.94 cm) and VS-1215 (25.50 cm).

The highest mean pod length was recorded during summer (19.24 cm), which was on par with *Rabi* (19.21 cm). However, during *Kharif* the mean pod length was lowest (17.80 cm).

4.2.10 Green biomass per plant

The data on green biomass yield are presented in table 12.

The green biomass was highest during summer for the accession VS-1026 (1112.00 g) followed by VS-1028 (875.00 g), VS-1030 (862.50 g), VS-1179 (837.50 g) and VS-1170 (762.50 g). The accession VS-1135 recorded highest green biomass during *Kharif* followed by VS-1177 (637.50 g), VS-1174 (612.50 g), VS-1140 (525.00 g), VS-1276 (Kanakamony) (1512.50 g) and VS-1179 (512.50 g). During *Rabi* the accession VS-1282 recorded the highest mean green biomass of 610.00 g followed by VS-1111 (562.50 g), VS-1170 (512.50 g), VS-1160 (412.50 g) and VS-1168 (350.00 g).

Table 12. Mean performance of cowpea accessions for green biomass per plant (g)

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	500.00	187.50	632.50	440.00
2	VS-1025	462.50	137.50	637.50	412.50
3	VS-1026	375.00	187.50	1112.00	558.30
4	VS-1028	325.00	273.50	875.00	491.20
5	VS-1030	255.00	200.00	862.50	439.20
6	VS-1032	250.00	312.50	512.50	358.30
7	VS-1034	272.50	165.00	312.50	250.00
8	VS-1035	450.00	312.50	625.00	462.50
9	VS-1042	275.00	212.50	312.50	266.70
10	VS-1047	362.50	250.00	462.50	358.30
11	VS-1053	237.50	195.00	287.50	240.00
12	VS-1054	237.50	162.50	312.50	237.50
13	VS-1058	462.50	212.50	262.50	312.50
14	VS-1075	462.50	212.50	200.00	291.70
15	VS-1104	225.00	312.50	287.50	275.00
16	VS-1111	262.50	562.50	187.50	337.50
17	VS-1133	337.50	187.50	312.50	279.20
18	VS-1135	637.50	162.50	262.50	354.20
19	VS-1140	525.00	162.50	287.50	325.00
20	VS-1151	255.00	140.00	312.50	235.8
21	VS-1153	295.00	237.50	300.00	277.50
22	VS-1156	250.00	112.50	537.50	300.00
23	VS-1160	262.50	412.50	525.00	400.00
24	VS-1166	337.50	187.50	487.50	337.50
25	VS-1168	312.50	350.00	337.50	333.30
26	VS-1170	300.00	512.50	762.50	525.00
27	VS-1171	350.00	137.50	762.50	416.70
28	VS-1172	275.00	187.50	662.50	375.00
29	VS-1173	237.50	175.00	300.00	237.50
30	VS-1174	612.50	162.50	600.00	458.30
31	VS-1175	275.00	200.00	587.50	354.20
32	VS-1177	637.50	235.00	475.6	449.40
33	VS-1179	512.50	287.50	837.50	545.80
34	VS-1180	262.50	137.50	287.50	229.20
35	VS-1185	325.00	292.50	512.50	376.70
36	VS-1213	262.50	165.00	312.50	246.70
37	VS-1215	225.00	150.00	212.50	195.80
38	VS-1220	375.00	112.50	362.50	283.30
39	VS-1221	337.50	110.00	237.50	228.30
40	VS-1230	475.00	212.50	300.00	329.20
41	VS-1231	225.00	170.00	162.50	185.80
42	VS-1235	225.00	170.00	210.00	201.70
43	VS-1248	237.50	137.50	187.50	187.50
44	VS-1263	287.50	212.50	225.00	241.70
45	VS-1276	512.50	300.00	425.00	412.50
46	VS-1277	425.00	287.50	587.50	433.30
47	VS-1282	362.50	610.00	625.00	532.50
48	VS-1294	212.50	210.00	612.50	345.00
49	VS-1266	237.50	237.50	325.00	266.70
50	VS-1286	237.50	237.50	637.50	370.80
	Mean	341.00	229.97	449.11	
	SE	20.72	20.72	20.72	-

The accession VS-1026, recorded the highest green biomass (558.30 g) followed by VS-1179 (545.80 g), VS-1282 (532.50 g), VS-1170 (525.00 g) and VS-1028 (491.20 g) when overall performance was considered.

During summer the biomass yield was highest (449.11 g) followed by *Kharif* (341.00 g) and *Rabi* (229.97 g).

4.2.11 Days to 80 per cent maturity

The data on days to 80 per cent maturity are presented in table 13.

During summer the accession VS-1231 recorded the lowest number of days to reach 80 per cent maturity 69.00, followed by VS-1166 (71.00), VS-1282, VS-1294, VS-1171, VS-1172, VS-1173, VS-1170, VS-1166, VS-1276 (Kanakamony), VS-1174 and VS-1263 (73.50). During *Rabi*, VS-1213 (64.00), VS-1030 (72.00), VS-1185 (75.50), VS-1026 (77.50) and VS-1172 (78.00) recorded the lowest days to 80 per cent maturity. During *Kharif*, the accessions VS-1213 (91.00), VS-1153 (94.50) and VS-1175 (99.50) recorded lowest number of days to 80 per cent maturity.

The overall performance of cowpea averaged over three seasons showed that the accession VS-1213 took the lowest number of days to achieve 80 per cent maturity (79.67) followed by VS-1235 (84.33), VS-1030 (84.67), VS-1185 (84.67), VS-1231 (86.67), VS-1231 (86.67) and VS-1266 (Kairali) (86.83).

The lowest number of days for 80 per cent maturity (76.66) was recorded during summer followed by *Rabi* (86.23) and *Kharif* (103.94).

Table 13. Mean performance of cowpea accessions for days to 80 per cent maturity

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	106.00	86.00	84.00	92.00
2	VS-1025	105.00	86.50	84.00	91.83
3	VS-1026	107.00	77.50	84.00	89.50
4	VS-1028	105.50	99.00	78.00	94.17
5	VS-1030	104.00	72.00	78.00	84.67
6	VS-1032	108.00	98.50	78.00	94.83
7	VS-1034	106.00	78.50	78.00	87.50
8	VS-1035	105.00	86.50	78.00	89.83
9	VS-1042	101.50	86.50	84.00	90.67
10	VS-1047	106.50	90.50	84.00	93.67
11	VS-1053	106.00	79.50	84.00	89.83
12	VS-1054	106.00	92.00	84.00	94.00
13	VS-1058	105.00	92.00	84.00	93.67
14	VS-1075	105.00	90.00	78.00	91.00
15	VS-1104	106.00	80.50	84.00	90.17
16	VS-1111	106.00	86.00	84.00	92.00
17	VS-1133	105.00	99.00	84.00	96.00
18	VS-1135	106.00	91.50	84.00	93.83
19	VS-1140	101.50	86.00	84.00	90.50
20	VS-1151	105.00	88.00	84.00	92.33
21	VS-1153	94.50	86.00	81.50	87.33
22	VS-1156	105.00	86.00	81.50	90.83
23	VS-1160	104.00	83.50	81.00	89.50
24	VS-1166	106.00	92.00	71.00	89.67
25	VS-1168	105.50	92.00	73.50	90.33
26	VS-1170	105.00	86.00	73.50	88.17
27	VS-1171	106.00	86.50	73.50	88.67
28	VS-1172	105.00	78.00	73.50	85.50
29	VS-1173	105.00	86.50	73.50	88.33
30	VS-1174	106.00	99.00	73.50	92.83
31	VS-1175	99.50	92.00	76.00	89.17
32	VS-1177	104.00	92.00	84.00	93.33
33	VS-1179	106.00	87.00	84.00	92.33
34	VS-1180	94.50	86.50	84.00	88.33
35	VS-1185	94.50	75.50	84.00	84.67
36	VS-1213	91.00	64.00	84.00	79.67
37	VS-1215	106.00	87.00	84.00	92.33
38	VS-1220	106.00	86.00	84.00	92.00
39	VS-1221	102.00	87.00	81.00	90.00
40	VS-1230	106.00	79.50	84.00	89.83
41	VS-1231	105.00	86.00	69.00	86.67
42	VS-1235	101.00	78.00	73.50	84.33
43	VS-1248	106.00	78.50	81.00	88.50
44	VS-1263	106.00	86.50	73.50	88.67
45	VS-1276	101.50	90.50	73.50	88.50
46	VS-1277	105.00	90.50	79.00	91.50
47	VS-1282	101.00	87.00	73.50	87.17
48	VS-1294	105.00	92.00	73.50	90.17
49	VS-1266	105.00	82.00	73.50	86.83
50	VS-1286	104.00	82.00	84.00	90.00
	Mean	103.94	86.23	79.66	-
	SE	0.73	0.73	0.73	-

4.2.12 Number of seeds per pod

The data on the number of seeds per pod are presented in table 14.

During summer, the accessions VS-1047 (18.80), VS-1104 (18.70), VS-1042 (18.50), VS-1156 (18.40), VS-1032 (18.20) recorded higher number of seeds per pod, whereas during *Rabi*, VS-1220 (Anaswara) (18.40), VS-1156 (18.10), VS-1042 (17.80), VS-1166 (17.70) and VS-1215 (17.60) recorded the highest number of seeds per pod. In *Kharif*, the accession VS-1030 recorded the highest mean value of 18.90 followed by 18.50 (VS-1015) and 17.40 (VS-1104 and VS-1215).

The accession VS-1030 recorded the highest number of seeds per pod (18.12) followed by the accession VS-1156 (17.87), VS-1215 (17.53), VS-1104 (17.50) and VS-1015 (17.47).

The highest number of seeds per pod (16.31) was recorded during summer followed by *Rabi* (15.97) and *Kharif* (14.39).

4.2.13 Seed yield per plant

The data on seed yield per plant is given in table 15.

The accession VS-1177 recorded maximum seed yield per plant during summer (76.50 g), followed by VS-1179 (67.00 g), VS-1172 (67.00 g), VS-1171 (60.50 g) and VS-1151 (59.00 g). During *Kharif* the accession VS-1177 recorded the maximum seed yield of 68.00 g. It was followed by VS-1174 (45.50 g), VS-1179 (38.50 g), VS-1030 (32.88 g) and VS-1047 (32.75 g). The lowest seed yield per plant was recorded during *Rabi* and the accession VS-1177 (53.00 g)

Table14. Mean performance of cowpea accessions for number of seeds per pod

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	18.50	16.10	17.80	17.47
2	VS-1025	15.10	16.90	17.80	16.60
3	VS-1026	14.20	15.60	16.60	15.47
4	VS-1028	16.60	16.50	17.10	16.73
5	VS-1030	18.90	17.60	17.85	18.12
6	VS-1032	14.80	17.50	18.20	16.83
7	VS-1034	13.60	15.60	17.30	15.50
8	VS-1035	13.90	16.60	16.40	15.63
9	VS-1042	14.50	17.80	18.50	16.93
10	VS-1047	15.00	17.40	18.80	17.00
11	VS-1053	12.00	12.80	14.70	13.17
12	VS-1054	12.60	15.90	16.90	15.13
13	VS-1058	14.10	15.30	17.40	15.60
14	VS-1075	16.00	17.50	17.20	16.90
15	VS-1104	17.40	16.40	18.70	17.50
16	VS-1111	15.70	13.80	15.90	15.13
17	VS-1133	10.80	14.80	14.90	13.50
18	VS-1135	13.20	15.00	16.60	14.93
19	VS-1140	12.80	15.20	16.00	14.67
20	VS-1151	14.50	15.90	15.10	15.17
21	VS-1153	12.40	17.00	17.50	15.63
22	VS-1156	17.10	18.10	18.40	17.87
23	VS-1160	13.50	14.80	12.90	13.73
24	VS-1166	16.50	17.70	17.90	17.37
25	VS-1168	15.00	15.80	16.40	15.73
26	VS-1170	12.90	16.50	17.00	15.47
27	VS-1171	13.40	16.80	16.90	15.70
28	VS-1172	11.70	17.10	17.50	15.43
29	VS-1173	14.60	16.60	16.60	15.93
30	VS-1174	12.60	17.00	18.10	15.90
31	VS-1175	14.40	15.30	14.60	14.77
32	VS-1177	15.70	16.40	16.00	16.00
33	VS-1179	14.30	13.20	14.40	13.97
34	VS-1180	16.40	14.70	14.60	15.23
35	VS-1185	16.30	16.00	16.20	16.17
36	VS-1213	13.50	16.50	16.10	15.37
37	VS-1215	17.40	17.60	17.60	17.50
38	VS-1220	14.50	18.40	18.80	17.23
39	VS-1221	10.60	13.60	13.30	12.50
40	VS-1230	15.50	17.10	17.40	16.67
41	VS-1231	10.20	12.80	12.30	11.77
42	VS-1235	11.10	13.10	12.40	12.20
43	VS-1248	13.60	11.90	5.70	10.40
44	VS-1263	15.40	16.00	17.40	16.27
45	VS-1276	15.90	17.20	18.30	17.13
46	VS-1277	14.30	17.40	17.90	16.50
47	VS-1282	12.30	15.80	15.80	14.63
48	VS-1294	12.80	15.00	16.10	14.63
49	VS-1266	15.60	17.30	15.60	16.17
50	VS-1286	16.20	15.80	16.00	16.00
	Mean	14.39	15.97	16.31	-
	SE	0.18	0.18	0.18	-

Table 15. Mean performance of cowpea accessions for seed yield per plant (g)

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	28.50	33.00	37.50	33.00
2	VS-1025	29.00	43.90	51.50	41.47
3	VS-1026	18.00	25.25	27.50	23.50
4	VS-1028	12.00	11.00	33.75	18.92
5	VS-1030	32.88	17.50	31.50	27.29
6	VS-1032	24.00	13.50	28.50	22.00
7	VS-1034	25.25	14.00	26.00	21.75
8	VS-1035	31.00	21.00	23.50	25.17
9	VS-1042	26.50	17.00	32.50	25.33
10	VS-1047	32.75	19.50	19.50	23.92
11	VS-1053	13.50	10.50	15.00	13.00
12	VS-1054	17.00	13.50	34.00	21.50
13	VS-1058	17.00	21.50	26.50	21.67
14	VS-1075	16.25	20.00	20.50	18.92
15	VS-1104	26.00	18.00	21.00	21.67
16	VS-1111	22.00	18.00	36.00	25.33
17	VS-1133	19.00	17.00	20.50	18.83
18	VS-1135	22.00	22.00	19.38	21.12
19	VS-1140	17.00	19.50	18.50	18.33
20	VS-1151	25.50	26.00	59.00	36.83
21	VS-1153	13.00	17.50	37.85	22.78
22	VS-1156	25.50	19.00	15.50	20.00
23	VS-1160	26.00	14.00	32.00	24.00
24	VS-1166	25.50	19.50	20.50	21.83
25	VS-1168	24.00	10.00	25.50	19.83
26	VS-1170	23.00	16.50	46.00	28.50
27	VS-1171	23.00	23.00	60.50	35.50
28	VS-1172	22.00	19.50	67.00	36.17
29	VS-1173	21.50	12.50	16.35	16.78
30	VS-1174	45.50	20.50	33.80	33.27
31	VS-1175	25.50	44.50	31.50	33.83
32	VS-1177	68.00	53.00	76.50	65.83
33	VS-1179	38.50	28.00	67.00	44.50
34	VS-1180	20.50	17.00	42.00	26.50
35	VS-1185	22.00	11.50	26.90	20.13
36	VS-1213	26.00	16.00	43.90	28.63
37	VS-1215	22.50	31.50	20.90	24.97
38	VS-1220	26.00	21.50	21.90	23.13
39	VS-1221	14.00	16.50	10.00	13.50
40	VS-1230	16.00	13.00	17.4	15.47
41	VS-1231	21.00	24.00	32.50	25.83
42	VS-1235	18.75	11.75	20.00	16.83
43	VS-1248	22.45	10.50	25.00	19.32
44	VS-1263	18.00	18.00	29.50	21.83
45	VS-1276	31 50	29.50	30.50	30.50
46	VS-1277	20.00	13.50	29.50	21.00
47	VS-1282	21.00	8.100	13.00	14.00
48	VS-1294	17 00	8.450	7.75	11.00
49	VS-1266	14.25	14.50	16.25	15.00
50	VS-1286	32.50	19.50	19.00	23.67
	Mean	23.99	19.68	30.36	-
	SE	1.16	1.16	1.16	-

recorded the highest during this season also, followed by the accessions VS-1175 (44.50 g), VS-1025 (43.90 g), VS-1015 (33.00 g) and VS-1215 (31.50 g).

From the pooled analysis the accession VS-1177 recorded maximum seed yield per plant (65.83 g). This was followed by VS-1179 (44.50 g), VS-1025 (41.47 g), VS-1151 (36.83 g) and VS-1172 (36.17 g).

Among the environments, the highest seed yield per plant was recorded during summer (30.36 g) followed by *Kharif* (23.99 g) and *Rabi* (19.68 g).

4.2.14 Hundred seed weight

The mean performance of cowpea accessions with regard to hundred seed weight is given in table 16.

During summer, the accession VS-1156 recorded maximum hundred seed weight (15.25 g), followed by VS-1220 (Anaswara) (15.00 g), VS-1286 (Varun) (14.75 g), VS-1276 (Kanakamony) (14.75 g), VS-1213 (14.75 g), VS-1140 (14.50 g). During *Rabi*, the accession VS-1156 recorded the highest mean value 15.85 g, followed by accession VS-1220 (Anaswara) (15.15 g), VS-1276 (Kanakamony) (15.05 g), VS-1213 (14.95 g) and VS-1030 (14.60 g). The accession VS-1156 recorded higher mean value during *Kharif* (15.30 g) followed by VS-1220 (Anaswara) (15.05 g), VS-1213 (14.95 g) and VS-1140 (14.75 g).

When comparing all the seasons, the accessions VS-1156 performed best (15.47 g) followed by VS-1220 (Anaswara) (15.07 g), VS-1213 (14.88 g), 1140 (14.73 g) and VS-1276 (Kanakamony) (14.62 g).

Table 16. Mean performance of cowpea accessions for hundred seed weight (g)

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	13.25	13.90	14.50	13.88
2	VS-1025	10.00	10.00	10.65	10.23
3	VS-1026	11.00	11.70	11.50	11.40
4	VS-1028	8.75	8.00	8.75	8.50
5	VS-1030	14.00	14.60	12.45	13.68
6	VS-1032	10.00	10.10	11.00	10.38
7	VS-1034	11.25	9.95	11.00	10.73
8	VS-1035	14.00	12.00	13.75	13.25
9	VS-1042	11.50	11.00	11.25	11.27
10	VS-1047	10.50	11.10	11.50	11.00
11	VS-1053	6.950	6.95	7.00	6.96
12	VS-1054	10.15	10.25	9.75	10.00
13	VS-1058	11 65	11.95	10.95	11.50
14	VS-1075	8.10	8.00	8.25	8.13
15	VS-1104	12.70	12.75	14.50	13.32
16	VS-1111	8.00	8.00	8.15	8.00
17	VS-1133	8.35	8.10	8.005	8.16
18	VS-1135	9.00	9.00	8.45	8.83
19	VS-1140	14.75	14.45	15.00	14.73
20	VS-1151	13.00	12.15	12.00	12.40
21	VS-1153	10.25	10.00	10.00	10.10
22	VS-1156	15.30	15.85	15.25	15.47
23	VS-1160	10.00	10.10	10.00	10.00
24	VS-1166	12.75	12.00	12.00	12.25
25	VS-1168	10.50	9.00	9.00	9.50
26	VS-1170	10.50	10.10	10.10	10.23
27	VS-1171	10.75	10.85	10.85	10.82
28	VS-1172	10.35	10.85	10.50	10.50
29	VS-1173	9.25	8.00	8.75	8.66
30	VS-1174	11.00	11.00	11.00	11.00
31	VS-1175	10.00	13.00	12.25	11.75
32	VS-1177	12.40	12.0	12.25	12.23
33	VS-1179	13.50	12.70	12.75	12.98
34	VS-1180	13.50	11.75	12.00	12.42
35	VS-1185	10.50	8.50	8.35	9.133
36	VS-1213	14.95	14.95	14.75	14.88
37	VS-1215	14.50	14.50	14.00	14.33
38	VS-1220	15.00	15.15	15.00	15.00
39	VS-1221	8.40	9.50	9.00	8.98
40	VS-1230	11.10	10.70	10.90	10.90
41	VS-1231	9.75	12.00	12.00	11.25
42	VS-1235	10.50	10.00	10.00	10.18
43	VS-1248	8.00	8.00	8.50	8.17
44	VS-1263	12.00	11.85	11.20	11.70
45	VS-1276	14.00	15.00	14.75	14.62
46	VS-1277	11.50	10.50	10.65	10.88
47	VS-1282	5.10	5.00	5.60	5.23
48	VS-1294	5.50	5.00	5.45	5.32
49	VS-1266	13.20	13.00	13.50	13.23
50	VS-1286	14.00	14.50	14.75	14.42
	Mean	11.10	10.99	11.00	-
	SE	0.008	0.008	0.008	-

The hundred seed weight was highest 11.10 g during *Kharif*, followed by summer (11.00 g) and *Rabi* (10.99 g).

4.2.15 Incidence of pod borer

The data on mean incidence of pod borer during different seasons is given in table 17.

During summer the incidence of pod borer was lowest in the accession VS-1111 (0.43 %) followed by VS-1025 (1.02 %), VS-1133 (2.00 %), VS-1180 (2.10 %) and VS-1015 (2.99 %). During *Kharif* also the pod borer infestation was lowest for the accession VS-1111 (0.43 %), followed by VS-1133 (1.78 %), VS-1025 (2.36 %), VS-1135 (3.02 %) and VS-1151 (4.18 %). In *Rabi* also the accession VS-1111 was least affected by pod borer (0.38 %) and was followed by the accessions VS-1025 (2.95 %), VS-1133 (4.07 %) and VS-1135 (5.50 %).

Considering the overall seasonal means, the accession VS-1111 showed the lowest incidence of pod borer (0.410 %), followed by VS-1025 (2.11 %) and VS-1133 (2.62 %).

The incidence of pod borer was lowest during summer (8.75 %) and highest during *Rabi* (17.21 %).

4.2.16 Incidence of coreid bug

The data on incidence of coreid bug is presented in table 18.

During *Kharif*, the accessions VS-1277 (0.00 %) and VS-1282 (0.00 %) were least affected by coreid bug followed by VS-1221 (2.50 %). In summer, the

Table 17.Mean performance of cowpea accessions for incidence of pod borer

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	4.50	6.00	10.80	7.15
2	VS-1025	2.36	2.95	1.00	2.11
3	VS-1026	9.150	16.88	8.82	11.62
4	VS-1028	6.44	13.40	8.00	9.30
5	VS-1030	6.50	20.40	10.50	12.47
6	VS-1032	9.69	12.85	9.40	10.65
7	VS-1034	18.70	21.50	6.36	15.50
8	VS-1035	9.28	20.00	7.47	12.25
9	VS-1042	9.95	14.65	3.21	9.27
10	VS-1047	10.84	14.00	9.60	11.50
11	VS-1053	5.45	15.25	6.50	9.00
12	VS-1054	5.37	11.90	3.00	6.77
13	VS-1058	8.15	13.20	6.40	9.25
14	VS-1075	8.50	15.00	17.50	13.71
15	VS-1104	7.35	20.00	7.30	11.50
16	VS-1111	0.42	0.37	0.43	0.41
17	VS-1133	1.77	4.00	2.00	2.61
18	VS-1135	3.00	5.50	3.45	3.98
19	VS-1140	5.85	8.00	2.99	5.63
20	VS-1151	4.17	12.93	6.40	7.83
21	VS-1153	32.45	10.95	9.00	17.47
22	VS-1156	8.85	12.00	16.20	12.37
23	VS-1160	8.135	20.90	24.15	17.73
24	VS-1166	15.50	19.00	14.72	16.43
25	VS-1168	10.85	13.50	11.33	11.89
26	VS-1170	13.73	26.00	6.49	15.41
27	VS-1171	10.80	9.95	7.30	9.35
28	VS-1172	9.90	8.95	5.50	8.14
29	VS-1173	11.95	10.65	14.00	12.2
30	VS-1174	7.65	12.50	3.50	7.89
31	VS-1175	8.00	11.46	3.00	7.50
32	VS-1177	6.45	8.80	6.00	7.11
33	VS-1179	6.20	14.00	4.00	8.00
34	VS-1180	12.25	38.30	2.10	17.50
35	VS-1185	9.60	18.94	10.26	12.94
36	VS-1213	7.80	46.50	12.6	22.33
37	VS-1215	8.50	24.32	18.00	16.94
38	VS-1220	17.48	14.00	21.90	17.81
39	VS-1221	14.88	15.96	10.45	13.76
40	VS-1230	14.90	21.65	14.75	17.10
41	VS-1231	8.215	19.45	16.10	14.50
42	VS-1235	8.00	37.10	3.20	16.11
43	VS-1248	10.44	38.50	3.24	17.40
44	VS-1263	12.60	16.50	13.10	14.00
45	VS-1276	7.300	13.32	4.70	8.44
46	VS-1277	25.00	43.40	19.9	29.43
47	VS-1282	10.25	17.90	4.50	10.90
48	VS-1294	14.00	13.50	3.90	10.49
49	VS-1266	29.17	40.50	13.25	27.64
50	VS-1286	11.50	12.60	9.00	11.00
	Mean	10.20	17.21	8.75	
	SE	0.88	0.88	0.88	

Table18. Mean performance of cowpea accessions for incidence of coreid bug

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	57.90	0.00	42.9	33.60
2	VS-1025	34.38	0.00	14.80	16.39
3	VS-1026	44.30	0.00	25.65	23.32
4	VS-1028	34.50	0.00	12.65	15.72
5	VS-1030	44.70	0.00	48.95	31.22
6	VS-1032	59.65	0.00	36.15	31.93
7	VS-1034	51.60	0.00	46.65	32.75
8	VS-1035	46.95	0.00	53.38	33.44
9	VS-1042	41.60	0.00	51.20	30.93
10	VS-1047	46.40	0.00	66.23	37.50
11	VS-1053	37.00	0.00	55.65	30.90
12	VS-1054	61.00	0.00	75.75	45.50
13	VS-1058	55.15	0.00	36.95	30.70
14	VS-1075	57.10	0.00	46.20	34.43
15	VS-1104	45.70	0.00	63.75	36.48
16	VS-1111	33.00	0.00	56.80	29.93
17	VS-1133	37.30	0.00	71.20	36.17
18	VS-1135	31.15	0.00	69.50	33.50
19	VS-1140	64.35	0.00	71.25	45.20
20	VS-1151	71.45	0.00	74.30	48.50
21	VS-1153	55.15	0.00	36.50	30.50
22	VS-1156	63.65	0.00	46.75	36.80
23	VS-1160	45.15	0.00	30.00	25.00
24	VS-1166	45.35	0.00	25.60	23.65
25	VS-1168	32.80	0.00	41.00	24.60
26	VS-1170	54.00	0.00	22.10	25.37
27	VS-1171	42.15	0.00	36.70	26.28
28	VS-1172	51.40	0.00	39.60	30.33
29	VS-1173	4 .70	0.00	51.00	30.90
30	VS-1174	38.70	0.00	35.65	24.78
31	VS-1175	40.35	0.00	40.00	26.78
32	VS-1177	23.50	0.00	36.65	20.00
33	VS-1179	41.60	0.00	39.00	26.87
34	VS-1180	62.40	0.00	28.00	30.13
35	VS-1185	52.90	0.00	32.00	28.30
36	VS-1213	57.40	0.00	30.50	29.32
37	VS-1215	80.80	0.00	48.35	43.00
38	VS-1220	38.30	0.00	57.25	31.85
39	VS-1221	2.500	0.00	76.50	26.33
40	VS-1230	40.35	0.00	52.95	31.10
41	VS-1231	27.14	0.00	32.45	19.86
42	VS-1235	49.10	0.00	46.50	31.88
43	VS-1248	44.505	0.00	34.45	26.33
44	VS-1263	32.35	0.00	29.25	20.50
45	VS-1276	58.00	0.00	12.20	23.40
46	VS-1277	0.00	0.00	51.00	17.00
47	VS-1282	0.00	0.00	68.9	22.97
48	VS-1294	26.60	0.00	61.50	29.37
49	VS-1266	47.95	0.00	52.75	33.50
50	VS-1286	41.25	0.00	27.00	22.75
	Mean	43.85	0.00	44.84	-
	SE	1.96	1.96	1.96	-

accession VS-1276 (Kanakamony) (12.20 %), VS-1028 (12.65 %), VS-1025 (14.80 %) and VS-1170 (22.10 %) were least affected.

The accession VS-1028 was least affected by coreid bug (15.72 %), followed by VS-1025 (16.39 %), VS-1231 (19.86 %), VS-1177 (20.05 %) when all the seasonal means are considered.

There was no incidence of coreid bug infestation at all during *Rabi*. The coreid bug infestation was maximum (44.84 %) during summer followed by *Kharif* (43.85 %).

4.2.17 Incidence of aphids

The data on per cent incidence of aphids is presented in table19.

There was no aphid incidence in accessions VS-1282, VS-1294, VS-1230, VS-1277, VS-1075, VS-1053, VS-1286 (Varun), VS-1111, VS-1133, VS-1276 (Kanakamony), VS-1034, VS-1032, VS-1266 (Kairali), VS-1177, VS-1231 and VS-1248 during *Kharif*. During summer the accessions VS-1282, VS-1230, VS-1047, VS-1151, VS-1276 (Kanakamony), VS-1263 and VS-1231 showed no incidence of aphids. In *Rabi* also the accessions VS-1140, VS-1230, VS-1047, VS-1151, VS-1168, VS-1156, VS-1160, VS-1263 and VS-1231 showed no aphid infestation.

The accessions VS-1230 and VS-1231 were free from aphid infestation during all the seasons.

In general the incidence of aphids was lowest during *Kharif* (32.50 %) followed by summer (34.99 %) and *Rabi* (35.64 %).

Table 19. Mean performance of cowpea accessions for incidence of aphids

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	41.90	12.50	64.62	39.67
2	VS-1025	44.50	57.00	63.10	54.87
3	VS-1026	52.50	25.00	21.00	32.83
4	VS-1028	42.00	52.15	53.50	49.22
5	VS-1030	0.00	12.50	20.00	10.83
6	VS-1032	0.00	36.65	47.50	28.00
7	VS-1034	0.00	49.65	67.50	39.00
8	VS-1035	45.85	34.35	32.90	39.00
9	VS-1042	55.00	47.75	5.50	36.11
10	VS-1047	21.00	0.00	0.00	7.00
11	VS-1053	0.00	66.50	72.15	46.22
12	VS-1054	86.60	41.50	30.00	52.70
13	VS-1058	39.40	60.00	46.30	48.50
14	VS-1075	0.00	71.12	20.00	30.38
15	VS-1104	52.50	46.50	22.00	40.33
16	VS-1111	0.00	26.15	29.50	18.50
17	VS-1133	36.65	18.75	25.00	26.80
18	VS-1135	36.90	20.00	21.00	26.00
19	VS-1140	44.50	0.00	31.40	25.30
20	VS-1151	18.25	0.00	0.00	6.00
21	VS-1153	60.50	56.25	40.50	52.42
22	VS-1156	68.30	0.00	27.8	32.00
23	VS-1160	65.60	0.00	23.50	29.7
24	VS-1166	60.30	20.88	21.00	34.00
25	VS-1168	23.65	0.00	39.45	21.00
26	VS-1170	91.85	30.62	86.84	69.77
27	VS-1171	52.50	36.65	23.50	37.50
28	VS-1172	63.00	44.95	33.00	46.98
29	VS-1173	52.50	50.35	23.50	42.12
30	VS-1174	29.70	26.25	13.00	22.98
31	VS-1175	57.85	29.28	13.15	33.43
32	VS-1177	0.00	28.50	61.62	30.00
33	VS-1179	50.00	36.18	51.50	45.89
34	VS-1180	76.00	65.00	59.00	66.67
35	VS-1185	50.00	30.50	13.15	31.22
36	VS-1213	21.00	41.67	80.65	47.77
37	VS-1215	13.10	63.50	19.40	32.00
38	VS-1220	39.40	36.40	36.70	37.50
39	VS-1221	34.15	34.70	10.50	26.45
40	VS-1230	0.00	0.00	0.00	0.00
41	VS-1231	0.00	0.00	0.00	0.00
42	VS-1235	71.00	35.75	86.32	64.36
43	VS-1248	0.00	82.00	100.00	60.67
44	VS-1263	26.30	0.00	0.00	8.76
45	VS-1276	0.00	31.50	0.00	10.50
46	VS-1277	0.00	62.50	47.35	36.62
47	VS-1282	0.00	44.50	0.00	14.83
48	VS-1294	0.00	49.65	41.50	30.38
49	VS-1266	0.00	100.00	100.00	66.67
50	VS-1286	0.00	66.25	23.50	29.92
	Mean	32.50	35.64	34.99	-
	SE	3.45	3.45	3.45	-

4.2.18 Incidence of anthracnose

The data on incidence of anthracnose is given in table 20.

During summer most of the accessions except VS-1140, VS-1235, VS-1220 (Anaswara), VS-1215, VS-1170, VS-1035 showed incidence of anthracnose. During *Kharif* the accessions VS-1294, VS-1140, VS-1235, VS-1047, VS-1171, VS-1286 (Varun), VS-1276 (Kanakamony), VS-1179, VS-1213, VS-1160, VS-1263, VS-1032, VS-1266 (Kairali) and VS-1248 were not infested by anthracnose.

Considering all the seasons, the accessions VS-1294, VS-1047, VS-1171, VS-1286 (Varun), VS-1276 (Kanakamony), VS-1179, VS-1213, VS-1160, VS-1263, VS-1032, VS-1266 (Kairali) and VS-1248 were free from the disease.

There was no incidence of anthracnose during *Rabi* season. During summer the per cent infestation of anthracnose was low (0.81 %). During *Kharif* 25.50 per cent of plants were affected.

4.2.19 Incidence of collar rot

The data on the incidence of collar rot is presented in table 21.

During summer, the accessions VS-1047 (5.55 %), VS-1025 (5.25 %), VS-1168 (5.20 %), VS-1180 (7.10 %), VS-1215 (5.50 %), VS-1185 (5.25 %), VS-1173 (3.80 %), VS-1104 (3.13 %), VS-1015 (3.13 %) and VS-1172 (2.60 %) expressed symptoms of collar rot. During *Kharif*, the accessions VS-1235 (46.15 %), VS-1231 (7.85 %), VS-1248 (7.85 %), VS-1220 (Anaswara) (2.60 %) and VS-1277 (2.60 %) and during *Rabi*, the accessions VS-1235 (4.15 %), VS-1140 (25.50 %), VS-1266 (Kairali) (21.50 %), VS-1047 (11.50 %), VS-1231 (7.60

Table 20. Mean performance of cowpea accessions for incidence of anthracnose

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	13.15	0.00	0.00	4.38
2	VS-1025	68.38	0.00	0.00	22.79
3	VS-1026	65.50	0.00	0.00	21.83
4	VS-1028	39.45	0.00	0.00	13.15
5	VS-1030	13.10	0.00	0.00	4.36
6	VS-1032	0.00	0.00	0.00	0.00
7	VS-1034	68.30	0.00	0.00	22.77
8	VS-1035	36.80	0.00	5.50	14.10
9	VS-1042	85.00	0.00	0.00	28.33
10	VS-1047	0.00	0.00	0.00	0.00
11	VS-1053	63.00	0.00	0.00	21.00
12	VS-1054	10.50	0.00	0.00	3.50
13	VS-1058	26.40	0.00	0.00	8.80
14	VS-1075	65.70	0.00	0.00	21.90
15	VS-1104	18.15	0.00	0.00	6.00
16	VS-1111	15.70	0.00	0.00	5.23
17	VS-1133	18.35	0.00	0.00	6.11
18	VS-1135	21.00	0.00	0.00	7.00
19	VS-1140	0.00	0.00	2.60	0.86
20	VS-1151	44.50	0.00	0.00	14.83
21	VS-1153	18.35	0.00	0.00	6.11
22	VS-1156	18.35	0.00	0.00	6.11
23	VS-1160	0.00	0.00	0.00	0.00
24	VS-1166	13.10	0.00	0.00	4.37
25	VS-1168	18.35	0.00	0.00	6.17
26	VS-1170	15.75	0.00	3.80	6.50
27	VS-1171	0.00	0.00	0.00	0.00
28	VS-1172	10.45	0.00	0.00	3.48
29	VS-1173	10.45	0.00	0.00	3.48
30	VS-1174	22.00	0.00	0.00	7.33
31	VS-1175	23.65	0.00	0.00	7.88
32	VS-1177	78.80	0.00	0.00	26.27
33	VS-1179	0.00	0.00	0.00	0.00
34	VS-1180	18.35	0.00	0.00	6.11
35	VS-1185	31.50	0.00	0.00	10.50
36	VS-1213	0.00	0.00	0.00	0.00
37	VS-1215	100.00	0.00	2.75	34.25
38	VS-1220	10.50	0.00	15.50	8.67
39	VS-1221	10.50	0.00	0.00	3.50
40	VS-1230	76.25	0.00	0.00	25.42
41	VS-1231	44.65	0.00	0.00	14.88
42	VS-1235	0.00	0.00	10.50	3.50
43	VS-1248	0.00	0.00	0.00	0.00
44	VS-1263	0.00	0.00	0.00	0.00
45	VS-1276	0.00	0.00	0.00	0.00
46	VS-1277	78.90	0.00	0.00	26.30
47	VS-1282	2.60	0.00	0.00	0.86
48	VS-1294	0.00	0.00	0.00	0.00
49	VS-1266	0.00	0.00	0.00	0.00
50	VS-1286	0.00	0.00	0.00	0.00
	Mean	25.50	0.00	0.81	-
	SE	2.30	2.30	2.30	-

Table 21. Mean performance of cowpea accessions for incidence of collar rot

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	0.00	0.00	3.12	1.00
2	VS-1025	0.00	8.30	5.25	4.50
3	VS-1026	0.00	0.00	0.00	0.00
4	VS-1028	0.00	0.00	0.00	0.00
5	VS-1030	0.00	0.00	0.00	0.00
6	VS-1032	0.00	0.00	0.00	0.00
7	VS-1034	0.00	0.00	0.00	0.00
8	VS-1035	0.00	0.00	0.00	0.00
9	VS-1042	0.00	4.15	0.00	1.38
10	VS-1047	0.00	11.50	5.50	5.68
11	VS-1053	0.00	0.00	0.00	0.00
12	VS-1054	0.00	0.00	0.00	0.00
13	VS-1058	0.00	0.00	0.00	0.00
14	VS-1075	0.00	0.00	0.00	0.00
15	VS-1104	0.00	0.00	3.12	1.00
16	VS-1111	0.00	0.00	0.00	0.00
17	VS-1133	0.00	0.00	0.00	0.00
18	VS-1135	0.00	0.00	0.00	0.00
19	VS-1140	0.00	25.50	0.00	8.50
20	VS-1151	0.00	0.00	0.00	0.00
21	VS-1153	0.00	0.00	0.00	0.00
22	VS-1156	0.00	0.00	0.00	0.00
23	VS-1160	0.00	0.00	0.00	0.00
24	VS-1166	0.00	0.00	0.00	0.00
25	VS-1168	0.00	2.60	5.20	2.60
26	VS-1170	0.00	0.00	0.00	0.00
27	VS-1171	0.00	0.00	0.00	0.00
28	VS-1172	0.00	0.00	2.60	0.86
29	VS-1173	0.00	0.00	3.80	1.27
30	VS-1174	0.00	0.00	0.00	0.00
31	VS-1175	0.00	0.00	0.00	0.00
32	VS-1177	0.00	0.00	0.00	0.00
33	VS-1179	0.00	0.00	0.00	0.00
34	VS-1180	0.00	0.00	7.10	2.37
35	VS-1185	0.00	0.00	5.25	1.75
36	VS-1213	0.00	0.00	0.00	0.00
37	VS-1215	0.00	0.00	5.50	1.83
38	VS-1220	2.60	0.00	0.00	0.86
39	VS-1221	0.00	0.00	0.00	0.00
40	VS-1230	0.00	0.00	0.00	0.00
41	VS-1231	7.85	7.60	0.00	5.15
42	VS-1235	46.15	4.15	0.00	16.77
43	VS-1248	7.85	0.00	0.00	2.61
44	VS-1263	0.00	0.50	0.00	0.17
45	VS-1276	0.00	0.00	0.00	0.00
46	VS-1277	2.60	0.00	0.00	0.87
47	VS-1282	0.00	0.00	0.00	0.00
48	VS-1294	0.00	2.90	0.00	0.96
49	VS-1266	0.00	21.50	0.00	7.17
50	VS-1286	0.00	0.00	0.00	0.00
	Mean	1.34	1.77	0.93	
	SE	0.69	0.69	0.69	

%), VS-1025 (8.30 %), VS-1168 (2.60 %), VS-1042 (4.15 %), VS-1294 (2.90 %) and VS-1263 (0.50 %) were affected by collar rot. Other accessions did not show any symptoms of collar rot.

The accession VS-1235 (16.77 %) showed the highest per cent incidence of collar rot over all the seasons while most accessions were free from the disease.

The incidence of collar rot was lowest during summer (0.93 %) followed by *Kharif* (1.34 %) and *Rabi* (1.77 %).

4.2.20 Incidence of mosaic

The data on incidence of mosaic is presented in table 22.

During summer the accessions VS-1173 (5.88 %), VS-1034 (5.25 %), VS-1140 (7.87 %), VS-1028 (3.50 %), VS-1168 (5.20 %), VS-1042 (5.20 %), VS-1025 (2.60 %), VS-1213 (2.60 %) and during *Kharif* the accessions VS-1173 (5.20 %), VS-1034 (5.20 %), VS-1231 (10.50 %), VS-1153 (7.85 %), VS-1277 (7.85 %), VS-1174 (6.40 %), VS-1028 (2.60 %), VS-1151 (5.25 %), VS-1166 (5.20 %), VS-1133 (5.20 %), VS-1180 (5.20 %), VS-1179 (5.20 %), VS-1294 (2.60 %) and VS-1235 (2.60 %) were affected by mosaic.

The accessions VS-1173 (3.69 %), VS-1034 (3.50 %), VS-1231 (3.50 %), VS-1140 (2.63 %), VS-1153 (2.62 %), VS-1277 (2.62 %), VS-1174 (2.13 %), VS-1028 (2.05 %), VS-1151 (1.75 %), VS-1166 (1.73 %), VS-1133 (1.73 %), VS-1180 (1.73 %), VS-1168 (1.73 %), VS-1179 (1.73 %), VS-1042 (0.93 %), VS-1025 (0.86 %), VS-1213 (0.86 %), VS-1294 (0.86 %) and VS-1235 (0.86 %) were affected by mosaic during all the seasons. Other accessions were free from any symptoms of mosaic.

Table 22. Mean performance of cowpea accessions for incidence of mosaic

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	0.00	0.00	0.00	0.00
2	VS-1025	0.00	0.00	2.60	0.86
3	VS-1026	0.00	0.00	0.00	0.00
4	VS-1028	2.60	0.00	3.50	2.00
5	VS-1030	0.00	0.00	0.00	0.00
6	VS-1032	0.00	0.00	0.00	0.00
7	VS-1034	5.25	0.00	5.25	3.50
8	VS-1035	0.00	0.00	0.00	0.00
9	VS-1042	0.00	0.00	2.80	0.93
10	VS-1047	0.00	0.00	0.00	0.00
11	VS-1053	0.00	0.00	0.00	0.00
12	VS-1054	0.00	0.00	0.00	0.00
13	VS-1058	0.00	0.00	0.00	0.00
14	VS-1075	0.00	0.00	0.00	0.00
15	VS-1104	0.00	0.00	0.00	0.00
16	VS-1111	0.00	0.00	0.00	0.00
17	VS-1133	5.20	0.00	0.00	1.73
18	VS-1135	0.00	0.00	0.00	0.00
19	VS-1140	0.00	0.00	7.87	2.62
20	VS-1151	5.25	0.00	0.00	1.75
21	VS-1153	7.85	0.00	0.00	2.61
22	VS-1156	0.00	0.00	0.00	0.00
23	VS-1160	0.00	0.00	0.00	0.00
24	VS-1166	5.20	0.00	0.00	1.73
25	VS-1168	0.00	0.00	5.20	1.73
26	VS-1170	0.00	0.00	0.00	0.00
27	VS-1171	0.00	0.00	0.00	0.00
28	VS-1172	0.00	0.00	0.00	0.00
29	VS-1173	5.20	0.00	5.88	3.69
30	VS-1174	6.40	0.00	0.00	2.13
31	VS-1175	0.00	0.00	0.00	0.00
32	VS-1177	0.00	0.00	0.00	0.00
33	VS-1179	5.20	0.00	0.00	1.73
34	VS-1180	5.20	0.00	0.00	1.73
35	VS-1185	0.00	0.00	0.00	0.00
36	VS-1213	0.00	0.00	2.60	0.86
37	VS-1215	0.00	0.00	0.00	0.00
38	VS-1220	0.00	0.00	0.00	0.00
39	VS-1221	0.00	0.00	0.00	0.00
40	VS-1230	0.00	0.00	0.00	0.00
41	VS-1231	10.50	0.00	0.00	3.50
42	VS-1235	2.60	0.00	0.00	0.86
43	VS-1248	0.00	0.00	0.00	0.00
44	VS-1263	0.00	0.00	0.00	0.00
45	VS-1276	0.00	0.00	0.00	0.00
46	VS-1277	7.85	0.00	0.00	2.61
47	VS-1282	0.00	0.00	0.00	0.00
48	VS-1294	2.60	0.00	0.00	0.86
49	VS-1266	0.00	0.00	0.00	0.00
50	VS-1286	0.00	0.00	0.00	0.00
	Mean	1.50	0.00	0.71	-
	SE	0.26	0.26	0.26	-

There was no incidence of mosaic during *Rabi*. The incidence was only 0.71 per cent during summer and 1.50 per cent during *Kharif.*

4.2.21 Pooled analysis of 50 semi erect cowpea accessions for yield and yield contributing characters using AMMI model.

Results obtained from the pooled analysis of 50 semi-erect cowpea accessions for yield contributing characters are presented in table 23.

The results of the G x E interactions obtained by AMMI model of statistical techniques showed that summer is the best season having the highest mean obtained for yield contributing characters like number of primary branches, length of main branches, number of clusters per plant, number of pods per plant, green pod yield per plant, green pod yield per plot, peduncle length, pod length, green biomass, number of seeds per pod, seed yield per plant and 100 seed-weight of 2565.8, followed by *Kharif* (2419.8). The lowest means for these characters were obtained during *Rabi* season (1693.2).

The accession VS-1177 showed a mean value of 4837, which was highest among the treatment means over all the seasons. This was followed by VS-1025 (3739), VS-1179 (3554), VS-1015 (3007), VS-1170 (2995), VS-1172 (2886), VS-1032 (2868), VS-1175 (2822), VS-1171 (2757) and VS-1111 (2640) (Table 23).

During summer the accession VS-1177 showed highest mean value of 5288, followed by VS-1179 (5159), VS-1172 (4455), VS-1025 (4187), VS-1170 (4125). The accession VS-1177 recorded the highest mean value of 5282 during *Kharif*, followed by VS-1042 (3535), VS-1025 (3503), VS-1174 (3492), VS-1179 (3152), VS-1104 (3088) and VS-1047 (3015). In *Rabi*, also

Table 23. Mean performance of cowpea accessions for pooled analysis of yield contributing characters

Sl No.	Accessions	*Kharif*	*Rabi*	Summer	Treatment means
1	VS-1015	2873	3047	3099	3007
2	VS-1025	3503	3528	4187	3739
3	VS-1026	1962	1664	3085	2237
4	VS-1028	2534	1386	2954	2291
5	VS-1030	2764	1023	3070	2285
6	VS-1032	2915	2820	2868	2868
7	VS-1034	2502	1617	2625	2248
8	VS-1035	2652	1882	2324	2286
9	VS-1042	3535	1614	2631	2593
10	VS-1047	3015	1915	2066	2332
11	VS-1053	1655	1367	1857	1626
12	VS-1054	2261	1587	3560	2469
13	VS-1058	2176	1707	2211	2032
14	VS-1075	1914	1904	2009	1942
15	VS-1104	3088	1585	2298	2324
16	VS-1111	2245	2358	3318	2640
17	VS-1133	2900	1823	2447	2390
18	VS-1135	2144	1754	1495	1798
19	VS-1140	1735	1156	1422	1437
20	VS-1151	1933	2065	3329	2443
21	VS-1153	1754	1773	2934	2154
22	VS-1156	2018	1279	1724	1674
23	VS-1160	1666	1164	1947	1592
24	VS-1166	2651	1214	1729	1865
25	VS-1168	2144	1009	2568	1907
26	VS-1170	2863	1996	4125	2995
27	VS-1171	2343	1878.00	4051	2757
28	VS-1172	2686	1516	4455	2886
29	VS-1173	1965	908.2	1735	1536
30	VS-1174	3492	1475	2602	2523
31	VS-1175	2670	3194	2602	2822
32	VS-1177	5282	3941	5288	4837
33	VS-1179	3152	2350	5159	3554
34	VS-1180	2502	1064	3745	2437
35	VS-1185	2704	1242	3062	2336
36	VS-1213	2577	1256	2774	2202
37	VS-1215	2264	2574	1619	2152
38	VS-1220	2336	1461	184.00	1881
39	VS-1221	1368	1099	965.50	1144
40	VS-1230	1952	1162	1643	1586
41	VS-1231	2213	1090	1909	1738
42	VS-1235	2346	1117	2332	1932
43	VS-1248	1425	649.9	1349	1141
44	VS-1263	1713	1477	2013	1734
45	VS-1276	2620	2129	2211	2320
46	VS-1277	2329	1410	2742	2160
47	VS-1282	1980	1186	1597	1588
48	VS-1294	1413	821.1	1428	1221
49	VS-1266	1592	1164	1602	1453
50	VS-1286	2664	2258	1681	2201
	Mean	2419.8	1693.2	2565.8	-
	SE	74.26	74.26	74.26	-

the accession VS-1177 showed the highest mean value of 3941, followed by VS-1025 (3528), VS-1175 (3194), VS-1015 (3047) and VS-1032 (2820).

4.3 VARIABILITY AND GENETIC PARAMETERS

Genetic variability in a crop is the basic requirement for its further genetic improvement. Variability in a population is measured by phenotypic and genotypic coefficients of variability. The extent of genetic variability with respect to different yield component characters in 50 accessions of semi-erect cowpeas was estimated for three seasons viz., *Kharif*, *Rabi* and summer.

The characters included were days to first flowering, days to 50 per cent flowering, number of primary branches, length of main branch, number of clusters per plant, number of pods per plant, green pod yield per plant, peduncle length, pod length, green biomass, days to 80 per cent maturity, number of seeds per pod, seed yield per plant and hundred seed weight.

The variability present in the cowpea accessions measured in terms of mean, range over all the three seasons are presented in table 24.

Among the three seasons, *Kharif* season recorded the highest mean values for days to first flowering (44.65), days to 50 per cent flowering (54.69), number of primary branches (7.11), length of main branch (155.58 cm), number of clusters per plant (16.19), days to 80 per cent maturity (103.94) and hundred seed weight (11.11 g).

Table 24. Range and mean of variability parameters of cowpea accessions over three seasons.

Sl. No:	Characters	Range				Mean			
		Kharif	*Rabi*	Summer	Overall	*Kharif*	*Rabi*	Summer	Overall
1	Days to first flowering	38.50-61.5	33.00-58.00	31.00-51.00	35.33-51.17	44.65±0.60	43.97±0.60	40.42±0.60	41.01±0.60
2	Days to 50 % flowering	43.50-70.00	42.00-64.00	34.50-53.00	40.00-56.67	54.69±0.60	49.79±0.60	43.52±0.60	49.33±0.60
3	Number of primary branches	3.50-10.50	3.50-7.50	5.00-10.00	5.66-6.90	7.11±0.18	6.17±0.10	5.20±0.18	6.16±0.18
4	Length of main branch (cm)	105.50-260.00	78.80-181.20	126.32-181.80	121.80-186.0	155.58±3.36	148.36±3.36	119.91±3.36	141.3±3.36
5	Number of clusters per plant	5.90-20.50	9.30 –23.80	8.70-23.50	13.53-16.67	16.19±0.39	15.19±0.39	13.01±0.39	14.80±0.39
6	Number of pods per plant	6.50-31.00	3.50-26.50	6.00-38.50	5.83-31.67	16.45±0.70	14.63±0.70	10.07±0.70	13.72±0.70
7	Green pod yield per plant (g)	35.00-199.00	10.00-159.00	17.00-206.90	26.33-188.5	55.55±3.33	79.29±3.33	82.29±3.33	72.38±3.33
8	Peduncle length (cm)	15.00-42.80	14.25-40.58	15.98-45.88	20.55-42.73	29.01±0.79	25.89±0.79	32.80±0.79	29.24±0.79
9	Pod length (cm)	10.80-31.20	9.80-29.64	10.33-33.08	11.58-30.39	17.80±0.24	19.21±0.24	19.24±0.24	18.75±0.24
10	Green biomass (g)	212.00-637.00	110.00-610.00	162.5-1112	187.5-558.3	341.05±20.72	229.97±20.72	449.11±20.72	340±20.72
11	Days to 80 % maturity	91.00-108.00	64.00-99.00	73.50-84.00	79.67-96.00	103.94±0.73	86.23±0.73	79.66±0.73	89.94±0.73
12	Number of seeds per pod	10.60-18.90	11.90-18.40	5.70-18.80	10.40-17.87	14.40±0.18	15.97±0.18	16.31±0.18	15.56±0.18
13	Seed yield per plant (g)	13.00-68.00	8.10-53.00	7.75-76.50	11.07-65.83	23.99±1.16	19.68±1.16	30.36±1.16	24.68±1.16
14	100 seed weight (g)	5.10-15.30	8.10-53.00	7.75-76.50	5.23-15.47	11.11±0.8	10.99±0.8	11.07±0.8	11.06±0.8

Number of pods per plant (16.45), green pod yield per plant (82.29 g), green pod yield per plot (1645.4 g), peduncle length (32.80 cm), pod length (19.24 cm), green biomass (449.11 g), number of seeds per pod (16.31) and seed yield per plant (30.36 g) had the highest mean values during summer.

The accessions displayed high amount of variability with respect to different characters studied. The mean performance, PCV, GCV, heritability and genetic advance over all the seasons for different characters are presented in table 25.

The PCV values were considerably high for characters such as green pod yield per plant (42.13), number of pods per plant (35.78), number of seeds per pod (35.33), green biomass (27.30), pod length (22.90), hundred seed weight (22.28), and number of clusters per plant (22.00), while it was moderate for peduncle length (14.68), number of seeds per pod (11.69) and length of main branch (11.43) and was low for days to 50 per cent flowering (6.76), days to first flowering (7.65), days to 80 per cent maturity (8.38) and number of primary branches (9.46).

The GCV which gives a picture of extent of genetic variability in the population ranged from 0.51 per cent (number of primary branches) to 36.02 per cent (green pod yield per plant). The yield contributing characters like green pod yield per plant (36.02), seed yield per plant (32.52), number of pods per

Table 25. Genetic parameters of cowpea accessions over three seasons

Sl. No:	Characters	PCV	GCV	Heritability %	Genetic advance
1	Days to first flowering	7.65	4.15	29.40	1.99
2	Days to 50 % flowering	6.76	3.76	31.00	2.13
3	Number of primary branches	9.46	0.51	0.00	0.00
4	Length of main branch	11.43	5.41	22.40	7.47
5	Number of clusters per plant	22.00	17.21	61.10	4.10
6	Number of pods per plant	35.78	30.55	72.90	7.37
7	Green pod yield per plant	42.13	36.02	73.10	45.92
8	Peduncle length	14.68	8.75	35.60	3.14
9	Pod length	22.90	21.13	85.20	7.53
10	Green biomass	27.30	15.63	32.80	62.71
11	Days to 80 % maturity	8.38	0.89	1.10	0.18
12	Number of seeds per pod	11.69	9.17	61.60	2.31
13	Seed yield per plant	35.33	32.52	84.70	15.21
14	100 seed weight	22.28	21.81	95.90	4.87

plant (30.55), hundred seed weight (21.81) and pod length (21.13) exhibited highest mean genotypic coefficient of variation over all the seasons. It was moderate for number of clusters per plant (17.21) and green biomass (15.63). Number of primary branches (0.51), days to 80 per cent maturity (0.89), days to 50 per cent flowering (3.76), days to first flowering (4.15), length of main branches (5.41), peduncle length (8.75) and number of seeds per pod (9.17) recorded the lowest mean genotypic coefficient of variation.

The genetic parameters like heritability and genetic advance estimated for yield component attributes over three seasons are presented in table 25.

High estimates (> 60 %) of mean heritability across three seasons were noticed for seven characters *viz.*, hundred seed weight (95.90 %), pod length (85.20 %), seed yield per plant (84.70 %), green pod yield per plant (73.10 %), number of pods per plant (72.90 %), number of seeds per pod (61.60 %) and number of clusters per plant (61.10%). It was moderate for peduncle length (35.60), green biomass (32.80) and days to 50 per cent flowering (31.00), length of main branch (22.40) and days to first flowering (29.40). The mean heritability percentage was lowest for number of primary branches (0.00) and days to 80 per cent maturity (1.10 %).

The highest mean genetic advance of 62.71 was observed in the case of green biomass followed by green pod yield per plant (45.92) where as genetic advance was zero for number of primary branches. Higher heritability (73.10) coupled with high genetic advance (45.92) was observed in green pod yield per plant (Table 25). Moderate heritability (32.80) coupled with higher genetic advance (62.71) was recorded for green biomass per plant.

4.4 PHENOTYPIC AND GENOTYPIC CORRELATIONS

The genotypic and phenotypic correlation among yield and yield attributes has been worked out for all seasons and the results are presented in table 26.

Green pod yield per plant had significant positive genotypic correlation with length of main branches (0.388), peduncle length (0.504), green biomass (0.631), days to 80 per cent maturity (0.759) and seed yield per plant (0.325). Number of primary branches had a significant negative genotypic correlation with green pod yield (- 0.364). Green biomass (0.545) had significant positive phenotypic correlation with yield.

4.5 PATH ANALYSIS

Path analysis was carried out to measure the direct and indirect contribution of various independent characters on the dependent character, the

Table 26. Genotypic (upper diagonal) and phenotypic (lower diagonal) correlation coefficients between yield and yield characters in cowpea genotypes during all seasons (2004-2005)

Sl. No	Character	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
1	(X_1)	**1.000**	0.904**	-0.193	0.106	-0.109	-0.374*	-0.340*	-0.026	0.039*	0.0336	0.680**	0.272	-0.266	0.160
2	(X_2)	0.947*	**1.000**	-0.201	0.154	-0.123	-0.392**	-0.33**	0.037	0.445**	-0.024	0.595**	0.265	-0.290	0.165
3	(X_3)	-0.173	-0.151	**1.000**	0.284	0.581**	0.448**	0.473**	-0.111	-0.094	0.490**	-0.286	0.098	0.475**	-0.364
4	(X_4)	0.087	0.142	0.254	**1.000**	0.164	-0.068	0.026	-0.142	0.178	0.426**	-0.192	0.459**	0.139	0.388*
5	(X_5)	-0.889	-0.088*	0.514*	0.136	**1.000**	0.385**	0.422**	-0.169	-0.199	0.529**	-0.301	0.169	0.421**	-0.101
6	(X_6)	-0.313	-0.339	0.406**	-0.053	0.364	**1.000**	0.872**	-0.096	-0.274	0.208	-0.036	-0.261	0.905**	-0.208
7	(X_7)	-0.263	-0.261	0.379*	0.040	0.346	0.832*	**1.000**	-0.051	0.139	0.267	0.176	0.136	0.952**	0.580**
8	(X_8)	-0.010	0.040	-0.28	-0.101	-0.127	-0.064	-0.012	**1.000**	0.175	-0.130	0.144	-0.114	-0.046	0.504**
9	(X_9)	0.325	0.355*	-0.078	0.118	-0.188	-0.231	0.097	0.132	**1.000**	0.639**	0.631**	0.687**	0.0661	0.631**
10	(X_{10})	0.075	0.043	0.424*	0.363*	0.455*	0.162	0.209	-0.092	0.032	**1.000**	-0.321	0.304	0.331	0.759*
11	(X_{11})	0.170	0.195	-0.082	-0.067	-0.038	0.002	0.143	0.071	0.309	-0.034	**1.000**	0.916**	0.125	0.259
12	(X_{12})	0.191	0.171	0.087	0.184	0.125	-0.223	0.088	-0.086	0.523*	0.206	0.032	**1.000**	0.024	0.325**
13	(X_{13})	-0.244	-0.260	0.453*	0.137	0.388*	0.869*	0.862*	-0.030	0.069	0.293	0.055	0.016	**1.000**	0.177
14	(X_{14})	0.114	0.115	-0.082	0.244	-0.091	-0.184	0.040	0.011	0.545*	0.060	0.157	0.260	0.177	**1.000**

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

X1 Days to first flowering X2 Days to 50 % flowering X3 Number of primary branches X4 Length of main branch
X5 Number of clusters per plant X6 Number of pods per plant X7 Peduncle length X8 Pod length X9 Green biomass
X10 Days to 80 % maturity X11 Number of seeds per pod X12 Seed yield per plant X13 100 seed weight X14 Green pod yield per plant

Table 27. Path analysis at genotypic level on green pod yield over all the seasons

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	**-0.770**	0.782	-0.002	-0.043	-0.087	-0.111	0.033	-0.086	-0.043	0.021	-0.185	-0.003
X2	-0.739	**0.815**	0.001	-0.099	-0.081	-0.071	0.045	-0.050	-0.053	0.065	-0.140	-0.002
X3	-0.155	-0.047	**-0.011**	0.213	-0.016	0.116	0.011	-0.218	-0.022	0.312	0.104	0.001
X4	0.073	-0.179	-0.005	**0.448**	0.175	0.024	-0.050	-0.089	0.100	-0.077	0.218	-0.003
X5	0.363	-0.355	0.001	0.424	**0.185**	0.093	-0.061	-0.107	0.049	-0.156	0.229	-0.003
X6	-0.429	0.287	0.007	-0.054	-0.086	**-0.200**	0.078	-0.021	0.040	0.378	-0.049	0.003
X7	-0.207	0.298	-0.001	-0.184	-0.093	-0.128	**0.122**	-0.003	0.061	0.311	0.054	0.007
X8	-0.426	0.264	-0.016	0.255	0.127	-0.026	0.003	**-0.156**	0.143	0.261	0.229	0.000
X9	0.381	-0.497	0.003	0.513	0.105	-0.091	0.085	-0.255	**0.087**	0.313	0.108	-0.003
X10	-0.038	0.123	-0.008	-0.080	-0.067	-0.176	0.088	-0.095	0.063	**0.431**	0.066	0.005
X11	0.428	-0.342	-0.004	0.292	0.127	0.029	0.020	-0.107	0.028	0.085	**0.333**	0.004
X12	0.210	-0.134	-0.001	-0.123	-0.062	-0.058	0.083	0.004	-0.031	0.220	0.139	**0.010**

X1 Days to first flowering X2 Days to 50 % flowering X3 Length of main branch X4 Number of clusters per plant
X5 Number of pods per plant X6 Peduncle length X7 Pod length X8 Green biomass X9 Days to 80 % maturity
X10 Number of seeds per pod X11 Seed yield per plant X12 100 seed weight

green pod yield. The estimates of path coefficient for the 12 component characters (Table 27) indicated that maximum positive direct effect on green pod yield was shown by days to 50 per cent flowering (0.815) and moderate positive direct effect was exerted by number of clusters per plant (0.448) and number of seeds per pod (0.431); while number of primary branches (-0.011) had maximum negative direct effect. High indirect effects were noticed for days to first flowering (0.782) for green pod yield through 50 per cent flowering.

5. DISCUSSION

The history of crop improvement begins with the early days of mankind changing his mode of life from a nomad to an agriculturist. The challenge for present day breeders is to develop varieties with high production potential coupled with better quality, which is stable across the range of environments. Of late, yielding stability as a selection trait is perpetually gaining importance over yielding ability. Consequently development of suitable genotypes that are stable to target environment with less interaction is an important objective of the scientific community.

In Kerala, cowpea is grown as a multipurpose crop which can fit into a variety of cropping systems. The low productivity and susceptibility to pests and diseases and differential response of cowpea genotypes to varied environmental conditions has long been recognized. Information on the "G x E interaction of semi-erect cowpea genotypes" provides a better measure of the varietal adaptability in varied environmental conditions. In this study, 50 semi-erect cowpea genotypes were evaluated over three seasons during 2004-2005 with the main objective of studying G x E interaction with respect to different characters and for identifying stable high yielding dual purpose genotypes.

5.1 MEAN PERFORMANCE AND STABILITY

Genotype x environment interaction (GEI) is a measure of differential response of genotypes to varied environmental conditions. Its effect is to limit the accuracy of yield estimation from environmental evaluation of varietal performance. There are various models developed by different workers to predict the Genotype x environment interaction. AMMI model (Additive main effects and multiplicative interactions) is extensively used these days. For all the quantitative characters studied only AMMI-1 PCA (Principal component

Table 28. Accessions selected for different characters over three seasons

Characters	Best five accessions performed over different seasons
1.Days to first flowering	1248 (43), 1025 (2), 1177 (32), 1180 (34), 1266 (49)
2.Days to 50 % flowering	1248 (43), 1025 (2), 1266 (49), 1034 (7), 1028 (4)
3.Number of primary branches	1025 (2), 1179 (33), 1177 (32), 1015 (1), 1175 (31)
4.Length of main branches	1282 (47), 1179 (33), 1286 (50), 1032 (6), 1266 (49)
5.Number of clusters per plant	1177 (32), 1025 (2), 1175 (31), 1179 (33), 1294 (48)
6.Number of pods per plant	1177 (32), 1025 (2), 1179 (33), 1111 (16), 1171 (27)
7.Green pod yield per plant	177 (32), 1025 (2), 1179 (33), 1015 (1), 1032 (6)
8.Peduncle length	030 (5), 1266 (49), 1156 (22), 1133 (17), 1140 (19)
9.Pod length	1015 (1), 1104 (15), 1220 (38), 1030 (5), 1054 (12)
10.Green biomass	1026 (3), 1179 (33), 1282 (47), 1170 (26), 1028 (4)
11.Days to 80 % maturity	1213 (36), 1235 (42), 1185 (35), 1231(41), 1266 (49)
12.Number of seeds per pod	1030 (5), 1156 (22), 1215 (37), 1104 (15), 1015 (1)
13.Seed yield per plant	1175 (32), 1179 (33), 1025 (2), 1151(20), 1172 (28)
14.100 seed weight	1156 (22), 1220 (38), 1213 (36), 1140 (19), 1276 (45)
15.Pod borer	1111 (16), 1025 (2), 1133 (17), 1135 (18), 1140 (19)
16.Coreid bug	1028 (4), 1025 (2), 1277 (46), 1231 (41), 1177 (32)
17.Aphids	1230 (40), 1231 (41), 1151 (20), 1047 (10), 1263 (44)
18.Anthracnose	1294 (48), 1277 (46), 1171 (27), 1286 (50), 1276 (45)
19.Collar rot	1177 (32), 1179 (33), 1111 (16), 1276 (45), 1286 (50)
20.Mosaic	1177 (32), 1266 (49), 1286 (50), 1220(38), 1276 (45)

(Values in parenthesis indicate the accession number as given in tables 3 to 23 and Figures 1 to 20) analysis) scores were found to be highly significant ($P < 0.05$) for the 50 semi-erect cowpea accessions. Hence the biplots obtained from AMMI-1 score against the means was taken into consideration for selecting better performing genotype over all the seasons. A genotype or environment discriminating away from origin of x-axis is to be considered as the better performing genotype for positive characters like number of primary branches, length of main branch, number of clusters per plant, number of pods per plant, green pod yield per plant, peduncle length, pod length, green biomass, number of seeds per pod, seed yield per plant and hundred seed weight. Similarly a genotype discriminating towards the origin of x-axis is considered a better one for negative characters like days to first flowering, days to 50 per cent flowering, days to 80 per cent maturity, incidence of pod borer, coreid bug, aphids, anthracnose, collar rot and mosaic.

Out of the 50 accessions the best five were selected for each character based on their mean performance over all the seasons, and is presented in table 28. The mean performance versus AMMI-1 PCA score for each accession serially numbered from 1 to 50 is represented as biplots (Fig.1-20).

Out of the selected five accessions (Table 28) the accession VS-1248 notated as (43) recorded lowest number of days to first flowering (Fig.1) and days to 50 per cent flowering (Fig. 2). Even though this has taken lower days to first flowering, it did not give good yield over all the seasons. These two characters being negatively contributing towards yield are discriminating towards the origin of x-axis in the biplots.

Among the selected five, the accession VS-1025 notated as (2) recorded the lowest days to first flowering (Fig.1), days to 50 per cent flowering (Fig.2), higher number of primary branches (Fig.3), number of clusters per plant (Fig.5), number of pods per plant (Fig.6), green pod yield per plant (Fig.7), seed yield

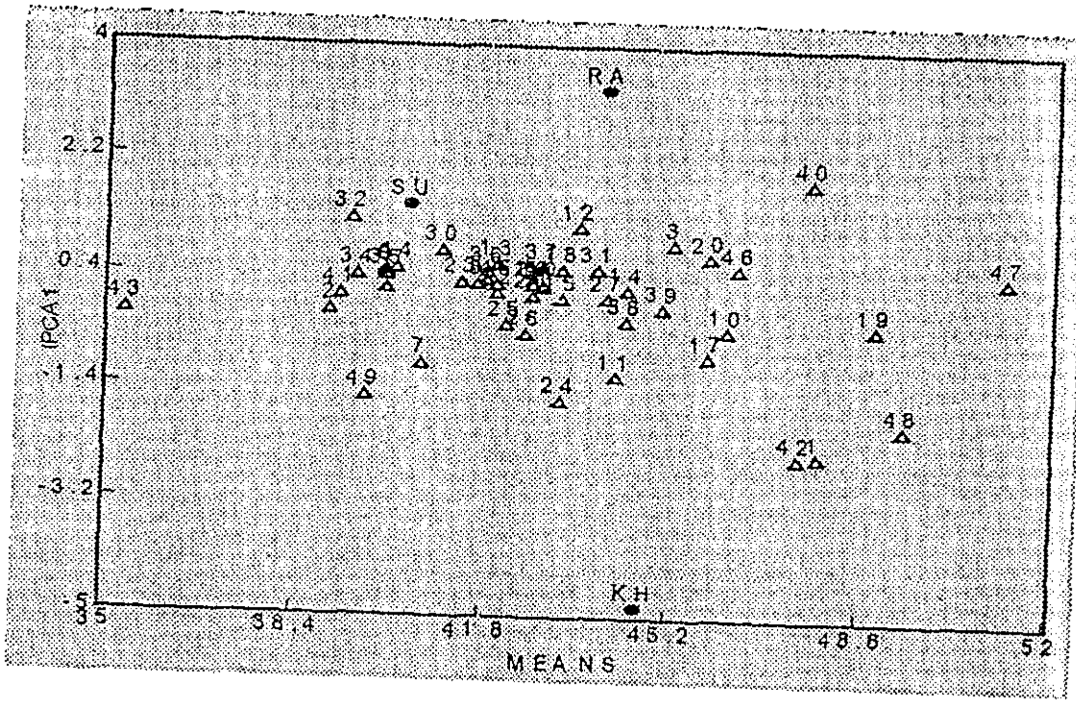

Fig.1. Biplot of mean performance versus 1st PCA for days to first flowering

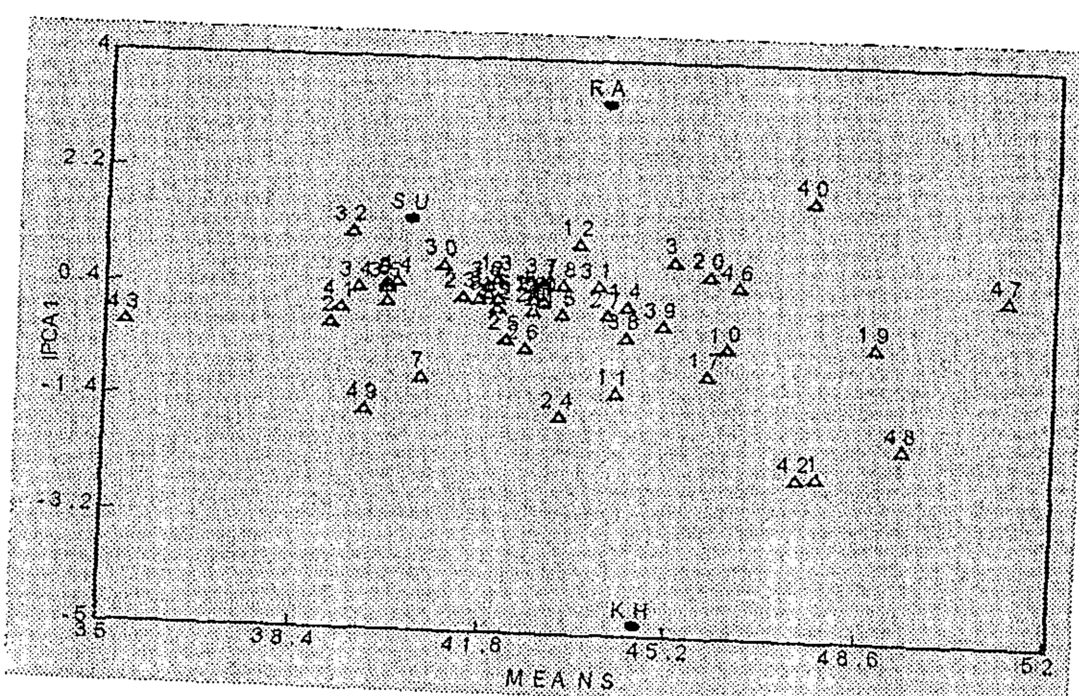

Fig.2. Biplot of mean performance versus 1st PCA for days to 50 per cent flowering

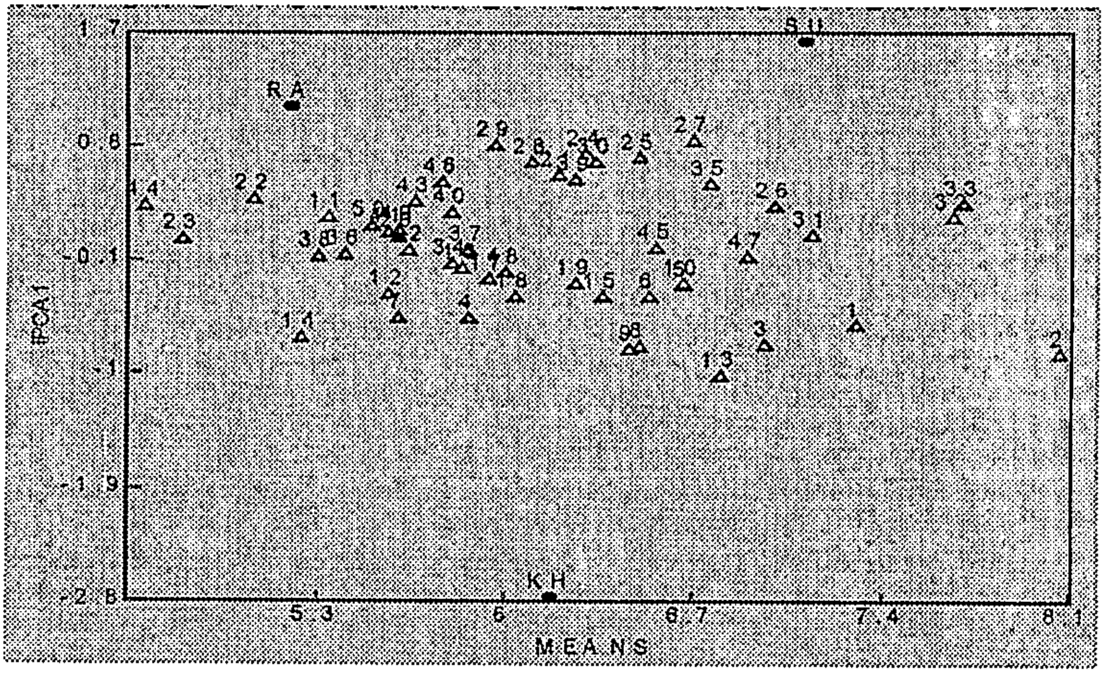

Fig.3. Biplot of mean performance versus 1st PCA for number of primary branches

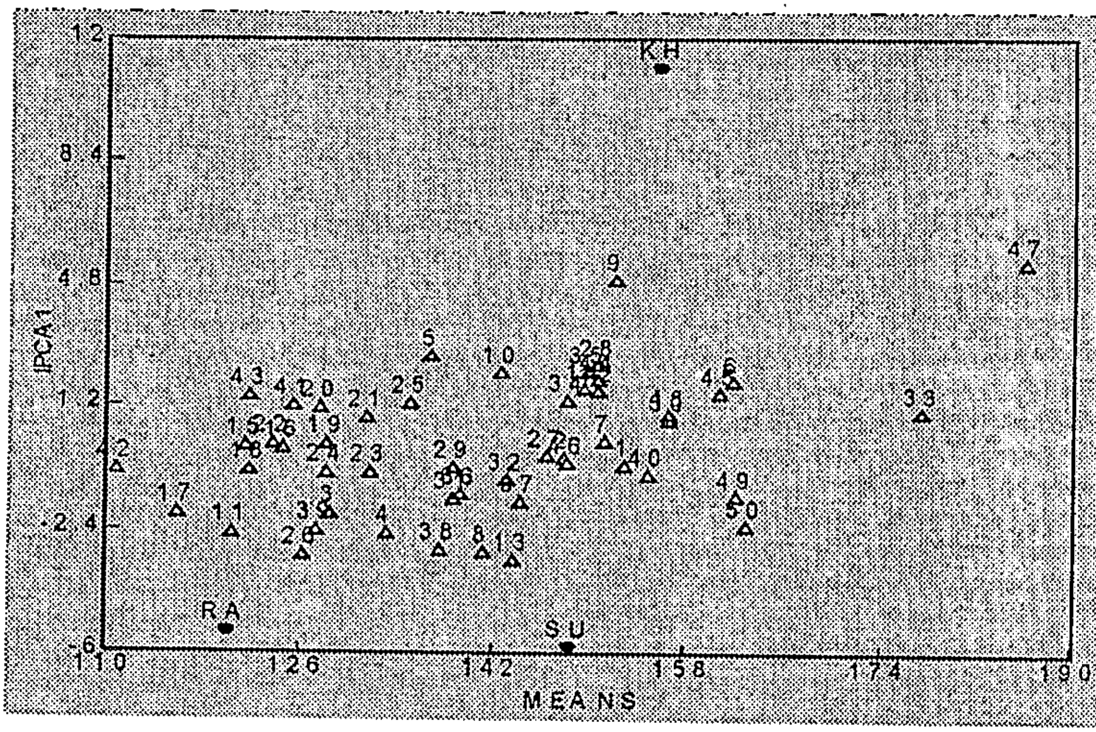

Fig.4. Biplot of mean performance versus 1st PCA for length of main branch

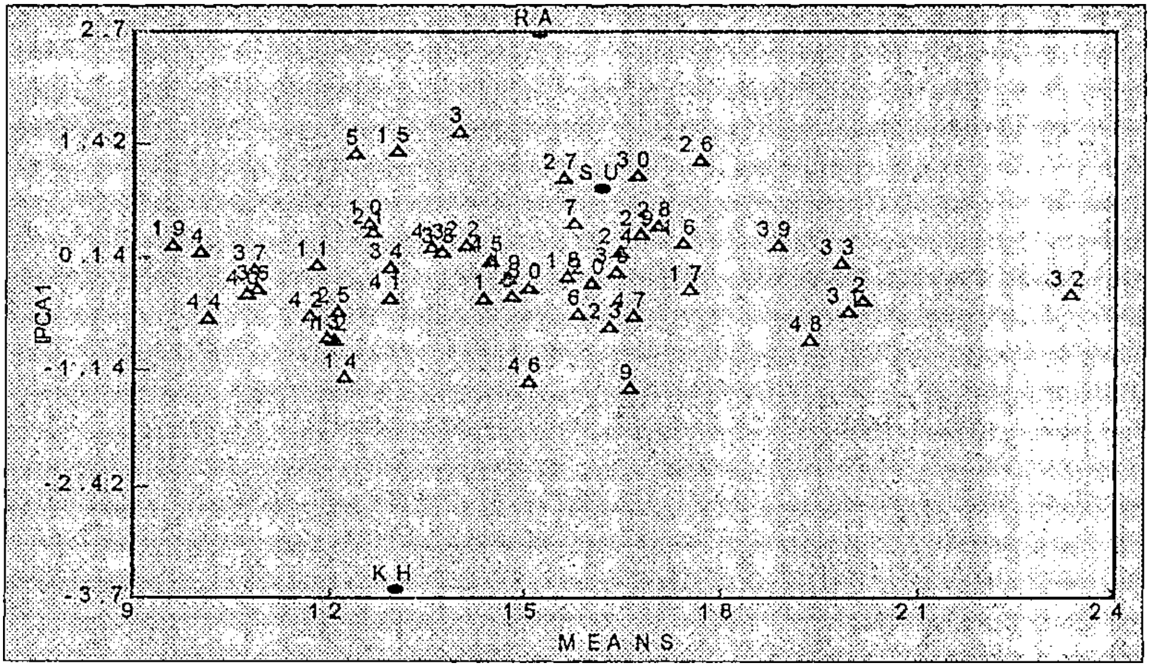

Fig.5. Biplot of mean performance versus 1st PCA for number of clusters per plant

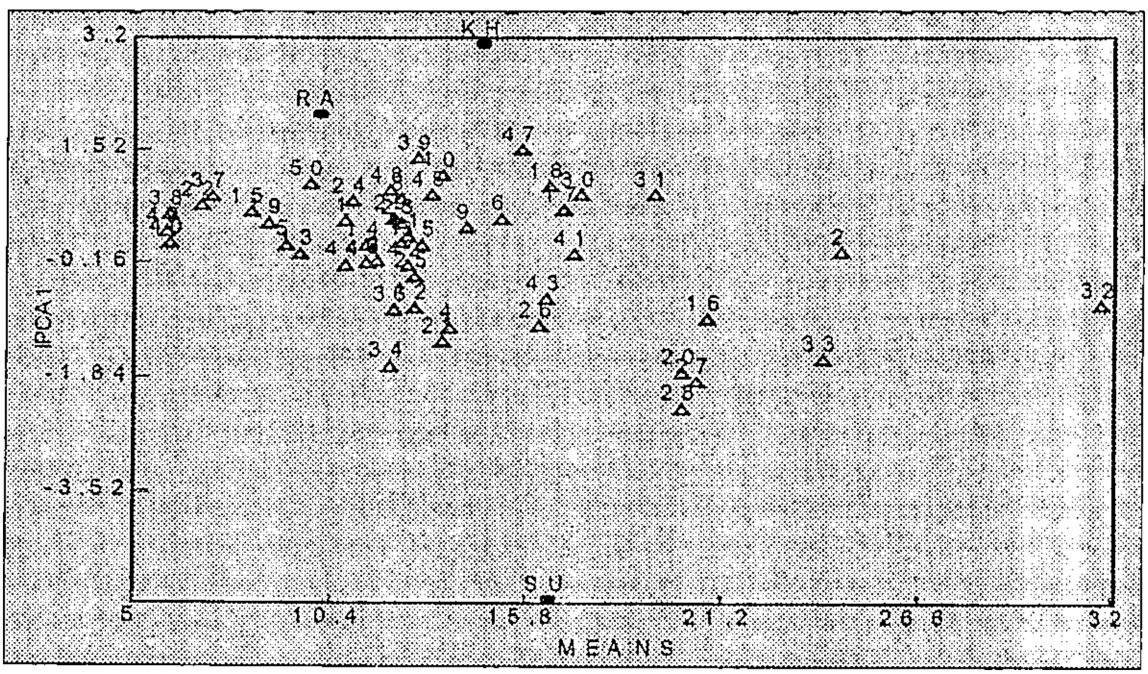

Fig.6. Biplot of mean performance versus 1st PCA for number of pods per plant

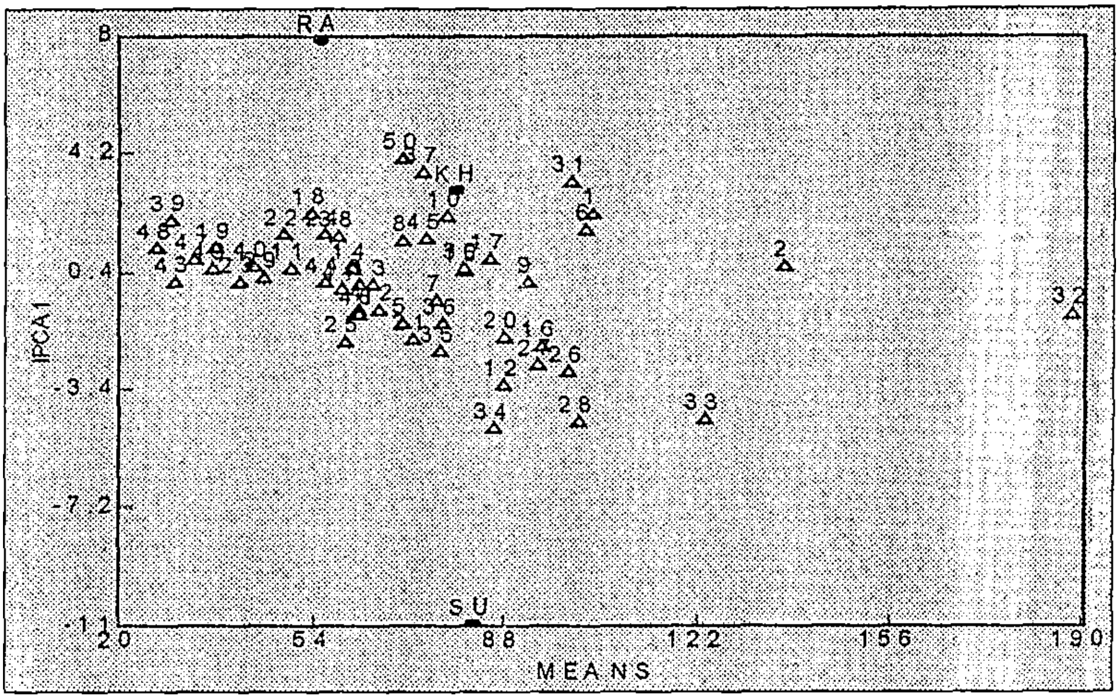

Fig.7. Biplot of mean performance versus 1st PCA for green pod yield per plant

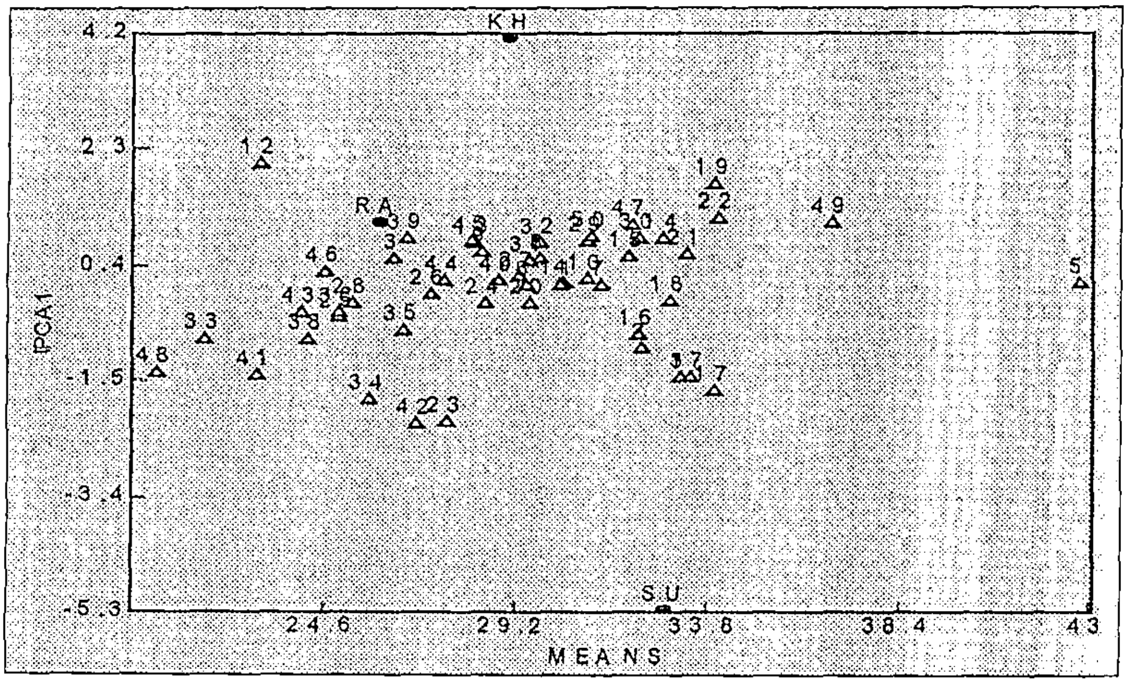

Fig.8. Biplot of mean performance versus 1st PCA for peduncle length

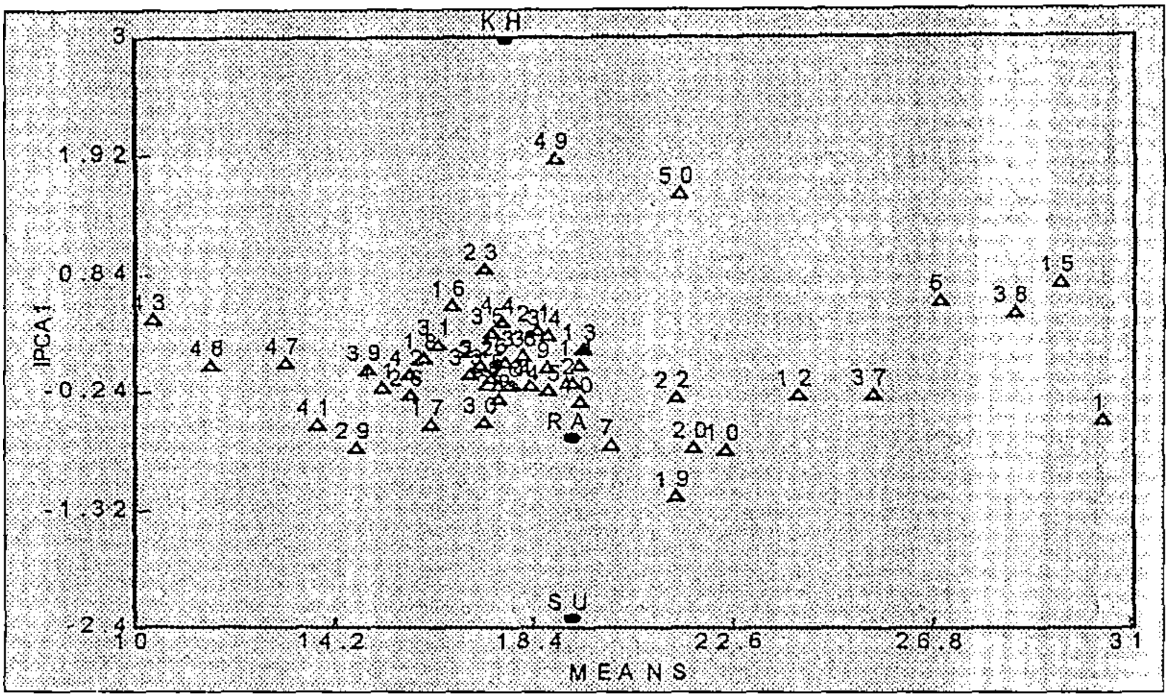

Fig.9. Biplot of mean performance versus 1st PCA for pod length

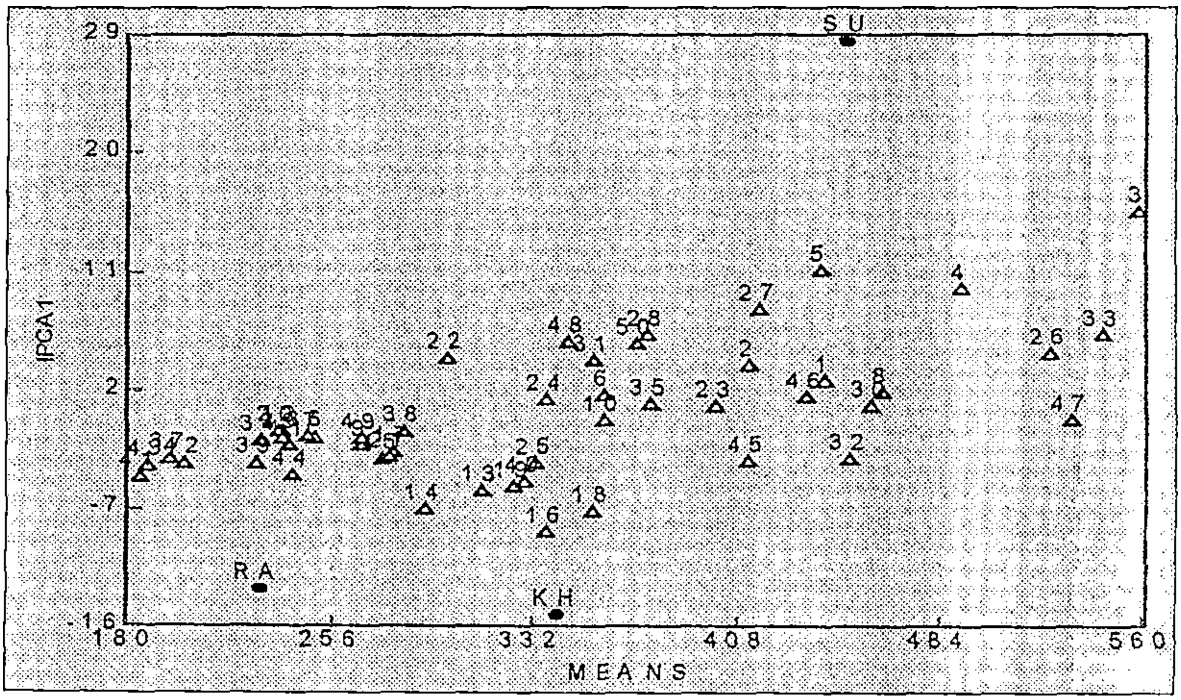

Fig.10. Biplot of mean performance versus 1st PCA for green biomass

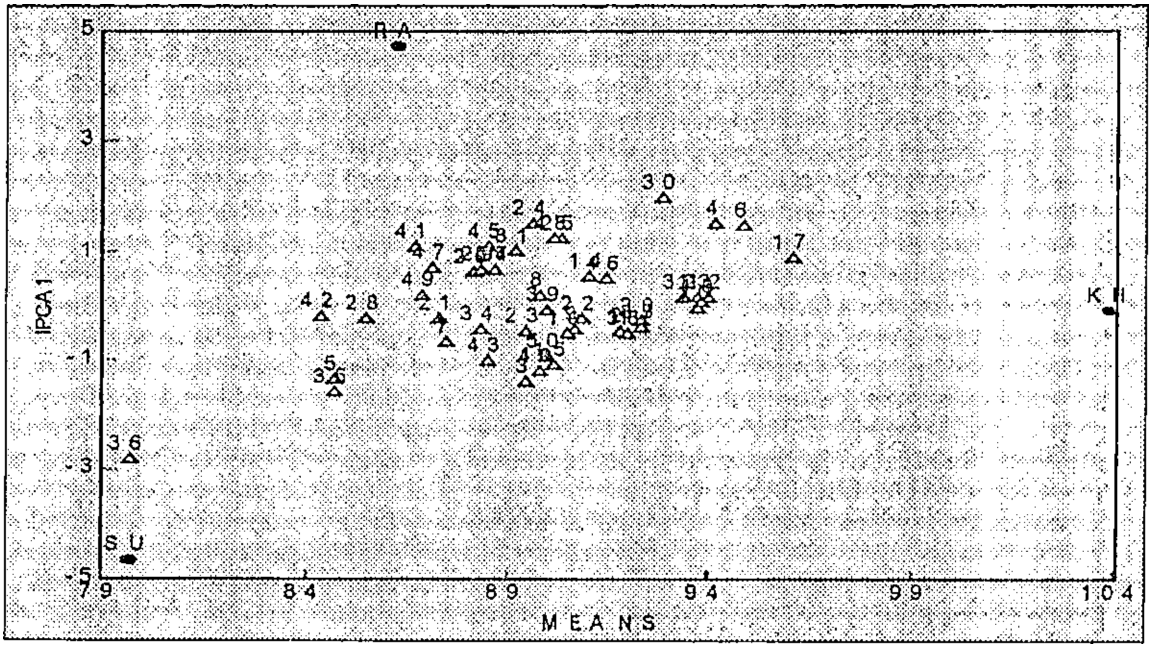

Fig.11. Biplot of mean performance versus 1st PCA for days to 80 per cent maturity

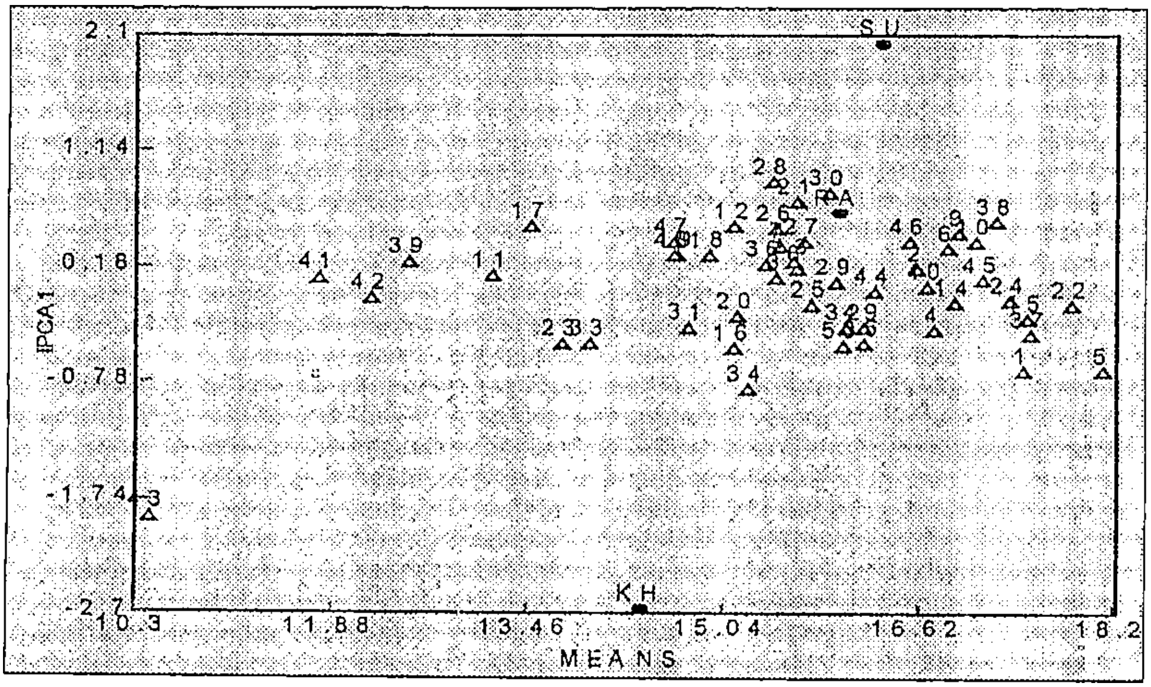

Fig.12. Biplot of mean performance versus 1st PCA for number of seeds per pod

per plant (Fig.13) and lower incidence of coreid bug (Fig.16). This can be considered as a high yielding and dual-purpose accession as its mean performance for green pod yield per plant, seed yield per plant and other characters were superior over all the three seasons.

The accession VS-1177 notated as (32) recorded the lowest days to first flowering (Fig.1) with the highest values for number of primary branches (Fig.3), clusters per plant (Fig.5), pods per plant (Fig.6), green pod yield per plant (Fig.7) and seed yield per plant (Fig.13). Lowest incidence of coreid bug (Fig.16) was recorded in this. It can be progressed as a dual-purpose variety over all the seasons since its performance was highly stable with high green pod yield and seed yield per plant.

The accession VS-1180 notated as (34) also took only lower number of days to first flowering (Fig.1), but the overall performance was not good. Even though the accession VS-1266 (Kairali) (49) recorded the lowest days to first flowering, days to 50 per cent flowering, days to 80 per cent maturity (Fig.11) with higher length of main branch (Fig.4), it did not perform well during all the seasons.

The accessions VS-1025 (2), VS-1179 (33), VS-1177 (32), VS-1015 (1), and VS-1175 (31) recorded higher number of primary branches and higher green pod yield. Number of clusters per plant, pods per plant, green pod yield per plant and seed yield per plant were also higher for the accessions VS-1177 (32), VS-1025 (2), VS-1179 (33) suggesting that these characters have significant influence on green pod yield and seed yield. The characters peduncle length, pod length, green biomass, days to 80 per cent maturity, number of seeds per pod have no influence on yield of these accessions.

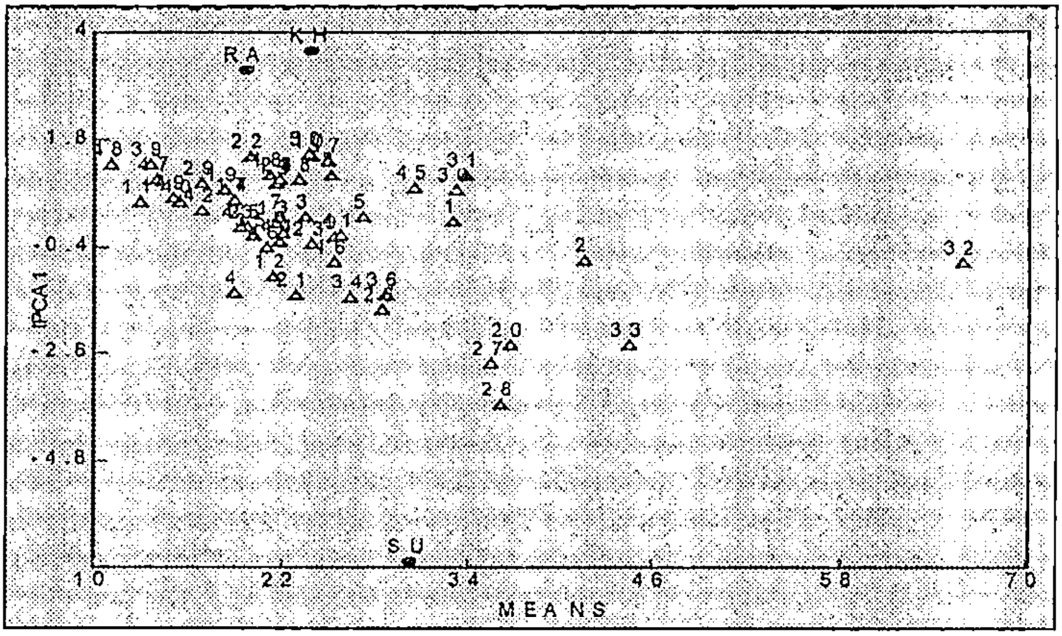

Fig.13. Biplot of mean performance versus 1st PCA for seed yield per plant

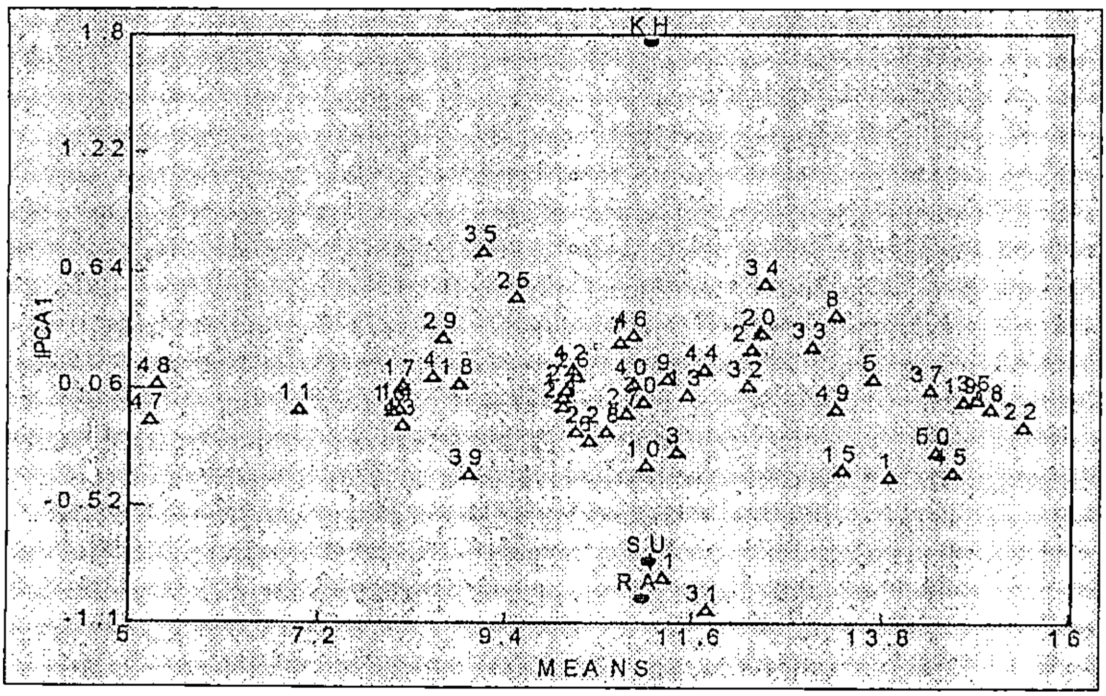

Fig.14. Biplot of mean performance versus 1st PCA for hundred seed weight

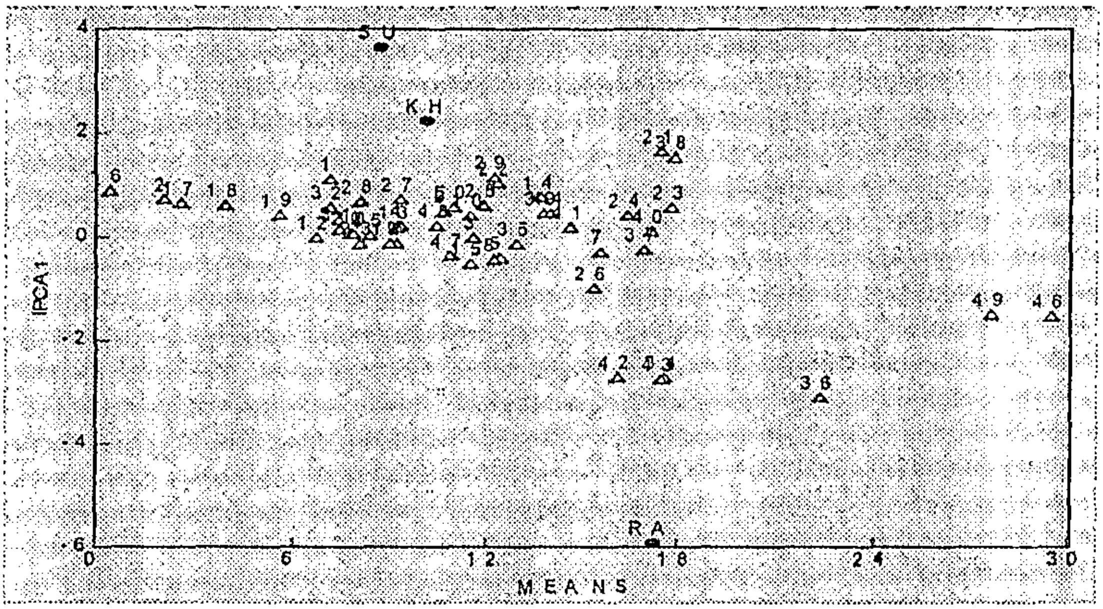

Fig.15. Biplot of mean performance versus 1st PCA for incidence of pod borer

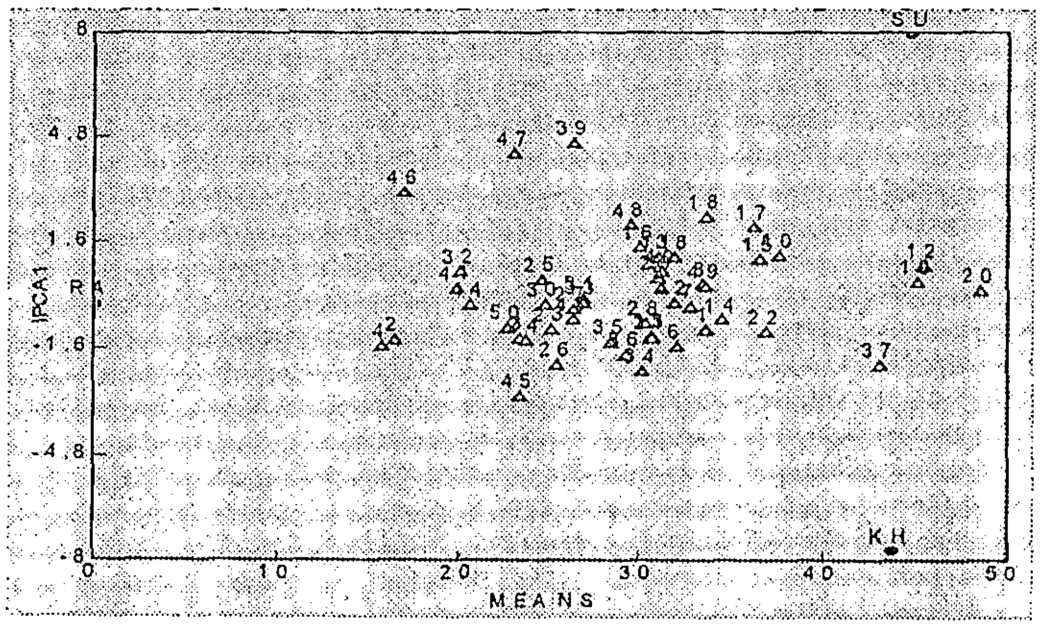

Fig.16. Biplot of mean performance versus 1st PCA for incidence of coreid bug

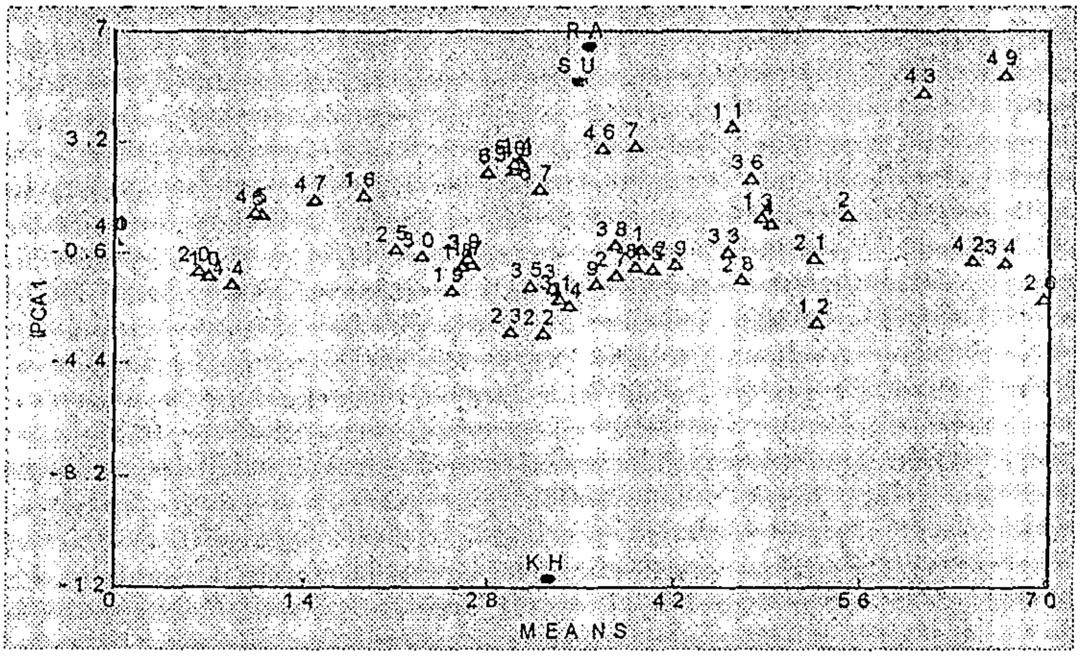

Fig.17. Biplot of mean performance versus 1st PCA for incidence of aphids

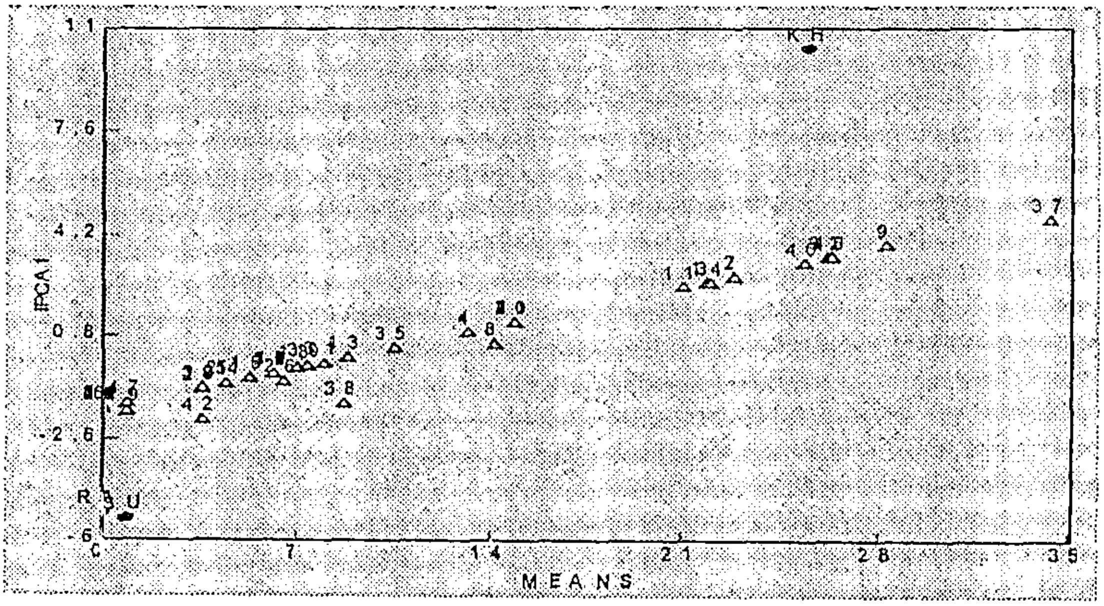

Fig.18. Biplot of mean performance versus 1st PCA for incidence of anthracnose

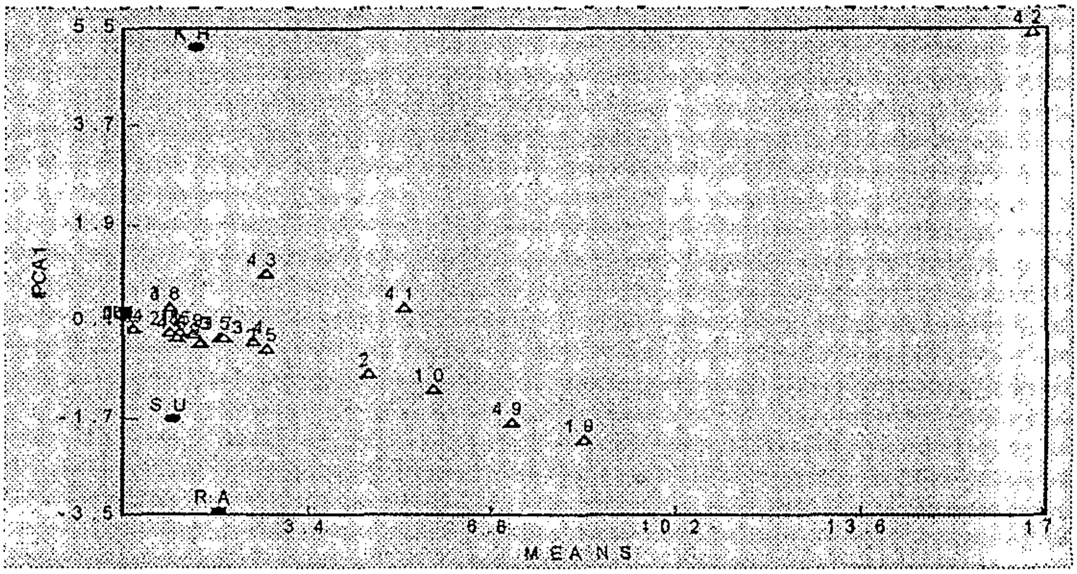

Fig.19. Biplot of mean performance versus 1st PCA for incidence of collar rot

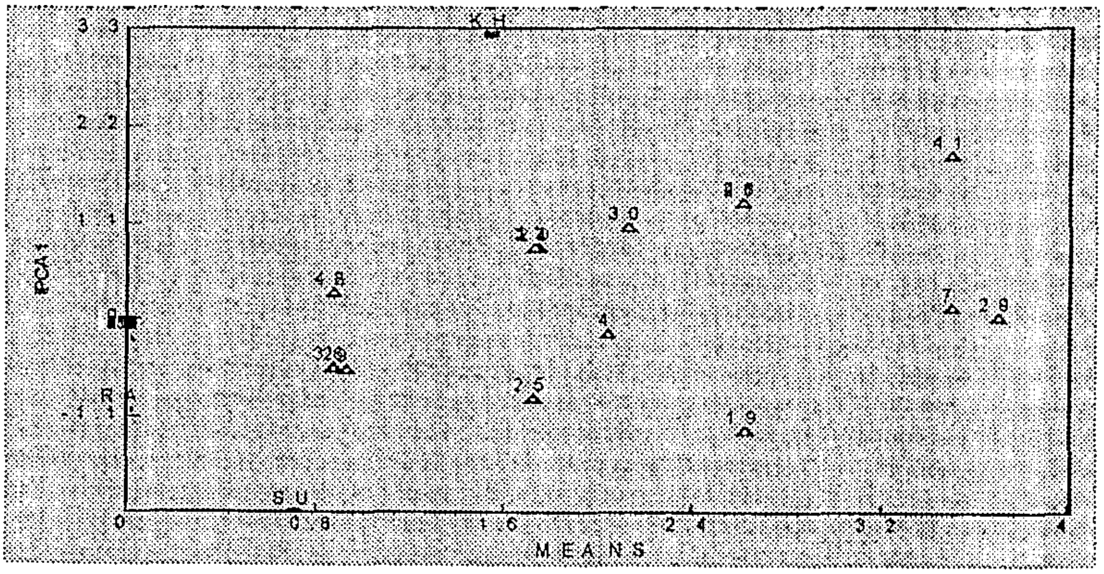

Fig.20. Biplot of mean performance versus 1st PCA for incidence of mosaic

The infestation of pod borer was below 2 per cent for the accession VS-1111 (16) during all the seasons suggesting that it can be popularized as a resistant variety after detailed evaluation and can be used in further breeding programmes. This accession also possesses high number of pods per plant.

From the pooled analysis using all the characters which contributed positively to yield (Table 29) *viz*, number of primary branches, length of main branches, number of clusters per plant, number of pods per plant, green pod yield per plant, peduncle length, pod length, green biomass, number of seeds per pod, seed yield per plant and hundred seed weight, the accessions VS-1177 (32), VS-1025 (2), VS-1179 (33), VS-1015 (1), VS-1170 (26) were found to perform best and can be recommended for year round cultivation (Plate 3 and 4).

Along with the accessions VS-1177 (32), VS-1179 (33) and VS-1025 (2) for year round planting, the accessions VS-1172 (28), VS-1170 (26) was also superior during summer and was particularly suited for summer and can be recommended along with VS-1177 (32), VS-1179 (33) and VS-1025 (2). Summer was the best season for cultivation of semi-erect cowpea lines. Superior biometrical characters observed during this season might have helped in the full expression of economical characters.

The accessions VS-1177 (32), VS-1042 (9), VS-1025 (2), VS-1174 (30) and VS-1179 (33) were found to perform well during *Kharif*. The accessions VS-1177 (32), VS-1025 (2) and VS-1179 (33) were suited for all the seasons but the accession VS-1042 (9) and VS-1174 (30) was specifically suited to *Kharif* and recommendations can be made accordingly.

In general the performance of all the accessions during *Rabi* was inferior to *Kharif* and summer. The lowest total rainfall and lowest humidity prevailed

Plate 3 Promising accessions of semi-erect cowpea

VS-1015

VS-1111

VS-1133

VS-1170

VS-1172

VS-1174

Plate 4 Promising accessions of semi-erect cowpea

VS-1177

VS-1025

Table 29. Pooled analysis of yield contributing characters

Sl No.	Seasons			Over all seasons
	Summer	*Kharif*	*Rabi*	
1	1177 (32)	1177(32)	1177 (32)	1177 (32)
2	1179 (33)	1042 (9)	1025 (2)	1025 (2)
3	1172 (28)	1025 (2)	1175 (31)	1179 (33)
4	1025 (2)	1174 (30)	1015 (1)	1015 (1)
5	1170 (26)	1179 (33)	1032 (6)	1170 (26)

during *Rabi* season might have contributed towards the lower performance of the crop (Appendix-I). All the biometrical parameters were also lower during this season, which might have directly reflected, in the poor performance. However, the accessions VS-1177 (32), VS-1025 (2), VS-1175 (31), VS-1015 (1) and VS-1032 (6) were found to perform better compared to other accessions. The accession VS-1175, VS-1015 and VS-1032 can be recommended for cultivation during *Rabi*.

During summer it took only fewer days for first flowering, 50 per cent flowering and 80 per cent maturity. The accessions VS-1248 (43), VS-1266 (49), VS-1231 (41), VS-1170 (26), VS-1168 (25) were early during summer (Table 29). The accession VS-1170 (26) though took only fewer days for flowering and maturity, its performance was superior. Even though the accessions VS-1213 (36), VS-1177 (32), VS-1248 (43), VS-1180 (34) and VS-1153 (21) took lower days for flowering and maturity during *Kharif*. The green pod yield was high for the accession VS-1177 (32).

During *Rabi*, the accessions VS-1266 (Kairali) (49), VS-1248 (43), VS-1034 (7), VS-1213 (36), VS-1030 (5) were early for days to flowering and maturity; but were poor in their performance.

5.2. VARIABILITY, HERITABILITY AND GENETIC ADVANCE

The presence of genetic variability constitutes foundation for further generic improvement. The information on variability is essential for selecting promising genotypes identifying characters amenable to genetic improvement. Further, critical assessment of nature and magnitude of variability contrives prerequisites in effective plant breeding, which decides interaction effects. The extent of genotypic and phenotypic factors on variability can be preliminarily studied by assessing the range of variability, mean, genotypic and phenotypic coefficients of variation.

The 50 accessions of semi erect cowpea used in the present investigation exhibited significant differences for all the traits. It is evident from table 25 that the range of variations for varietal means was quite large with respect to green pod yield per plant (26.33 – 188.5 g), green biomass (187.5 – 558.3 g), seed yield per plant (11.07 – 65.83 g), number of pods per plant (5.83 –31.67) and length of main branch (121.8 – 186.0 cm) suggesting the scope for improvement of these characters through selection. Similar results were reported by Ramachandran *et al.* (1980) in cowpea and Vidya *et al.* (2002) in yard long bean.

The Phenotypic coefficient of variation (PCV) ranged from 6.78 for days to 50 per cent flowering to 42.13 for green pod yield per plant, followed by number of pods per plant (35.78) and seed yield per plant (35.33). It was moderate for green biomass (27.30), pod length (22.90), hundred seed weight (22.28) and number of clusters per plant (22.00). The relative magnitude of PCV indicated a higher degree of environmental fluctuation in the case of green pod yield per plant, number of pods per plant, and seed yield per plant. GCV also revealed the same pattern of genetic variability as shown by the PCV in general for all other characters. The GCV was high for green pod yield per plant (36.02), seed yield per plant (35.52) and number of pods per plant (30.55) which indicated that these traits exhibited larger variability that can be ascribed to the genotype. Similar trend of variation in these characters were also reported by Rajaravindran and Das (1997), Das and Chakraborty (1998) in mungbean, Resmi (1998), Vardhan and Savithramma (1998) in cowpea, Reddy *et al.* (2003) in mungbean.

The characters such as 100 seed weight (21.81) and peduncle length (21.13) showed moderately high GCV values thereby suggesting that these characters also showed variability. The low value of GCV for number of primary branches (0.51) followed by days to 80 per cent maturity (0.89) indicated the limited scope for improvement through these characters. This is in accordance with the results obtained by Reddy (1997) in mungbean.

The GCV and PCV do not offer full scope to estimate the variation that is heritable and therefore, estimation of heritability becomes inevitable. Most of the characters under study were highly heritable in nature (Table 25). In the present study, heritability values ranged from 0.00 % for number of primary branches to 95.90 % for hundred seed weight. The high heritability of more than 60 percent was noticed in characters like hundred seed weight (95.90) followed by pod length (85.20), seed yield per plant (84.70), green pod yield per plant (73.10), number of pods per plant (72.90), number of seeds per pod (61.60) and number of clusters per plant (61.10). The high heritability for hundred seed weight, pod length, seed yield per plant, green pod yield per plant and number of pods per plant were reported by Angadi *et al.* (1978), Sreekumar *et al.* (1996), Vardhan and Savithramma (1998) in cowpea and Veeramani *et al.* (2005) in black gram. The high heritability estimates of these characters indicated scope for transferring characters to the progenies effectively. It is generally presumed that GCV along with heritability estimates gives a clear picture regarding the extent of genetic advance for further selection.

Burton (1952), Lerner (1958) and Johnson *et al.* (1995) were of the view that heritability estimates when used in combination with genetic advance would provide better information than the heritability estimates alone in predicting the resultant best individuals. Ponmariamma and Das (1996) also expressed that this type of genetic variance could further be exploited by intermating of desirable genotypes in further generations. The genetic advance over three seasons was high for green biomass (62.71) and moderate for green pod yield per plant (45.92). This result indicated that these characters were controlled by additive gene action and phenotypic selection for the improvement of these characters will be highly effective. This high value of heritability, GCV and PCV estimates in conjunction with high genetic advance was noticed for green pod yield per plant and seed yield per plant suggesting that worthwhile improvement in these characters can be achieved through selection. Similarly high heritability with moderate GCV and genetic advance for seed yield per plant and pod length indicate that improvement for these character also may be possible whereas high heritability with low GCV and genetic advance for number of clusters per plant, number of pods per plant, number of seeds per pod and others indicate a condition arises due to non-additive gene action (Liang and Walter, 1968). This confirms that high heritability alone does not signify an increased genetic advance. Similar results were reported by Aravindhan and Das (1996) in vegetable cowpea.

High heritability and genetic advance over three seasons observed for green pod yield per plant, seed yield per plant, hundred seed weight and pod length indicated that the variation in these characters was most likely due to additive genes, hence simple direct selection may be effective to improve these characters.

5.3 CORRELATIONS AND PATH ANALYSIS

The phenotypic and genotypic correlations were in the same direction and significant for length of main branch, days to 80 per cent maturity, peduncle length and pod length The genotypic correlation coefficient estimates were higher than the phenotypic correlation coefficient for these characters indicating an inherent association between these characters with green pod yield per plant. These findings were in agreement with Singh and Malhotra (1973), Wakankar and Yadav (1975), Ram *et al.* (1976) in red gram.

The path coefficient analysis is helpful in partitioning total correlation into direct and indirect effects, so that direct influence of component traits are uncompounded by other traits and their effects can be clearly understood. The direct and indirect effects of different characters on green pod yield per plant were worked out using path coefficient analysis at genotypic level (Table 27). Among the different contributing characters days to 50 per cent flowering (0.815) registered highest positive direct effect on green pod yield per plant. The characters such as number of clusters per plant (0.448) and number of seeds per pod (0.431) recorded moderately high positive direct effect on green pod yield per plant. Days to first flowering showed high indirect effects on green pod yield per plant through days to 50 per cent flowering. The direct and indirect effects indicate that the breeder should lay emphasis on days to 50 per cent flowering followed by number of clusters per plant and number of seeds per pod for improvement of green pod yield *per se*. The residual effect was low (0.0296) in the present study indicating that the contributing characters on green pod yield which were not included in the study, was very low.

Summary

SUMMARY

Investigations were undertaken in the Department of Olericulture, College of Horticulture, Vellanikkara during *Kharif, Rabi* and summer 2004-2005 to estimate "G x E interaction of semi-erect cowpea genotypes". The experiments were carried out with the objective of identifying stable, high yielding and dual purpose semi erect cowpea genotypes and estimating the G x E interaction of different characters

Fifty semi-erect cowpea accessions were evaluated in three environments *viz., Kharif* (June 2004 - September 2004), *Rabi* (October 2004 - February 2005) and summer (February - May 2005). The results are summarized below.

1. The analysis of variance revealed the presence of considerable variability among the genotypes for all the characters studied.

2. PCV and GCV values were maximum for green pod yield per plant, number of pods per plant and seed yield per plant.

3. Heritability was more than 60 per cent for characters like hundred seed weight (95.90), pod length (85.20), seed yield per plant (84.70), green pod yield per plant (73.10), number of pods per plant (72.90), number of seeds per pod (61.60) and number of clusters per plant (61.10).

4. Maximum correlation with yield was observed for length of main branch, days to 80 per cent maturity, peduncle length and pod length.

5. Maximum positive direct effect on green pod yield per plant was exhibited by days to 50 per cent flowering (0.815).

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6. The green pod yield and other yield contributing characters were better during summer than that of *Kharif* and *Rabi*

7. The mean pod borer infestation was below 2 per cent for the accession VS-1111 during all the seasons and can be used in further breeding programmes.

8. The accessions VS-1230 and VS-1231 were completely free from aphid infestation throughout the growing seasons.

9. Mean performance of all the accessions across the environments revealed that the accessions VS-1177, VS-1025 and VS-1179 performed better with respect to green pod yield of 9.5, 6.9 and 6.2 tonnes per hectare respectively and seed yield of 3.3, 2.1, 2.3 tonnes per hectare respectively. In addition the accessions VS-1172 and VS-1170 were also superior during summer. During *Kharif* the accessions VS-1174 and VS-1042 and during *Rabi* VS-1175 and VS-1015 also performed well.

10. The accessions VS-1177, VS-1025 and VS-1179 were identified as stable, high yielding, dual purpose, semi-erect cowpea accessions suitable for year round planting

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* Original not seen

APPENDICES-I

Weather parameters during period of study (May 2004 - June 2005)

	Temperature (^0C)		Relative humidity (%)	Total rainfall (mm)	Total sunshine hours	Rainy days
	Maximum	Minimum				
May-04	34.4	22.0	84	578.3	104.3	21
Jun-04	31.3	21.6	85	786.0	98.9	24
Jul-04	31.8	21.6	85	369.6	66.4	24
Aug-04	31.3	21.5	83	386.9	137.1	14
Sep-04	32.8	22.6	80	208.8	154	10
Oct-04	33.8	20.8	73	493.2	185.3	11
Nov-04	32.8	21.4	65	71.7	211.9	3
Dec-04	33.6	18.6	55	0.0	279.9	0
Jan-05	35.0	19.8	56	7.6	264	1
Feb-05	37.6	17.4	53	00.0	280.7	0
Mar-05	38.2	22.0	42	00.0	193.2	0
Apr-05	36.7	22.8	74	171.4	208.2	10
May-05	35.5	21.5	72	89.2	217.5	5
Jun-05	33.2	21.8	86	711.4	94.3	23

G x E INTERACTION OF SEMI - ERECT COWPEA GENOTYPES

By

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ABSTRACT OF THE THESIS

submitted in partial fulfilment of the requirement for the degree of

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ABSTRACT

Experiments on "G x E interaction of semi-erect cowpea genotypes" were carried out at the Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur during *Kharif, Rabi* and summer 2004-2005. The study was aimed at identification of stable high yielding and dual purpose semi-erect cowpea accessions over different seasons and to assess the G x E interaction with respect to different characters. Fifty accessions of cowpea collected from various parts of Kerala were used for the study.

The analysis of variance revealed considerable variability for most of the characters among the genotypes. The magnitude of PCV was higher for green pod yield per plant (42.13 %), number of pods per plant (35.75 %) and seed yield per plant (35.33 %). Heritability values of more than 60 per cent was noticed for characters like 100 seed weight, pod length, seed yield per plant, green pod yield per plant, number of pods per plant, number of seeds per pod and number of clusters per plant.

The pest and disease infestation scenario during cultivation showed that the accession VS-1111 had a pod borer infestation below 2 per cent and can be progressed further as a resistant material for future programmes. The coreid bug infestation was maximum during summer followed by *Kharif* and was nil during *Rabi*. None of the accessions were found resistant to coreid bug. The incidence of aphids was lowest during *Kharif* followed by summer and *Rabi*. The accessions VS-1230 and VS-1231 were free from aphid attack during all the seasons. There was no incidence of anthracnose during *Rabi* season. VS-1294, VS-1047, VS-1171, VS-1286 (Varun), VS-1276 (Kanakamony), VS-1179, VS-1213, VS-1160, VS-1263, VS-1032, VS-1266 (Kairali) and VS-1248 were free from anthracnose. The incidence of collar rot was lowest during summer followed by *Kharif* and *Rabi*. There was no incidence of mosaic during *Rabi*.

The performance of the accessions was the best during summer followed by *kharif*. The productivity was maximum in VS-1177 (green pod yield of 9.5 tonnes and a seed yield of 3.3 tonnes per hectare) followed by VS-1025 (green pod yield of 6.9 tonnes and a seed yield of 2.1 tonnes per hectare) and VS-1179 (green pod yield of 6.2 tonnes and a seed yield of 2.3 tonnes per hectare). Considering the performance over three seasons, the above accessions were found adaptable for green pod yield and seed yield. Hence these accessions can be selected as dual purpose, adaptable, semi-erect cowpea for large scale cultivation throughout the year in Kerala and can be recommended after further experimentation.