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CERTIFICATE

This is to certify that the thesis entitled "**GENOTYPE × ENVIRONMENT INTERACTION IN COWPEA (*Vigna unguiculata* (L.) Walp)**" submitted to the Faculty of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra State in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **GENETICS AND PLANT BREEDING**, embodies the results of a piece of *bona fide* research carried out by **Miss. ANJANEE ULHAS KUBADE** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma. All the assistance and help received during the course of investigation and the sources of literature has been duly acknowledged by her.

Place : Dapoli

Date: June, 2005

(V.W.Bendale)
Chairman,
Advisory Committee
and
Research Guide

“GENOTYPE × ENVIRONMENT INTERACTION IN COWPEA (*Vigna unguiculata* (L.) Walp)”

A thesis submitted to the

DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH, DAPOLI

(Agricultural University)

Dist.: Ratnagiri (Maharashtra State)

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE (AGRICULTURE)

in

GENETICS AND PLANT BREEDING

by

ANJANEE ULHAS KUBADE

B.Sc. (Hort.)

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CHAPTER I

INTRODUCTION

Pulses have important role in diet as well as in Agriculture. Besides, the only source of vegetable protein, they also provide the much-needed minerals and vitamins. Pulses are rich in proteins and they contain 20-30 per cent vegetable protein on dry weight basis, which is nearly three times than cereals.

The area under pulse crops in India was around 21.2 million ha with production of 11.31 million tonnes and productivity was about 536 kg per ha (Anonymous, 2003). In Maharashtra, pulses were grown on an area of 33.9 lakh ha. with production of 18.8 lakh tonnes and average productivity of 555 kg per ha. Total area of cowpea in Maharashtra and Konkan region was about 11800 ha and 1200 ha, respectively. The productivity of cowpea in Konkan region in 400 kg per ha and in Maharashtra 390 kg per ha cowpea in grown mostly during *rabi* season after rice crop in Konkan region (Apte and Jadhav, 2002).

Pulses are important source of proteins and constitute about 10 to 12 per cent of the Indian diet. The pulse protein is rich in lysine but poor in sulphur containing essential amino acid, methionine. Ipso-facto, a regular cereal-pulse (Dal-Roti) course is a perfect food. Unfortunately, during 50's the per capita intake of 64 g per day of pulses has come down to less than 40 g per day, whereas, FAO/WHO has recommended a minimum pulses intake of 80 g per day per capita. It is feared that the average Indian may have to pay 'protein penalty' if pulses are not available in adequate quantity, at a lower cost. (Hunsigi, 1998). This situation envisages the urgent attention on developing high yielding stable varieties of pulse crops suitable for growing in different locations.

Cowpea (*Vigna unguiculata* (L.) Walp) 2n=22 is an important leguminous crop in India. It is an early multiseason and multipurpose crop. It has realized the importance on account of drought tolerance and adaptation to wide range of soil types. It is mainly grown in Kerala, Madhya Pradesh, Maharashtra, Andra Pradesh, Tamilnadu, Uttar Pradesh, Punjab and Delhi.

Cowpea is gaining more popularity among farmers because of its manifold uses like green pods and tender foliage as vegetables and seed as pulse. The edible pod contains protein 3.59 g, calcium 72.0 mg, phosphorus 59.0 mg, iron 2.5 mg, carotene 564.0 mg, thiamine 0.07 mg, riboflavin 0.09 mg and vitamin C 24.0 mg per 100 gram of edible pods. The cowpea seed contains 23.4 per cent protein, 18 per cent fat and 60.3 per cent carbohydrates. It is also the rich source of calcium and iron (Chhiddha Singh, 1983).

Cowpea (*Vigna unguiculata* (L.) Walp) is under cultivation since very ancient times in the tropics of old world. Vavilov (1939) considered Africa as main centre of origin and India is considered as secondary centre of origin. Cowpea is a self-pollinated crop and belongs to family leguminaceae; sub family fabaceae and genus vigna. The species is a herbaceous annual and can be sub-divided into five subspecies as *unguiculata, cylindrica* and *sequipedalis* are cultivated, while *dekintiana* and *mensensis* are wild sub species.

At present, most of varieties of cowpea are low yielding, susceptible to yellow mosaic virus and thermo - photosensitive. Some varieties are only suitable for growing in *rabi* season, while some are lacking in stability. A number of varieties of cowpea from different state are available for cultivation though their adaptability across zones and/or seasons needs to be tested. The present investigation is carried out to study the phenotypic stability i.e. G × E interaction of some cowpea genotypes over three seasons.

The phenotypic performance is an interaction between genotype with the environmental conditions in which it is grown. The number of genotypes and environments determine the number of G × E interactions. Identification of well buffered cultivar; therefore constitute the basic requirement in designing a successful pulse production programme. Several models have been developed for isolation of well-buffered cultivars of crop plants. This has led to greater emphasis on Genotype × Environment interaction in plant breeding.

Various models like Finlay and Wilkinson (1963), Eberhart and Russell (1966) and Perkins and Jinks (1968) are known to be useful for this purpose. Eberhart and Russell (1966) model of G × E interaction is one of the most popular amongst them. With the help of this model, linear and non-linear components of interaction can be worked out, which help in judging the degree of predictable and non-predictable responses of individual genotypes as well as population under various kinds of environmental conditions.

Precise information on stability parameters thus obtained could be an essential step for identification of widely adaptable genotypes. Estimation of extent of such (G × E) interaction and magnitude of its linear and non-linear components would be of great use in the identification of stable genotype of this crop. Thus, with this profile, the present investigations are concerned with the evaluation of cowpea genotypes for their stability for growth, development and green pod yield for vegetable purpose along with its contributing characters. The objectives of the present investigation are:

1. To estimate the stability parameters in cowpea genotypes for green pod yield and its important components.
2. To ascertain nature and extent of genotype × environment interaction in different genotypes of cowpea.
3. To identify genotypes with desired response at varying environmental conditions.
4. To study correlation coefficient among different attributes of stability.

CHAPTER II

REVIEW OF LITERATURE

Genotype-by-environment interaction is a widespread phenomenon. It indicates that genotypes react in different ways if environmental conditions change and is of significance for breeder. When genotypes are compared over environments, the relative rankings usually differ. Such changes in order, ranking and relative values among genotypes over several environments are due to phenomenon of genotype × environment interactions (G × E). The occurrence of G × E interaction has long provided a major challenge to better understanding of genetic control of variability and thus to the rationalization of procedures for breeding improved genotypes in crop plants.

These interactions are usually present under all conditions including self and cross-pollinated crops, hybrids and any other materials used for breeding. In self-pollinated crops, different methods for increasing and stabilizing grain yield have been tried. Many studies in self-pollinated crops have been reported to assess the yield performance and stability of heterogeneous and homogenous populations.

The present investigation was undertaken with a view to identify stable, high yielding genotypes in cowpea. The suitable parameters are necessary to provide the criteria to rank varieties for selection of high yielding and stable genotype. Different models were proposed by various scientists such as Finlay and Wilkinson (1963), Eberhart and Russell (1966) and Perkins and Jinks (1968). The appropriate model depends on the materials, environments, and adequacy of model and ultimate interest of the experimenter. Eberhart and Russell's (1966) model was the most widely used and being relatively simple. The model has the ability to predict performance across environments over generations, if linearity of regression is preponderant.

The literature pertaining to this respect was reviewed and the most significant findings were presented in the text.

Eberhart and Russell (1966) have presented evidence to show that the model, $Yij=\mu ij + biIj + \delta ij$, defines stability parameters that may be used to describe the performance of a variety mean of i^{th} variety at the j^{th} environment, μi is the i^{th} variety mean over all environments, bi is the regression coefficient that measures the response of the i^{th} variety to varying environments, δ ij is the deviation from regression of the i^{th} variety at the j^{th} environment, and Ij is the environmental index.

The data from two single-cross diallels and a set of 3-way crosses were examined to see whether genetic differences could be detected. Genetic differences among lines were indicated for the regression of the lines on the environmental index with no evidence of non-additive gene action. The estimates of the squared deviations from regression for many hybrids were zero, whereas extremely large estimates were obtained for other hybrids.

Acharya and Singh (1979) studied G × E interactions for quality attributes in fifteen varieties of fodder cowpea. Chingra and No. 177 were stable genotypes for leaf stem ratio and crude protein yield; Ch-1 and PN-3 were most responsive in improvements of leaf-stem ratio and crude protein yield respectively in the varying environmental conditions.

Saini *et al.* (1979) evaluated ten genotypes of cluster bean for green fodder yield and two parameters of stability bi and S^2di over a period of 5 years. The response as well as deviation around regression slope of each genotype was considered separately. The estimates of (Sb) showed that there were distinct differences between the ten cluster-bean varieties in the deviation around regression slope. The genotypes namely, HFG 119, No. 2 and FS 227 appear to be stable genotypes and had low Sb value.

Jain *et al.* (1984) gave a summery of pooled analysis of variance revealed the existence of high genotype-environment (G × E) interaction for all the character. Inspite of the non-significance of linear component of

$G \times E$ interaction, few genotypes exhibited $b > 1$ or $b < 1$ for seed yield per plant, seeds per pod and harvest index. The regression analysis of Eberhart and Russell (1966) has been useful in assessing the adaptation of various genotypes. Accordingly, the genotypes showing wide adaptability and specific adaptation were identified. K-4 was found suitable for better management conditions. Pant G-110 showed promise for moderate input management and Kaka, NEC-240 and Pink-2 appeared worthwhile for poor environmental conditions.

Kandasamy *et al.* (1985) reported the stability of yield and component characters in ten genotypes of cowpea under nine different environments. Six genotypes out of ten were stable in respect of pod length and seeds per pod and were not correlated with bi and S^2di value of yield. Pods per plant and clusters per plant showed significant correlation with yield. The pods per plant, clusters per plant and 100 seed weight showed in the non-stability of yield in the genotypes.

Sulochana and Peter (1987) estimated that fifteen genotypes of cowpea (*Vigna unguiculata* (L.) Walp) and one yard long bean genotype under two contrasting environments to identify vegetable types suited for high and low yielding environments. All the genotypes were significantly different for nodes to first flower, days to harvest, pod length, 100 - seed weight and pod yield per plant. The environments were significantly different to create significant difference for days to harvest, pod length, 100-seed weight and pod yield per plant.

Katiyar R.P. (1988) believed that nineteen diverse and elite strains/cultivars of urdbean at three locations of Himachal pradesh to characterize the stability of yield and its components. IU 78-3 was the most stable variety with yield potential above the overall mean. High stability for pods per plant and seeds per pod conferred stability for yield on JU 78-

3. All the fine components varied in compensatory fashion to import homeostasis to the final and complete character of yield.

Parab (1988) evaluated correlation studies in moth bean. He revealed that only one character cluster per plant showed significant correlation with bi while no any character with S^2di value of yield for the mean performance with grain yield per plant showed significant correlation for the characters *viz.*, clusters per plant, pod length, plant height and seeds per pod.

Patil and Narkhede (1989) summarized those sixteen green gram genotypes grown over four seasons, for stability of pod length and seeds per pod. All the genotypes were responsive towards environmental variations. Both predictable and non-predictable components were equal for the G × E interaction. However, a mean performance of pod length could be predicted across the environment and it was also associated with linear component of G × E interaction. The genotypes RM-76-40, J-781 for pod length and J-781 and S-8 for seeds per pod were found to be stable. The genotypes RM-75-25-6-10 having more seed yields would be acceptable for commercial cultivars since it was found to be the most stable and average in response and performance for both the characters.

Sood and Saini (1989) reported that fourteen varieties of *Vigna mungo,* HPU-392, HPU-394, HPU-410, HPU-402, HPU-384, HPBU-9, HPBU-52, PDU-1, Pant U-19, UH-2, UH-27, UH-42, UH-45 and T-9 were studied for stability parameters with respect to yield and maturity. Genotype × environment interaction was significant for both characters. Linear and nonlinear components were predominant in genotype × environment (G × E) interaction in case of yield, whereas linear component accounted for most of G × E interactions for maturity. HPBU-9 was the most stable genotype with respect to yield, while UH-2 and UH-42 were highly stable for maturity. No correlation among the three stability parameters was observed for both characters. It is proposed to consider all the three parameters while breeding stable varieties of mash.

Holkar *et al.* (1991) evaluated the phenotypic stability of seed yield of fifteen pigeon pea genotypes. Mean difference between genotype and environment of seed yield and other characters, genotype × environment (linear) for seed yield and water use efficiency and non-linear component against pooled deviation for all the characters was found significant

Senapati and Roy (1991) estimated that fifty one bunch type of groundnut genotypes collected from diverse sources were tested under randomized block design with three replications to assess their stability with regard to yield and maturity following the model of Eberhart and Russell (1966). The experiments were conducted under four environments. Relative judgment of the genotypes from their different stability parameters and mean performance revealed that genotypes JL-24, ICGV 87123, ICGV 86006 and ICGV 87170 are suitable for West Bengal conditions.

Thaware *et al.* (1991) studied ten genotypes of cowpea (*Vigna unguiculata* L.) for assessment of components of Genotype × Environment interaction for forage yield during *kharif* and *rabi* seasons of the year 1984 to 1986. The material under investigation exhibited significant genotypic variability in respect of forage yield. The linear component of Genotype × Environment interaction was totally absent whereas non-linear Environment component in five genotypes UPC 9021, UPC 5286, HFC 721, Russian Giant and FOS 1 however, suggest a scope for growing these genotypes for predicted performance in a given set of environmental conditions.

Thiyagarajan and Rajasekaran (1991) studied the magnitude of genotype × environment interaction of cowpea (*Vigna unguiculata* L.) were tested during 1984 in a randomized block design, with three replications in six environments. The environments were created by different seasons, namely *kharif* and *rabi*. The genotypes CO 3 × C 152, KC 199 × C 152, Co 3, KC 199 and C 152 were stable.

Bejiga *et al.* (1992) found that chickpea National yield Trials (CNYT) were carried out over three years to determinate the adaptability and performance of some chickpea varieties over wide range of environments. The results showed that there were significant differences among locations in 1986-87 and 1988-89 suggesting that these locations can be used as testing sites for different environments. Location × variety interaction was not significant except in 1986-87 indicating that these varieties did not differ in response to different environments.

Birari *et al.* (1993) reported that stability parameters for grain yield and eight, yield reported components in seven promising genotypes of cowpea (*Vigna unguiculata* L. Walp) during five seasons. The highest yielding genotypes were V-16 (9.39 g/plant) and ACSS-210 (8.17 g/plant). ACSS-210 showed a high degree of predictability for pods per plant, pod length, 100 seed weight and harvest index and was rated as the most stable genotype. The correlation coefficients among different attributes were also estimated.

Sharma *et al.* (1993) studied 12 genotypes of rajmah grown in randomized block design with 3 replications during winter seasons of 1989-90 to 1991-92 under residual soil moisture conditions. The mean square due to genotype environment interaction was significant when tested against pooled error and revealing that genotypes interacted considerably with the environmental conditions. The genotypes DFB 1, DFB 2 and DFB 6 gave considerably high yield and stable under fluctuating environmental conditions.

Jahagirdar *et al.* (1994) studied 12 genotypes of mungbean for number of pods per plant, number of seeds per pod, 100-grain weight (g) and grain yield kg per ha in three summer seasons (1988, 1989 and 1990). The G × E interaction for all traits except was found significant. Both linear and non-linear components G x E interaction were significant for all traits except for 100-grain weight.

Mandal and Dana (1994) evaluated twelve promising *Vigna unguiculata* genotypes were studied at 10 environments in West Bengal during 1992. Genotype × environment interactions were significant and non-linear. High yielding cv. Chingra was unstable across environment. D 1271 and Co1 showing average yield performance were stable across environments and the most promising for cultivation as green fodder plants.

Renganayaki (1995) studied ten promising genotypes of mungbean and were evaluated for yield and its components for three years. Genotype × environment component was significant for all the characters indicating divergent linear response of genotypes to environmental changes. Non-predictable component of clusters per plant and predictable component (linear) for grain yield indicated the non-linear response of the genotypes to the chance of environments. Co-4 exhibited high mean grain yield, number of clusters per plant, length of pod and number of seeds among ten genotypes.

Viswanathan and Nandarajan (1996) estimated that thirteen varieties of cowpea (*Vigna unguiculata)* were evaluated in 3 environments and stability parameters were studied for yield. Varieties IT-86-D-1056 and Co-4 showed average response to changes in environmental conditions with higher mean yields against the population mean yield. VCP-4 had the highest mean seed yield among the materials studied and was specially suited for the unfavourable growing season.

Manivannan *et al.* (1997) studied eight black gram genotypes during five seasons for their stable performance for seed yield. The results indicated that varieties Vamban 1, LBG 17 and Co 5 were stable. Vamban 1 recorded below average responsiveness to environment and Co 5 as average responsiveness to environment. Genotypes VBG 20, Vamban 1, VBG 11 and T 9 recorded high mean seed yield. Hence, the variety Vamban 1 may be recommended to all environments because of its low responsiveness to environment with high seed yield.

Murugan *et al.* (1997) observed seventeen pigeon pea genotypes and studied their stability for seed yield over three years. The linear component of regression is not significant against pooled error indicates that the prediction of performance of late maturing pigeon pea genotypes over environments is difficult. However, two genotypes ICP 7991 and ICP 7346 were found stable and also more responsive to environments with high seed yield. These two genotypes can be recommended for highly favourable environments.

Ghangurde (1999) in her experiment on Genetic studied on biomass partitioning in lablab bean reported significantly higher mean values of yield realization index and yield realization index per day (53.21 % and 0.5190, respectively) for selected progenies than their parents (40.146% and 0.3864, respectively).

Kulkarni and Birari (1999) studied eight genotypes of asparagus bean for green pod yield in four environments. The mean square for G × E interaction was significant indicating substantial variation among genotypes over different environments. Genotypes × environment and pooled deviation were highly significant indicating the significant differences among the genotypes for both linear and non-linear response to environments. The genotype × environments interaction (linear) was found to be significant. Genotype WALI-3A had unpredictable performance, while the genotype WALI-4 had significant linear as well as non-linear component.

Sood *et al.* (1999) observed 15 genetically diverse strains of soyabean evolved at Vishvavidyalaya, Palampur along with one check grown under 5 environments. The mean squares for G × E interaction were significant for days to maturity and seed yield (kg/ha) revealing differential response of genotypes under different environments. Significant pooled deviations for both the traits revealed that non-linear component was important in the manifestation of G × E interaction. For seed yield P 3-3 and P 6-6-1 were stable with good seed yield and average response to change in environmental conditions. 'P 3-2' 'Himso 473' and 'P 6-1-1' were stable for early maturity and average response to change in environmental conditions. Thus 'P 6-1-1' with above average yield and early maturity was found stable which can be used as a variety.

Sharma and Sharma (2000) studied seven genotypes of peas evaluated during four *summer* seasons of hilly area in randomized complete block design. Partitioning of g × e interaction into linear and non-linear component expressed the predominance of the former component making it easier to predict the performance of the genotypes. The genotypes 'Palampriya' and 'Azad P 1' with high mean values showed average regression coefficient (bi=1) and least deviation from regression coefficient (S^2di=0) hence identified as stable in performance.

Cisse (2001) estimated low spacing × genotype interaction caused by changes in genotype ranking could require twice the resources to identify superior genotypes. This study was conducted to estimate the magnitude of genotype × row spacing interaction and its effects on testing and selection procedures used in cowpea (*Vigna unguiculata)* cultivar development. Ten genotypes were evaluated for grain yield and harvest index with 50 × 50 and 50 × 25 cm spacings, for two years (1988 and 1989) at two locations (Louga and Bombay, Senegal). Within row spacing (WRS) did not have a significant effect on either trait. Genotype × within row spacing interaction effects were not significant, suggesting that selection at low densities would be effective in identifying superior and productive genotype for further testing in either within row spacing. Because of significant genotype × environment and WRS interaction effects, this effectiveness would require stable genotypes to be tested more than a year. Also, preliminary testing of large populations in high-productivity environment only, would not maximize gain from selection in low-productivity zones. But the most productive genotypes in both zones can be identified through concomitant selection for yield in high productivity environments and for harvest index in low-productivity conditions.

Henry (2001) evaluated ninety-nine germplasm of moth bean collected from different growing areas was tested for their genotype × environment interactions under rainfed condition for 3 years. The majority of genotypes tried had significant deviation value and had low grain yield potential. Genotypes like 'NM sel 7' and 'Jag-1' had high mean yield and stable under fluctuating environmental conditions, whereas genotypes like 'PLMO 84-A', 'PLMO-215', SO-15', 'P sel-4 (J)', 'P Sel-11 (J)', 'So-Sel-5', 'Su-4'and NM-7 suitable for favourable growing conditions. Genotypes like 'Des Sel-4' and 'NM Sel-8' specially suited for diverse growing conditions. Exploitation of these genotypes in breeding programme in advocated for increasing the productivity of moth bean in its growing areas.

Henry and Kacker (2001) estimated genotype × environment interactions was investigate in important genotypes of cluster bean (*Cyamopsis tetragonoloba* (linn.) Taub) under late sown conditions during *kharif* season at Bikaner and Jodhpur. It was observed that the genotypes interacted significantly with the environments and linear and non-linear components were significant. The genotype 2470/12 was found to be the best among all the genotypes tested as it had high grain yield and average stability.

Sultana *et al.* (2001) observed the pooled analysis of variance for stability in 25 genotypes of green gram in three different environments indicated that both linear and non-linear components were responsible for interaction of genotypes with environments since the genotype, environments, genotype × environment interaction and environment (linear) components exhibited significance for all the characters studied. Among the three environments, environment 1 was found to be most favourable for plant height, number of clusters per plant, number of pods per plant, number of seeds per pod, protein content and seed yield per plant while environment 3 was found to be unfavourable as most of the characters recorded low values except days to 50 per cent flowering and days to maturity. The genotypes LGG 444 exhibited stable performance for seed yield per plant.

Thakur *et al.* (2001) reported the twelve genotypes of french bean (*Phaseolus vulgaris* L.) were evaluated for 4 years (1995-98) under rainfed conditions at Research Station, Katrain in Kullu valley for stability of yield and maturity. Pooled analysis of variance revealed significant differences amongst genotypes and substantial G × E interaction effect on grain yield. Linear and non-linear components of G × E interaction were important for both grain yield and maturity period with preponderance of the former. Genotypes '62-1 P1', 'HPR 207' and "Hans' were found high yielding and suitable for high-input conditions of cultivation and 'HPR 207' was high yielding and most stable amongst the 3.

Henry and Kacker (2002) studied Genotype-environment interaction for grain yield in moth bean (*Vigna acontifolia* Marechal) by growing 20 genotypes for 3 years in 4 different environment representing major moth bean growing areas during monsoon seasons (1981-83). There significant variation for genotypes and genotype × environment interaction for seed yield. The linear as well as non-linear components were significant. The genotypes like ‘IPCMO 522’, ‘IPCMO 935’, ‘IPCMO 937’, ‘RDM 211’ and ‘T 16’ were stable under fluctuating environmental conditions. Genotypes like ‘JMM 60’ and ‘JMM 211’ were the best for favourable growing seasons. An improvement in the stability of the high yielding genotypes like ‘JMM 259’ and ‘IPCMO 323’ through breeding programmes will help the improvement of the productivity of the crop in its growing tracts.

Manikannan *et al.* (2002) evaluated 31 black gram genotypes over three environments clusters per plant, pods per plant, seeds per pod, 100 seed weight and seed yield per plant. The data were analyzed over environments for stability parameters and three genotypes for stability parameters and three genotypes *viz.,* ‘VBG-20’, ‘VBG-58’ and ‘CO-5’ identified as stable genotypes for seed yield and possessed stability for yield components *viz.,* 100 seed weight (CO-5), pods per plant (VBG-20) and seeds per pod (VBG-58).

Hemanth Kumar and Hussain saheb (2003) tested thirteen genotypes of pearl millet in the three stimulated environments, differed significantly against pooled deviation and pooled error. The prediction of genotypes of grain yield and non-prediction for fodder yield was observed. ‘ABH 664’ and ‘HHB 60’ for grain yield and ‘AHB 664’ and ‘AHB 213’ for fodder yield were found to be stable across environments. In Anantpur region, where abiotic stress plays a vital role in determining crop yields, ICTP 8203 along with MBH 130, AHB 664 and HHB 60 were found promising.

Kavitha *et al.* (2003) evaluated twenty-one genotypes of cowpea grown during *kharif* 2000 in Hisar, Haryana, India were studied for stability of grain yield per plant. Significant mean sum of squares due to genotypes was observed for grain yield in all four environments, indicating presence of genetic variation among the genotypes for this trait. The linear component (59.96%) of genotype × environment interaction was higher than the non-linear component. Ten genotypes had above average mean performance, average responsiveness and stable for grain yield, hence, there use in future breeding programme aimed at stable grain yield in cowpea is advocated.

Khatri *et al.* (2003) studied stability of 21 diverse genotypes of cowpea for test weight grown during *kharif* 2000 in Hisar, Haryana, India. Both linear as well as non-linear components of genotype × environment interactions were equally important for seed test weight. Genotypes HC 98-40, HC 98-33 and GC 9732 had above average mean performance and average responsiveness coupled with better stability. The use of these genotypes as doner parents for stable test weight in future breeding programme in cowpea is suggested.

Pujari *et al.* (2003) reported the fifteen genotypes of cowpea were grown in two seasons and at three levels of phosphate fertilizer to study the phenotypic stability for pod yield and related pod characters. Presence of genotype × environment interaction was observed for all the six characters studied. The genotypes Sel 2-1, IIHR 61-B, Sel. 263, DCP-120 and Faizabadi L-1 were found to be good performers and showed stability for a number of traits. These genotypes can be further utilized in cowpea breeding programmes.

Singh *et al.* (2003) reported that fifteen genotypes of cowpea were evaluated during *kharif* 1988, 1989, 1990 and 1991 in Fatehpur-Shekhawati, Rajasthan, India. Data were recorded for seed yield per plot, days to maturity, plant height, and number of pods per plant and test weight. Analysis of variance indicated significant differences among genotypes. The interaction sum of squares of genotype × year was highly significant, indicating the effect of environment on character expression. Genotypes FTC-4, FTC-9 and FTC-27 had some potential of stability, and the use of their potential in future breeding programme is suggested to develop genotypes with high seed yield and stability in diverse environments.

Asfaw *et al.* (2004) had worked stability of 42 genotypes of black gram (*Vigna mungo*) was conducted for grain yield at four different environments created by different sowing dates and seasons at Hisar. The most commonly used stability parameters like bi, $\overline{S}^2di$, 6^2i, S^2xi and Cvi were employed. Significance of main environmental and interaction effects indicated the differential response of the genotypes to changing environments. The likely areas of adaptation of genotypes were identified. The genotypes, namely IPU-97, UH-94-10 and DPU-91-5, though low yielder, were identified for general growing conditions due to average stability. These are likely to give some assured yield.

Raje and Rao (2004) observed two hundred germplasm lines of mungbean along with 6 commercial check varieties of mungbean were evaluated over four diverse environments to identify high yielding and stable genotypes for seed yield per plant. Variance due genotype, environment, genotype × environment, environment + (genotype × environment), genotype × environment (linear), environment (linear) and pooled deviation were significant for seed yield per plant. On the basis of stability analysis genotypes, showing above and below average stability along with higher mean values of genotypes were found promised. These genotypes will be useful in breeding programme to evolve stable and high yielding variety of mung bean.

Rao and Rao (2004) studied thirty promising genotypes of chickpea (*Cicer arietinum* L.) for stability parameters to identify genotypes with reasonable degree of stability for yield and its components. Significant differences were observed due to genotypes, environments and genotype × environment (linear) interaction for all the traits. However, genotype × environment (non-linear) was found to be non-significant for plant height, harvest index and yield per plant. Five genotypes *viz.*, 'Phule-G 95311', 'ICCV 42', 'ICCV 95334', 'Pusa 390' and 'Pusa 362' were sorted out with high seed yield (higher than grand mean over environments) alongwith stability for yield and other yield contributing traits on the basis of bi=1.00 and $S^2di = 0$.

Rao *et al.* (2004) showed ten mung bean genotypes were evaluated at five locations to study their stability/adaptability. Based on three parameters, overall mean, regression coefficient (bi) and mean deviation from regression (S^2di), the genotype MGG 347 could be considered as the most stable amongst all the genotypes and its performance could be predicted over the environments.

CHAPTER III

MATERIALS AND METHODS

The information pertaining to the experimental details and analytical methodology followed in Genotype × Environment interaction in Cowpea (*Vigna unguiculata* (L.) Walp) has been presented below:

3.1 Experimental site

The present investigation was carried out at Research Farm of Department of Agricultural Botany, College of Agriculture, Dapoli, Dist.- Ratnagiri during February 2004 to February 2005.

Geographically, Dapoli in situated in the sub-tropical region on the 17 45' north latitude and 73 12' east longitudes having an elevation of 250 m above mean sea level. The mean annual precipitation is around
3500-4000 mm, which is generally, received during the period from June to October. The Meteorological data during the period of investigation was collected from the Meteorological Observatory, Department of Agronomy, College of Agriculture, Dapoli (Appendix -I).

3.2 Experimental Material

The parental material consisted of 21 vegetable cowpea genotypes (*Vigna unguiculata* (L.) Walp) of genetic divergence studied previously. The material collected from Central Experimental Research Station, Wakawali. The salient features of genotypes involved in the present investigation are given in Table 1.

3.3 Seasons and sowing procedures

The cowpea (*Vigna unguiculata* (L.) Walp) crop was grown during the season *summer* –2004 (E_1), *late Kharif* -2004 (E_2) and *rabi*-2004 (E_3).

Table 1. Silent features of cowpea (*Vigna unguiculata* (L.) Walp)

Sr. No.	Name of the Genotypes	Plant height	Plant type	Leaf colour	Flower colour		Pod shape	Seed arrangement	Grain colour
					Standard	Wing			
1	BCS-1	**Erect**	Determinate	Green	White	White	Pendent	Dense	White with light brown eye
2	**Arka Garima**	Erect+viny	Indeterminate	Green	Violet	Whitish Violet	Pendent	Sparse	Pink with strips
3	RCV-326	Erect	**Determinate**	Dark Green	White	White	Pendent	Dense	Brown
4	IVRCP-1	Erect + viny	Indeterminate	Green	Violet	Whitish Violet	Pendent	Sparse	Black
5	RCV-395	Erect	Determinate	Dark Green	Violet	Whitish Violet	Pendent	Dense	Light reddish brown
6	IIHR Sel.11	Erect	Determinate	Green	Violet	Whitish Violet	Pendent	Dense	Whitish Wrinkled
7	IIHR Sel.16	Erect	Determinate	Green	Violet	Whitish Violet	Pendent	Dense	Light reddish brown
8	Konkan Safed	Erect	Determinate	Green	White	White	Erect	Dense	White
9	Pusa Komal	Erect	Determinate	Green	Light Violet	Light Violet	Pendent	Dense	Whitish yellow
10	Pusa Dofasli	Erect	Determinate	Green	Violet	Violet	Pendent	Dense	Whitish yellow

Table 1. Silent features of cowpea (*Vigna unguiculata* (L.) Walp) Cont..

Sr. No.	Name of the Genotypes	Plant height	Plant type	Leaf colour	Flower colour		Pod shape	Seed arrangement	Grain colour
					Standard	Wing			
11	**VS-15**	Erect	Determinate	Green	Whitish Violet	Whitish Violet	Erect	Dense	Whitish yellow
12	**Arka Samruddhi**	Erect	Determinate	Green	Whitish Violet	Violet	Erect	Dense	Whitish yellow
13	KLS-30	Erect	Determinate	Green	Whitish Violet	Violet	Pendent	Sparse	Reddish brown
14	Ajeet-11	Erect	Determinate	Green	Whitish Violet	Violet	Pendent	Sparse	White yellowish wrinkled
15	BCP-3	Erect	Determinate	Green	Whitish Violet	Violet	Pendent	Sparse	Reddish brown
16	CHCP-2	Viny	Indeterminate	Green	White	White	Pendent	Sparse	White brown
17	RCV-7	Erect	Determinate	Green	White	White	Pendent	Sparse	Whitish Wrinkled with black eye
18	Sel. 263	Erect	Determinate	Green	Whitish Violet	Whitish Violet	Pendent	Dense	Light yellowish with brown eye
19	IVRCP-2	Erect	Determinate	Dark Green	Violet	Violet	Erect	Dense	Light brown
20	CHCP-1	Viny	Indeterminate	Green	Violet	Violet	Pendent	Sparse	Light brown
21	Konkan Sadabahar	Erect	Determinate	Dark Green	White	White	Erect	Dense	Whitish yellow

Three environments are as follows:

Environments	Period
E_1	4th Feb. 2004 to 30th April. 2004
E_2	5th Oct. 2004 to 9th Jan. 2005
E_3	8th Nov. 2004 to 20th Feb. 2005

The experiment was conducted in a Randomized Block Design with three replication over three environments.

The details of the field experiment are given below:

1. Design	:	Randomized Block Design
2. No. of replications	:	Three
3. Plot size	:	3 m x1.5 m
4. Spacing	:	30 × 30 cm

3.3.1 Cultural Practices

Fertilizer application was done at the rate of 25 kg N, 50 kg P_2O_5 and 50 kg K_2O per ha. The complete dose of phosphorus in the form of single super phosphate and potash in the form of Murate of potash along with half dose of nitrogen was in the form of urea was applied at the time of sowing and remaining dose of nitrogen was top dressed in two splits *i.e.* one and two months after sowing. Other cultural practices such as weeding and spraying were carried out as per the requirements. The experiment was irrigated as and when required.

3.4 Observations recorded

The observations were recorded on five randomly selected plants per replication of different characters of 20 genotypes and a check (Konkan Sadabahar).

1. **Plant height (cm)**

   The plant height was measured in cm from the base to the tip of main stem, at the time of first pod maturity.

2. **Number of branches per plant**

The total numbers of branches present on plant were counted at the time of maturity.

3. **Number of compound leaves per plant**

The total numbers of compound leaves present on plant were counted at the time of first pod maturity

4. **Number of peduncles per plant**

The total numbers of peduncles present on the plant were recorded individually.

5. **Number inflorescence per plant**

The total numbers of inflorescence of selected five plants were counted.

6. **Days to flower initiation**

Numbers of days for flower initiation were recorded from date of sowing to the appearance of first flower in each treatment and replication.

7. **Number of flowers per plant**

All the flowers borne in the selected five plants were counted daily for the period from initiation of flowering to harvesting of pods per plant.

8. **Number of green pods per plant per picking**

The total numbers of green pods per plant were counted from individual plants of each picking.

9. **Weight of green pods per plant per picking**

The weight of randomly selected five pods from each plant recorded in grams of each picking.

10. **Number of pods per peduncle**

The total numbers of pods per peduncle were counted.

11. Pod length (cm)

The five pods were selected randomly per plant and pods length was measured in centimeters. The average was recorded as a pod length.

12. Biological yield per plant (g)

The biological yield of plant includes sum of dry weight of stem, leaves and pods which was recorded in gram.

13. Days to complete maturity

Numbers of days for complete maturity were recorded from the date of sowing to date of complete maturity of plant in each treatment and each replication.

14. Seed yield per plant (g)

The mature pods were collected from sample plants. All the pods were dried, threshed, cleaned and weighed in gram as seed yield per plant.

15. 100-seed weight (g)

The weight of randomly selected 100 seeds was recorded in grams, in each genotype from each replication.

16. Harvest index (%)

The proportion of economic yield with biological yield was worked out in percentage using following formula.

$$\text{H.I.} = \frac{\text{Economic yield per plant}}{\text{Biological yield per plant}} \times 100$$

Where, economic yield refers to the seed yield of plant and biological yield denoted dry weight of particular plant.

17. Yield realization index (%)

The yield realization index (YRI) is the proportion of pods developed from flowers borne per plant in percentage.

$$YRI = \frac{\text{Pods per plant}}{\text{Flowers per plant}} \times 100$$

18. Number of green pods per plant

The total numbers of green pods per plant were recorded in each genotype from each replication.

19. Weight of green pods per plant (g)

The total weight of green pods per plant recorded in grams in each genotype from each replication.

3.5 Statistical analysis

3.5.1 Analysis of variance

The mean values computed on the measurement recorded on five randomly selected plants for nineteen characters were used for statistical analysis. The following statistical methods were adopted for presentation of data on different quantitative attributes by using technique outlined by Panse and Sukhatme (1985).

Stability parameters:

Source of variation	D.F.	M.S.S.	'F' Value
Replications	(r-1)	Mr_{II}	Mr_{II}/Me_{II}
Treatments	(t-1)	Mt_{II}	Mt_{II}/Me_{II}
Error	(r-1) (t-1)	Me_{II}	

Where,

r = Number of replication

t = Number of treatments (genotypes)

Mr_{II}, Mt_{II} and Me_{II} represented mean sum of squares due to replication, treatment and error, respectively.

3.5.2 Stability Parameters

Stability parameters were estimated by using procedure suggested by Eberhart and Russell (1966). The genotype × environment (linear) interaction and pooled deviation mean squares provide a test of genetic differences among treatments for their regression upon the environmental indices. The mean of a variety in each environment was suggested upon the environmental index and the regression coefficient (bi) together with the deviation from the regression 'S^2di' were used as parameters for evaluating stability performance over different environments.

Eberhart and Russell (1966) proposed the following model:

$$Yij = \mu i + bi\ Ij + \delta ij$$

Where,

Yij = Mean yield of the i^{th} variety in the j^{th} environments.

μi = Average yield of the i^{th} variety over all environments.

bi = Regression coefficient that measures the response of i^{th} variety to varying environments.

Ij = Environmental index as the deviation of the mean of all varieties in the j^{th} environment from grand mean.

$$\left[\ Ij = \left(\sum_{i} Y_{ij}/t\right) - \left(\sum_{i}\sum_{j} Y_{ij}/ts\right)\ \right],\ \sum_{j} I_j = 0$$

δij = The deviation from regression of the i^{th} variety at the j^{th} environment.

The first stability parameter in regression coefficient estimated as:

$$bi = \sum_{j=1}^{s} Y_{ij}Ij / \sum_{j} I^2_j$$

The performance of each variety can be predicted by using the estimate of the parameters Where, $Y_{ij} = X_i + biI_j$

Where,

Xi is an estimate of the μi. The deviations ($\delta ij = Y_{ij} - \overline{Y_{ij}}$) can be square and summed to provide an estimate of another stability parameter (S^2di).

$$S^2di = [\sum_j \delta_{ij}^2/(S-2)]-(S_e^2/r)]$$

Where,

S_e^2/r is the estimate of the pooled error (or the variance of a variety mean of the $_j{}^{th}$ location) and,

$$\sum_j I_j = [\sum_j Y_{ij}^2 - Y_i^2/S] - (\sum_j Y_{ij}.I_j)^2/\sum_j I_j^2$$

The analysis of variance when stability parameters were estimated as suggested by Eberhart and Russell (1966) is as below:

Source	d.f.	S.S	M.S
Total	st-1	$\sum_i\sum_j Y^2ij$-C.F	
Genotypes	t-1	$(1/s)(\sum_i Y^2i$-C.F)	
Environment + (G×E)	t (s-1)	$\sum_i\sum_j Y^2ij-\sum_i Y^2i/s$	
Environment (Linear)	1	$(1/t)(\sum_j Y.jIj)^2/\sum Ij^2$	
Genotype × Env. (Linear)	(t-1)	$\sum_i[(\sum_j Yij.Ij)^2/\sum_i I^2j]$- I Envi. (lin.) S.S.	Ms_2
Pooled deviation	t (s-2)	$\sum_i\sum_j \delta^2ij$	Ms_3
Genotype -1 : : :	(s-2) : : :	$\sum_j \delta^2ij$: : :	
Genotype - t	(s-2)	$\sum_j \delta^2sj$	
Pooled error S (r-1) (t-1)			

F = Ms_1/Ms_3 tests the significance of difference among variety means and,

F =Ms_2/Ms_3 approximately tests the hypothesis that there is no significant difference among variation for the regression on environmental lines.

F = [(Σδ²ij)/(s-2)] / pooled error tests individual deviation from linear regression.

3.5.3 Test of significance

The significance of regression coefficient (bi) is tested by 't' test.

1. Test of significance for bi-1

$$T = \frac{1-bi}{S.E.\ (bi)}$$

Standard error of 'bi' is calculate as:

$$S.E.(bi) = \sqrt{\frac{(\Sigma\delta^2 ij\ /n-2)}{\underset{j}{\Sigma}\ I^2 j}}$$

$\Sigma I^2 = I_1^2 + I_2^2 + I_3^2$ +--------+ $In^2 = 0$

$$\Sigma Ij = \frac{\underset{j}{\Sigma Yij}}{t} \quad \frac{\underset{t\,j}{\Sigma\Sigma Yij}}{t\ s}$$

Where,

ΣI^2 = Environmental index.

$\delta^2 ij$ + ij/n-2 = Mean square component of pooled deviation corresponding to i^{th} genotype.

Σ Yij = Total of all variance at j^{th} location.

$\underset{i\,j}{\Sigma\Sigma Yij}$ = Grand total

t = Number of genotypes

ts = Number of observations

Calculated value of 't' is tested against table 't' for (n-2) degree of freedom for significance.

2. Test of significance for b = 0

$$T = \frac{bi-0}{S.E.(bi)}$$

3. Test of significance for 'S²di'

The significance of the 'S^2di' is tested by using 'F' test.

$F = [\Sigma di^2/(S-2)]$ / pooled error M.S.S.

Where,

S = Number of environments under consideration.

The calculated 'F' value is tested with table 'F' value for respective (S-2) degrees of freedom. If the value is significant at 1 per cent level, two asterisks were placed on 'S^2di' where as one asterisk at 5 per cent level of significance.

This is same in 'bi' and 'S^2di' values.

Correlation:

Correlation coefficient among different attributes was computed according to the method given by Panse and Sukhatme (1985).

The degree of correlation between two variables is measured by a correlation coefficient (ρ) and defined as:

$$\frac{\delta \times y}{\delta \times . y}$$

$$\text{Where XY} = \frac{(X-\overline{X})\ (Y-\overline{Y})}{N}$$

δ×y= Covariance between × and y variables (Positive or negative)

Estimate of ρ calculated from a sample is denoted by 'r'. The correlation coefficient necessarily varies between + 1 and –1.

CHAPTER IV
EXPERIMENTAL RESULTS

Assessment of cowpea genotypes for their fitness and flexibility under varying environmental conditions was a major objective of the current investigation.

The results in respect of environmental performance, stability parameters and components of variance for nineteen quantitative characters of twenty-one cowpea (*Vigna unguiculata* (L.) Walp) genotypes are presented in Tables 3 to 21.

The mean sum of squares due to treatment was found to be significant for all nineteen characters. Therefore, stability studied was worked out for nineteen characters (Table 2).

4.1 Mean performance of different characters

4.1.1 Plant height (cm)

The data regarding mean plant height under three environmental conditions and the stability parameters of the trait of twenty-one genotypes, of cowpea, under consideration are presented in Table 3 (a). The plants under E_3 conditions were tallest (32.57cm) followed by E_2 (30.97cm) and E_1 (23.07 cm) conditions. In general, E_3 was found to be the most favourable environment. The range of height was between 12.52 to 140.03 cm under E_3, 11.12 to 115.52 cm under E_1 and 11.11 to 143.82 cm under E_2 environmental conditions.

The CHCP-1 (133.12 cm) showed the highest plant height and BCP-3 (11.58 cm) recorded the lowest plant height. The regression coefficient was highly significant for RCV-326, IVRCP-1, RCV-395, Konkan Safed, VS-15, Arka Samruddhi, CHCP-2, RCV-7, IVRCP-2, CHCP-1 and Konkan Sadabahar. The genotypes Arka Garima and Pusa Komal showed

Table 2.Analysis of variance of genotypes in cowpea (*Vigna unguiculata* (L.) Walp)

Sr. No.	Characters	Replication (d.f. =2)			Treatments (d.f. =20)			Error (d.f. =40)		
		E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
1	Plant height (cm)	108.34	406.70	113.31	1543.53**	3784.49**	3677.63**	65.15	100.90	66.4
2	Number of branches/plant	2.01	0.30	0.93	0.33*	1.89**	2.27**	0.15	0.42	0.37
3	Number of compound leaves/plant	0.67	82.35	6.99	37.24**	20.14**	16.88*	2.13	8.05	8.19
4	Number of peduncles /plant	4.11	0.13	5.04	3.80**	1.00*	0.66*	0.83	0.48	0.33
5	Number of inflorescence/plant	61.93	461.43	98.85	42.72**	29.03*	29.44**	15.44	13.18	3.16
6	Days to initiation of flowering	8.68	22.17	8.06	36.35**	69.13**	28.52*	2.66	3.52	14.08
7	No. of flowers/plant	0.35	41.03	22.70	42.87**	34.57**	73.81**	4.79	12.21	9.34
8	Number of green pods /plant/picking	0.35	0.79	0.47	0.35*	0.91**	1.91**	0.17	0.27	0.02
9	Weight of green pods /plant/picking	17.33	23.34	1.47	97.58**	165.31**	224.97**	5.73	18.64	7.05
10	Number of pods /peduncle	0.07	0.39	0.19	0.23**	0.27**	0.53**	0.09	0.10	0.04
11	Pod length (cm)	1.01	1.31	1.89	28.01**	34.62**	61.92**	1.07	1.04	0.79

12	Biological yield (g)	5.62	11.33	5.97	5.66**	8.45**	27.85**	1.19	1.64	3.37
13	Days to complete maturity	0.09	6.16	8.43	62.75**	47.24**	37.36**	1.31	3.24	0.65
14	Seed yield/plant (g)	4.77	1.35	0.06	10.10**	10.87**	8.26**	1.64	0.84	0.23
15	100 seed weight (g)	0.29	0.36	1.01	10.76**	10.46**	9.13**	0.35	0.55	0.54
16	Harvest index (%)	102.46	12.83	7.54	75.11**	58.69**	17.82**	18.13	8.64	4.38
17	Yield realization index(%)	18.28	26.33	5.78	31.83**	31.40**	39.35**	11.79	12.00	12.4
18	Number of green pods /plant	4.09	8.40	4.89	3.82*	8.38**	13.32**	1.90	2.87	0.29
19	Weight of green pods/plant (g)	185.86	239.65	18.30	917.62**	1695.69**	1999.47**	60.77	202.06	77.49

Table 3. (a): Environmentwise performance and stability parameters for plant height (cm) of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	(S^2di)
		E1	E2	E3			
1.	BCS-1	15.33	18.47	24.50	19.436	0.7830	-64.5630
2.	Arka Garima	22.83	26.38	30.70	26.637	0.7064*	-71.0183
3.	RCV-326	13.47	21.00	23.17	19.210	0.9992**	-76.0766
4.	IVRCP-1	13.83	21.10	24.23	19.721	1.0385**	-75.1294
5.	RCV-395	15.25	22.03	23.03	20.106	0.8319**	-76.1868
6.	IIHR Sel. 11	17.80	17.87	15.77	17.147	-0.1424	-74.4339
7.	IIHR Sel. 16	28.50	22.81	22.07	24.459	-0.6910	-76.1757
8.	Konkan Safed	18.47	20.93	22.33	20.577	0.3765**	-75.9147
9.	Pusa Komal	15.43	16.93	19.30	17.221	0.3373*	-74.5262
10.	Pusa Dofasali	18.50	21.72	18.07	19.429	0.0997	-68.7895
11.	VS-15	17.08	26.52	29.94	24.513	1.3022**	-75.3249
12.	Arka Samruddhi	20.03	23.92	25.52	23.158	0.5502**	-75.9732
13.	KLS-30	15.60	14.21	15.26	15.023	-0.0806	-75.5224
14.	Ajeet - 11	16.17	16.72	20.10	17.661	0.3036	-71.9397
15.	BCP-3	11.12	11.11	12.52	11.580	0.0997	-75.4417
16.	CHCP-2	49.50	130.11	134.01	104.538	9.3143**	-14.0573
17.	RCV-7	14.67	16.65	18.77	16.697	0.3742**	-75.0521
18.	Sel. 263	19.73	15.52	19.65	18.301	-0.1769	-66.2574
19.	IVRCP-2	11.13	23.65	24.17	19.653	1.4406**	-74.6069
20.	CHCP-1	115.52	143.82	140.03	133.122	2.9015**	-39.7592
21.	Konkan Sadabahar	14.50	18.91	20.84	18.082	0.6322**	-75.8083
	Mean	23.07	30.97	32.57	28.87		
	S.E.±	4.66	5.80	4.71	5.041		
	CD at 5%	13.31	16.57	13.45	14.40		

*,** indicates significant at 5% and 1% levels, respectively.

Table 3.(b): Pooled analysis of variance for Genotype × Environment for plant height per plant of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	55564.834	2778.2416** ++
Environment + (G×E)	42	5559.6096	132.3716**++
Environment (linear)	1	1086.6353	1086.6353**++
Genotype × Environment (linear)	20	4324.4233	216.2211**++
Pooled deviation	21	148.55094	7.0738
Pooled error	126	3100.5584	24.6076

*,** significant against pooled error at 5% and 1% levels, respectively.
+,++ significant against pooled deviation at 5% and 1% levels, respectively.

significant values for ‘bi’. The third stability parameters 'S^2di' was not significant for these genotypes.

The differences due to the genotypes were highly significant against pooled error and deviation for this character was presented in (Table 3 b). The contribution due to environment (linear), Environment + (G ×E) and Genotype × Environment (linear) was also highly significant. The pooled deviation was not significant against pooled error for plant height.

4.1.2 Number of branches per plant

The experimental mean for number of branches per plant was 2.88. The population mean under different environmental conditions ranged between 2.68 (E_1) to 3.09 (E_3) for branches per plant. The mean number of branches per plant observed 3.09, 2.88 and 2.68 under E_3, E_2 and E_1 conditions, respectively.

The pooled mean varied from 1.93 (Konkan Sadabahar) to 4.49 (Pusa Komal) for number of branches per plant. The remaining genotypes had comparatively average branches per plant over the experimental mean (2.88).

The regression coefficient (bi) was highly significant for RCV-395, IIHR Sel. 11, Ajeet-11, RCV-7 and Sel. 263 for this character. The 'bi' values were significant in four genotypes *viz.,* Pusa Komal, Pusa Dofasali, IVRCP-2 and CHCP-1. The variation due to non-linear component was highly significant in Konkan Safed and Pusa Komal. Other genotypes showed non-significant values for ‘bi’ and ‘S^2di’ for this character.

The difference among the genotypes and environment (linear) were highly significant for number of branches per plant against pooled error and pooled deviation (Table 4 b). The Environment + (G × E) and Genotypes × Environment (linear) was significant against pooled error. The pooled deviation found to be significant against pooled error for number of branches per plant.

Table 4. (a): Environmentwise performance and stability parameters for number of branches per plant of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S^2}$di)
		E1	E2	E3			
1.	BCS-1	3.17	2.44	2.33	2.65	-2.0544	-0.2471
2.	Arka Garima	2.67	2.11	2.48	2.42	-0.4515	-0.1686
3.	RCV-326	2.67	2.89	2.33	2.63	-0.8438	-0.2119
4.	IVRCP-1	2.67	2.22	2.11	2.33	-1.3757	-0.2932
5.	RCV-395	2.92	3.11	3.55	3.19	1.5613**	-0.3022
6.	IIHR Sel. 11	2.33	3.66	4.00	3.33	4.0862**	-0.1432
7.	IIHR Sel. 16	2.67	2.66	3.22	2.85	1.3671	-0.2599
8.	Konkan Safed	2.83	1.44	2.55	2.27	-0.6758	0.7346**
9.	Pusa Komal	2.83	5.33	5.33	4.50	6.1246*	0.7542**
10.	Pusa Dofasali	3.00	3.11	4.11	3.41	2.7404*	-0.1818
11.	VS-15	3.00	2.55	2.33	2.63	-1.6475	-0.3035
12.	Arka Samruddhi	2.67	2.77	2.11	2.52	-1.3771	-0.2150
13.	KLS-30	3.00	2.44	3.00	2.81	0.0015	-0.1045
14.	Ajeet - 11	2.67	3.44	4.11	3.41	3.5523**	-0.3100
15.	BCP-3	2.83	2.77	2.33	2.65	-1.2424	-0.2885
16.	CHCP-2	2.17	3.44	3.00	2.87	2.0367	0.1819
17.	RCV-7	2.67	3.33	3.77	3.26	2.7225**	-0.3034
18.	Sel. 263	2.17	2.33	3.11	2.54	2.3276**	-0.2510
19.	IVRCP-2	2.83	3.55	3.66	3.35	2.0380*	-0.2485
20.	CHCP-1	2.83	2.89	3.44	3.05	1.5061*	-0.2712
21.	Konkan Sadabahar	1.75	2.07	2.00	1.94	0.6038	-0.2862
	Mean	2.68	2.88	3.09	2.88		
	S.E.±	0.23	0.38	0.35	0.32		
	CD at 5%	0.65	1.07	1.01	0.92		

*,** indicates significant at 5% and 1% levels, respectively.

Table 4. (b): Pooled analysis of variance for Genotype × Environment for number of branches per plant of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	18.3766	0.9188**++
Environment + (G×E)	42	13.4138	0.3193**
Environment (linear)	1	1.7324	1.7324**++
Genotype × Environment (linear)	20	7.8413	0.3920**+
Pooled deviation	21	3.8401	0.1828*
Pooled error	126	12.7022	0.1008

*,** significant against pooled error at 5% and 1% levels, respectively.
+,++ significant against pooled deviation at 5% and 1% levels, respectively.

4.1.3 Number of compound leaves per plant

The data regarding mean number of compound leaves per plant under three environmental conditions and three stability parameters for this trait are given in Table 5 (a). As seen from Table 5 (a), the mean of all populations over the environments in respect of compound leaves per plant was 22.77. The population mean under different environmental conditions ranged between 16.71 leaves (E_1) to 26.66 leaves (E_3) for number of leaves per plant. In general E_3 was found to be most favourable environment.

The pooled mean for the number of compound leaves was highest in RCV-395 (25.51) and lowest in Konkan Sadabahar (19.07).

The regression coefficient (bi) was not significant for only two genotypes, *viz.,* Arka Samruddhi and RCV-7. The third stability parameter deviation from regression i.e. S^2di was found ~~to~~ to be significant at 5 per cent level in two genotypes IIHR Sel. 11 and Konkan Safed. In remaining nineteen genotypes, it was non-significant at both levels.

The difference due to Genotypes and Genotype × Environment (linear) as seen from pooled analysis of variance, for this character were highly significant against pooled error. The Environment + (G×E) and Environment (linear) were highly significant for number of compound leaves per plant against pooled error and pooled deviation. The pooled deviation was highly significant against pooled error for number of compound leaves per plant in Table 5 (b).

4.1.4 Number of peduncles per plant

The population mean for number of peduncles per plant and three stability parameters are given in Table 6 (a). The number of peduncles was highest in E_2 condition (7.86) followed by E_3 (7.57) and E_1 (6.91) conditions.

Table 5. (a): Environmentwise performance and stability parameters for number of compound leaves per plant of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	$\overline{(S^2di)}$
		E1	E2	E3			
1.	BCS-1	20.00	25.55	27.30	24.28	0.7141**	-6.1593
2.	Arka Garima	13.17	28.55	31.10	24.27	1.8216**	-6.1399
3.	RCV-326	15.33	26.00	27.13	22.82	1.2193**	-5.8443
4.	IVRCP-1	10.67	25.33	32.17	22.72	2.0385**	-0.5396
5.	RCV-395	21.00	27.33	28.20	25.51	0.7373**	-6.2245
6.	IIHR Sel. 11	16.17	28.89	24.57	23.21	1.0652*	13.0410*
7.	IIHR Sel. 16	15.67	27.77	27.03	23.49	1.2451**	-2.0859
8.	Konkan Safed	17.00	22.22	29.57	22.93	1.0626*	9.4000*
9.	Pusa Komal	14.33	23.88	23.33	20.52	0.9845**	-3.7479
10.	Pusa Dofasali	13.33	27.55	25.47	22.12	1.3790**	3.8229
11.	VS-15	19.33	26.89	26.99	24.40	0.8156**	-5.4500
12.	Arka Samruddhi	19.67	22.11	27.98	23.25	0.6638	5.2086
13.	KLS-30	15.67	21.66	28.32	21.88	1.0983**	5.4421
14.	Ajeet - 11	20.17	22.44	26.23	22.95	0.5033*	-1.8967
15.	BCP-3	12.33	22.44	25.09	19.95	1.2633**	-6.1810
16.	CHCP-2	15.33	24.44	25.73	21.84	1.0635**	-6.1632
17.	RCV-7	22.33	26.11	23.93	24.12	0.2546	-2.8035
18.	Sel. 263	11.67	24.66	25.67	20.67	1.4602**	-5.1682
19.	IVRCP-2	22.33	26.55	25.40	24.76	0.3724*	-4.6543
20.	CHCP-1	19.83	24.44	25.99	23.42	0.5995**	-6.1635
21.	Konkan Sadabahar	15.50	19.00	22.72	19.07	0.6299**	-2.6975
	Mean	16.71	24.94	26.66	22.77		
	S.E.±	0.84	1.64	1.65	1.45		
	CD at 5%	2.41	4.68	4.72	4.14		

*,** indicates significant at 5% and 1% levels, respectively.

Table 5. (b): Pooled analysis of variance for Genotype × Environment for number of compound leaves per plant of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	155.2552	7.7628**
Environment + (G×E)	42	1519.3568	36.1752**++
Environment (linear)	1	1190.5208	1190.5208**++
Genotype × Environment (linear)	20	231.4641	11.5732**+
Pooled deviation	21	97.3719	4.6368**

Pooled error	126	256.3487	2.0345

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

Table 6. (a): Environmentwise performance and stability parameters for number of peduncles per plant of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S}^2di$)
		E1	E2	E3			
1.	BCS-1	8.51	7.95	8.07	8.18	-0.5992	-0.5216
2.	Arka Garima	6.11	6.83	7.74	6.89	1.0449	0.2951
3.	RCV-326	8.51	8.89	7.96	8.45	0.1982	-0.1019
4.	IVRCP-1	6.29	7.51	6.96	6.92	1.2436**	-0.5060
5.	RCV-395	6.29	7.60	7.51	7.13	1.4537**	-0.4548
6.	IIHR Sel. 11	7.03	7.42	7.51	7.32	0.4660*	-0.4946
7.	IIHR Sel. 16	6.48	7.13	7.18	6.93	0.7514**	-0.4818
8.	Konkan Safed	8.33	8.13	6.63	7.69	-0.5914	1.0379*
9.	Pusa Komal	8.88	7.89	7.40	8.06	-1.2351	-0.1108
10.	Pusa Dofasali	5.74	8.09	7.07	6.96	2.4022**	-0.4758
11.	VS-15	5.37	7.30	7.96	6.88	2.3492	0.5022
12.	Arka Samruddhi	6.48	7.46	8.07	7.34	1.2650	0.0143
13.	KLS-30	6.11	8.65	7.96	7.57	2.7031**	-0.5164
14.	Ajeet - 11	5.18	9.00	7.96	7.38	4.0560**	-0.5068
15.	BCP-3	6.11	8.11	7.07	7.09	2.0023**	-0.4192
16.	CHCP-2	6.85	8.45	7.51	7.60	1.5824**	-0.4046
17.	RCV-7	8.51	7.56	7.63	7.90	-1.0554	-0.4891
18.	Sel. 263	6.01	8.11	7.95	7.36	2.3278**	-0.3610
19.	IVRCP-2	7.86	7.56	8.18	7.87	-0.1890	-0.3506
20.	CHCP-1	7.31	8.22	7.85	7.79	0.9344**	-0.5194
21.	Konkan Sadabahar	7.22	7.25	6.71	7.06	-0.0969	-0.3469
	Mean	6.91	7.86	7.57	7.45		
	S.E.$\pm$	0.53	0.40	0.33	0.42		
	CD at 5%	1.51	1.15	0.96	1.19		

*,** indicates significant at 5% and 1% levels, respectively.

Table 6. (b): Pooled analysis of variance for Genotype × Environment for number peduncles per plant of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	13.8289	0.6914**+
Environment + (G×E)	42	33.4671	0.7968**++
Environment (linear)	1	9.9498	9.9498**++
Genotype × Environment (linear)	20	17.7288	0.8864**++
Pooled deviation	21	5.7885	0.2756
Pooled error	126	21.3018	0.1691

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

Mean number of peduncles over all genotypes and environments was observed to be 7·45.

The pooled means for each of the genotypes showed the considerable variation in number of peduncles per plant. The range of pooled mean was 6.86 (VS-15) to 8.45 (RCV-326).

The regression coefficient (bi) over environments was highly significant in IVRCP-1, RCV-395, IIHR Sel. 16, Pusa Dofasali, KLS-30, Ajeet-11, BCP-3, CHCP-2, Sel. 263 and CHCP-1. While IIHR Sel. 11 was significant for 'bi' values. The deviation from regression (S^2di) was significant in Konkan Safed at 5 per cent level. The remaining genotypes showed non-significant values of 'bi' and 'S^2di' for number of peduncles per plant.

The pooled analysis of variance was carried out to determine difference among genotypes, environments and genotypes × environment interaction. The difference among the genotypes, Environment + (Genotypes × Environment), Environment (linear) and Genotype × Environment (linear) were highly significant for number of peduncles per plant. The pooled deviation against pooled error was to be found non-significant.

4.1.5 Number of inflorescences per plant

The data on environment wise inflorescence per plant, regression coefficient (bi) and deviation from the regression (S^2di) for the twenty-one genotypes of cowpea were given in Table 7 (a). The population mean over all the environments for number of inflorescence per plant was 16.49.

The population mean under different environmental conditions varied between E_1 (12.44) to E_3 (18.65) for inflorescence per plant. The range of performance was between 6.17 to 21.33 under E_1, 14.33 to 26.22 under E_2 and 14.93 to 26.29 under E_3 conditions.

Table 7. (a): Environmentwise performance and stability parameters for number of inflorescence per plant of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	$(\overline{S^2di})$
		E1	E2	E3			
1.	BCS-1	11.67	15.00	17.31	14.66	0.7490**	-8.1581
2.	Arka Garima	8.50	18.11	15.47	14.03	1.3479**	-5.9906
3.	RCV-326	11.83	22.54	22.50	18.96	1.7550**	-10.3056
4.	IVRCP-1	9.83	16.89	17.60	14.77	1.2207**	-10.3427
5.	RCV-395	16.00	23.55	25.51	21.69	1.4113**	-9.1417
6.	IIHR Sel. 11	12.50	18.44	19.86	16.93	1.0995**	-9.7711
7.	IIHR Sel. 16	13.67	16.99	18.25	16.30	0.6563**	-9.8253
8.	Konkan Safed	14.50	15.22	16.20	15.31	0.2034	-9.9965
9.	Pusa Komal	18.75	18.00	17.56	18.10	-0.1621	-10.3454
10.	Pusa Dofasali	13.33	16.89	19.27	16.50	0.7915**	-8.0373
11.	VS-15	9.00	18.67	18.15	15.27	1.5429**	-10.0179
12.	Arka Samruddhi	8.67	22.44	21.13	17.41	2.1483**	-8.7158
13.	KLS-30	9.00	17.33	14.93	13.75	1.1589**	-6.8153
14.	Ajeet - 11	11.67	17.44	20.97	16.69	1.2559**	-5.2655
15.	BCP-3	10.42	14.33	16.39	13.71	0.8224**	-8.7065
16.	CHCP-2	21.33	16.00	16.83	18.06	-0.8033	-9.8882
17.	RCV-7	15.47	26.22	26.29	22.66	1.7726**	-10.3555
18.	Sel. 263	9.58	17.67	17.74	15.00	1.3341**	-10.3906
19.	IVRCP-2	17.33	19.67	18.43	18.48	0.2754	-9.5712
20.	CHCP-1	12.00	14.66	15.65	14.10	0.5232**	-10.0622
21.	Konkan Sadabahar	6.17	20.22	15.51	13.96	1.8971**	3.0665
	Mean	12.44	18.39	18.65	16.49		
	S.E.±	2.27	2.10	1.03	1.86		
	CD at 5%	6.49	5.99	2.94	5.33		

*,** indicates significant at 5% and 1% levels, respectively.

Table 7. (b): Pooled analysis of variance for Genotype × Environment for number of inflorescence per plant of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	378.1791	18.9090**++
Environment + (G×E)	42	814.8041	19.4001**++
Environment (linear)	1	518.2905	518.2905**++
Genotype × Environment (linear)	20	256.2209	12.8110**++
Pooled deviation	21	40.2927	1.9187
Pooled error	126	423.9583	3.3647

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

Amongst three stability parameters, the pooled means for each of the genotypes showed the considerable variation in number of inflorescence per plant. The mean inflorescence per plant was highest in RCV-7 (22.66). The lowest inflorescence per plant was found in genotype BCP-3 (13.71).

The regression coefficient (bi) was highly significant in all genotypes except Konkan Safed, Pusa Komal, CHCP-2 and IVRCP-2. While, the deviations from regression (S^2di) values were not significant in these genotypes.

The mean squares due to genotypes and environments were highly significant when tested against pooled deviation and pooled error given in Table 7(b). The pooled deviation was not significant when tested against the pooled error.

4.1.6 Days to initiation of flowering

The data on environment wise duration for days to initiation of flowering and three stability parameters are given in Table 8 (a). The period for initiation of flowering was shortest under E_2 conditions (45.30 days), while, it was longest under E_1 conditions (63.10 days) followed by E_3 (61.51 days) conditions.

Mean number of days to initiation of flowering over all genotypes and environments were observed to be 56.63 days.

The pooled means for each of the genotypes showed considerable variation in days to initiation of flowering. The minimum days to initiation of flowering were recorded in Konkan Sadabahar (46.76 days) and highest in VS-15 (63.01 days).

The regression coefficient (bi) was highly significant in these genotypes. The deviation from regression (S^2di) was non significant except VS-15 and Arka Samruddhi which were significant at 5 per cent level of significance.

Table 8(a): Environmentwise performance and stability parameters for days to initiation of flowering of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S}^2di$)
		E1	E2	E3			
1.	BCS-1	63.86	52.14	64.14	60.04	0.6918**	-5.6888
2.	Arka Garima	63.59	38.07	60.23	53.96	1.4063**	-6.0137
3.	RCV-326	66.55	45.63	59.50	57.22	1.0451**	8.0036
4.	IVRCP-1	61.34	43.33	60.20	54.96	1.0237**	-6.5286
5.	RCV-395	63.02	44.66	62.27	56.65	1.0539**	-6.2205
6.	IIHR Sel. 11	64.32	45.62	63.02	57.65	1.0599**	-6.5723
7.	IIHR Sel. 16	63.96	44.92	63.38	57.42	1.0976**	-5.9658
8.	Konkan Safed	61.78	45.13	62.50	56.47	0.9907**	-4.0055
9.	Pusa Komal	63.35	45.41	61.87	56.88	1.0108**	-6.6403
10.	Pusa Dofasali	64.48	48.61	61.22	58.10	0.8452**	-4.8006
11.	VS-15	63.50	56.57	68.98	63.02	0.5423*	13.6244*
12.	Arka Samruddhi	70.14	41.44	62.32	57.97	1.4801**	8.4228*
13.	KLS-30	66.06	38.81	60.21	55.02	1.4450**	-0.2651
14.	Ajeet - 11	60.57	44.16	59.26	54.67	0.9259**	-6.6353
15.	BCP-3	61.76	43.66	60.71	55.38	1.0311**	-6.4754
16.	CHCP-2	62.45	48.69	63.98	58.37	0.8420**	-2.5252
17.	RCV-7	62.46	42.37	62.18	55.67	1.1663**	-5.3969
18.	Sel. 263	64.24	43.64	64.54	57.47	1.2106**	-4.1745
19.	IVRCP-2	64.51	51.49	58.86	58.29	0.6187**	4.3528
20.	CHCP-1	62.20	50.14	59.67	57.34	0.6409**	-5.4954
21.	Konkan Sadabahar	50.89	36.72	52.66	46.76	0.8722**	-1.6432
	Mean	63.10	45.30	61.51	56.63		
	S.E.±	0.94	1.08	2.17	1.49		
	CD at 5%	2.69	3.10	6.19	4.25		

*,** indicates significant at 5% and 1% levels, respectively.

Table 8(b): Pooled analysis of variance for Genotype × Environment for days to initiation of flowering of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	545.3743	27.2687**++
Environment + (G×E)	42	4424.1725	105.3374**++
Environment (linear)	1	4076.0833	4076.0833**++
Genotype × Environment (linear)	20	259.1253	12.9563**++
Pooled deviation	21	88.9639	4.2364*
Pooled error	126	270.3510	2.1456

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

The pooled analysis of variance revealed significant differences for the characters indicating presence of considerable variability among genotypes Table 8 (b). The genotypic differences, Environment + (G × E), Environment (linear) and Genotype × Environment (linear) found to be highly significant. Pooled deviation was found to be significant when tested against pooled error.

4.1.7 Number of flowers per plant

The data regarding number of flowers per plant of 21 genotypes under three environmental conditions and estimates of stability parameters for these characters are presented in Table 9 (a). In general, E_3 was found to be the most favourable environment. As seen from Table 9 (a), population mean over all environments was 47.14. The averages for number of flowers per plant were 49.50, 47.06 and 44.86 under the environments E_3, E_2 and E_1 respectively.

The pooled performance in respect of number of flowers per plant was excellent in RCV-326 (53.08) followed by Arka Samruddhi (52.77). It was very low in Konkan Sadabahar (37.04).

The regression coefficient (bi) was highly significant in RCV-326, IIHR Sel. 11, IIHR Sel. 16, Pusa Komal and VS-15. The BCS-1, Arka Garima, RCV-395, Konkan Safed and Ajeet-11 showed significant 'bi' values. The deviation from regression found to be non-significant except Arka Samruddhi.

From Table 9 (b), it is seen that the genotypic differences are highly significant against pooled deviation and pooled error. The environment +

(G × E), Environment (linear) and G × E (linear) were highly significant. The component of pooled deviation when tested against pooled error was also highly significant.

Table 9(a): Environmentwise performance and stability parameters for number of flowers per plant of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	$(\overline{S}^2di)$
		E1	E2	E3			
1.	BCS-1	47.73	47.49	53.93	49.72	1.3614*	-1.8883
2.	Arka Garima	42.96	48.83	49.13	46.98	1.3105*	-2.8900
3.	RCV-326	48.23	51.07	59.94	53.08	2.5465**	-3.6754
4.	IVRCP-1	40.51	49.42	49.43	46.45	1.8908	5.9277
5.	RCV-395	45.19	45.07	54.61	48.29	2.0656*	5.4070
6.	IIHR Sel. 11	37.62	43.89	45.95	42.49	1.7818**	-5.0956
7.	IIHR Sel. 16	39.70	44.57	48.89	44.39	1.9796**	-8.4771
8.	Konkan Safed	46.17	46.87	54.80	49.28	1.8867*	-0.9244
9.	Pusa Komal	45.22	49.88	52.06	49.05	1.4667**	-7.3200
10.	Pusa Dofasali	47.45	46.06	54.70	49.40	1.5998	6.9387
11.	VS-15	45.78	47.48	49.75	47.67	0.8581**	-8.6176
12.	Arka Samruddhi	47.22	56.50	54.59	52.77	1.5477	13.6235*
13.	KLS-30	47.69	47.07	47.20	47.32	-0.1044	-8.5399
14.	Ajeet - 11	46.47	47.60	47.75	47.27	0.2725*	-8.4602
15.	BCP-3	46.43	45.88	47.46	46.59	0.2305	-7.9151
16.	CHCP-2	48.09	44.25	48.10	46.82	0.0297	1.2221
17.	RCV-7	46.22	45.63	46.46	46.10	0.0568	-8.3176
18.	Sel. 263	47.25	42.94	44.99	45.06	-0.4639	-1.6728
19.	IVRCP-2	45.87	49.33	49.27	48.15	0.7205	-6.3670
20.	CHCP-1	46.18	48.58	43.28	46.01	-0.6528	0.8320
21.	Konkan Sadabahar	34.10	39.93	37.10	37.04	0.6159	4.2619
	Mean	44.86	47.06	49.50	47.14		
	S.E.$\pm$	1.26	2.02	1.76	1.70		
	CD at 5%	3.61	5.77	5.04	4.85		

*,** indicates significant at 5% and 1% levels, respectively.

Table 9. (b): Pooled analysis of variance for Genotype × Environment for number of flowers per plant of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	685.4011	34.2701**++
Environment + (G×E)	42	548.6676	13.0635**+
Environment (linear)	1	225.6594	225.6594**++
Genotype × Environment (linear)	20	183.4835	9.1742**
Pooled deviation	21	139.5247	6.6440**
Pooled error	126	351.4234	2.7891

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

4.1.8 Number of green pods per plant per picking

The data regarding the mean performance number of green pods per plant per picking and the three stability parameters for this trait are given in Table 10 (a). As seen from Table 10 (a), population mean over all environments was 3.38. In general, E_3 was found to be the most favourable environment. The average number of green pods per plant per picking in this environment was upto the tone of 4.29 pods per plant followed by 3.79 pods per plant under E_2 and 3.12 pods per plant under E_1 conditions.

The pooled performance in respect of number of green pods per picking per plant was highest in RCV-326 (4.71 green pods) followed by Konkan Safed (4.46 green pods). It was very low in CHCP-1 (2.71 green pods).

The 'bi' values were highly significant in BCS-1, RCV-326, IVRCP-1, RCV-395, IIHR Sel. 11, Konkan Safed, Pusa Komal, Pusa Dofasali, VS-15, KLS-30, Ajeet-11 and CHCP-2. The 'bi' value was significant at 5 per cent level in six genotypes *viz.,* Arka Garima, IIHR Sel. 16, Arka Samruddhi, BCP-3, IVRCP-2 and CHCP-1. Remaining genotypes showed non-significant 'bi' values. The variation due to non-linear component was non-significant in these genotypes except Arka Garima.

The difference among the genotypes in number of green pods per plant per picking was highly significant. The contribution of environments inclusive of G × E i.e. (E + G × E) to the total variation in number of green pods per plant per picking was found to be considerable magnitude. Further partitioning of three components revealed that environment linear and G × E (linear) accounted for highly significant portion of the variation. The component of pooled deviation when tested against pooled error was also significant.

Table 10(a): Environmentwise performance and stability parameters for number of green pods per plant per picking of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S}^2$di)
		E1	E2	E3			
1.	BCS-1	2.76	4.09	4.63	3.83	1.6138**	-0.1166
2.	Arka Garima	2.89	3.10	5.13	3.71	1.8256*	0.6048**
3.	RCV-326	3.77	4.44	5.93	4.71	1.7994**	0.0525
4.	IVRCP-1	2.77	3.44	4.80	3.67	1.6862**	0.0011
5.	RCV-395	3.22	4.27	4.83	4.11	1.3845**	-0.1487
6.	IIHR Sel. 11	3.33	4.07	4.43	3.94	0.9486**	-0.1514
7.	IIHR Sel. 16	3.44	4.07	4.07	3.86	0.5559*	-0.1112
8.	Konkan Safed	3.89	4.50	5.00	4.46	0.9465**	-0.1582
9.	Pusa Komal	2.88	4.17	4.80	3.95	1.6481**	-0.1359
10.	Pusa Dofasali	3.11	3.97	4.97	4.01	1.5677**	-0.1306
11.	VS-15	2.89	4.07	4.27	3.74	1.2077**	-0.0583
12.	Arka Samruddhi	2.89	4.50	4.53	3.97	1.4580*	0.1384
13.	KLS-30	3.22	3.73	4.20	3.72	0.8339**	-0.1572
14.	Ajeet - 11	2.77	3.73	4.57	3.69	1.5222**	-0.1556
15.	BCP-3	3.33	3.50	3.50	3.44	0.1508*	-0.1551
16.	CHCP-2	2.63	2.83	2.97	2.81	0.2847**	-0.1586
17.	RCV-7	3.22	3.40	3.33	3.32	0.1060	-0.1499
18.	Sel. 263	3.17	3.30	3.20	3.22	0.0378	-0.1500
19.	IVRCP-2	3.44	4.50	4.50	4.15	0.9403*	-0.0230
20.	CHCP-1	2.66	2.73	2.73	2.71	0.0621*	-0.1580
21.	Konkan Sadabahar	3.21	3.20	3.73	3.38	0.4203	-0.0951
	Mean	3.12	3.79	4.29	3.73		
	S.E.±	0.24	0.30	0.10	0.23		
	CD at 5%	0.70	0.87	0.28	0.66		

*,** indicates significant at 5% and 1% levels, respectively.

Table 10(b): Pooled analysis of variance for Genotype × Environment for number of green pods per plant per picking of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	13.8056	0.6903**++
Environment + (G×E)	42	22.0288	0.5245**++
Environment (linear)	1	14.5699	14.5699**++
Genotype × Environment (linear)	20	5.5444	0.2772**++
Pooled deviation	21	1.9145	0.0912*
Pooled error	126	6.4510	0.0512

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

4.1.9 Weight of green pods per plant per picking (g)

The population mean of weight of green pods per plant per picking over three environments 19.25 g. The population mean was highest for E_3 (22.05 g) followed by E_2 (19.22 g) and E_1 (16.48 g). The pooled mean was highest in VS-15 (34.00 g), followed by BCS-1 (32.11 g). It was noticed low in Konkan Sadabahar (9.22 g), which was closer to Arka Samruddhi (11.00 g).

The regression coefficient (bi) was highly significant in BCS-1, Arka Garima, RCV-395, IIHR Sel. 11, Pusa Dofasali, Arka Samruddhi and KLS-30. Whereas, it was significant at 5 per cent level in VS-15, Ajeet-11 and Konkan Sadabahar. Remaining genotypes showed non-significant 'bi' values. The third stability parameter i.e. 'S^2di', was highly significant in RCV-7. The genotype IVRCP-2 showed significant deviation at 5 per cent level of significance. Remaining genotypes were non-significant for both levels.

From the Table 11 (b), it is seen that the high degree of variation existed among genotypes in this character. The contribution of environments inclusive of G × E i.e. (E + G × E) to the total variation in weight of green pods per plant per picking was found to be of considerable magnitude. Further partitioning of these components revealed that Environment (linear) and G × E (linear) accounted for significant portion of variation. The component of pooled deviation when tested against pooled error was also highly significant.

4.1.10 Number of pods per peduncle

The environment wise data on mean number of peduncles per plant, regression coefficient (bi) and deviation from regression (S^2di) for the twenty-one genotypes of cowpea are given in Table 12 (a). The population mean of number of pods per peduncle pooled over the three environments was 1.86 pods per peduncle. The number of pods per

Table 11(a): Environmentwise performance and stability parameters for weight of green pods per plant per picking (g) of cowpea.

Sr. No.	Genotypes	Environment			Pooled Mean	bi	($\bar{S}^2$di)
		E1	E2	E3			
1.	BCS-1	24.00	29.33	43.00	32.11	3.4171**	0.5249
2.	Arka Garima	28.67	27.67	30.67	29.00	0.3624	-7.6802
3.	RCV-326	23.00	25.67	28.67	25.78	1.0173**	-10.2982
4.	IVRCP-1	18.67	24.00	23.33	22.00	0.8324	-4.1756
5.	RCV-395	17.33	22.33	32.00	23.89	2.6363**	-6.9972
6.	IIHR Sel. 11	14.00	17.00	26.33	19.11	2.2189**	-3.9899
7.	IIHR Sel. 16	14.33	14.33	14.00	14.22	-0.0601	-10.2909
8.	Konkan Safed	13.00	12.00	14.33	13.11	0.2421	-8.4782
9.	Pusa Komal	12.00	11.67	16.00	13.22	0.7219	-6.7676
10.	Pusa Dofasali	12.00	14.67	19.00	15.22	1.2577**	-9.8997
11.	VS-15	28.00	36.67	37.33	34.00	1.6683*	0.7145
12.	Arka Samruddhi	9.33	10.00	13.67	11.00	0.7803**	-8.8701
13.	KLS-30	16.33	20.67	25.33	20.78	1.6156**	-10.3019
14.	Ajeet - 11	12.33	12.33	19.67	14.78	1.3224*	-1.6000
15.	BCP-3	19.67	17.33	17.67	18.22	-0.3567	-9.0983
16.	CHCP-2	18.00	16.67	18.33	17.67	0.0624	-8.8137
17.	RCV-7	9.67	20.67	14.67	15.00	0.8829	38.2590**
18.	Sel. 263	15.00	12.00	14.00	13.67	-0.1752	-6.1187
19.	IVRCP-2	13.67	22.33	17.67	17.89	0.7065	19.5725*
20.	CHCP-1	18.33	27.67	27.00	24.33	1.5469	6.7707
21.	Konkan Sadabahar	8.67	8.67	10.33	9.22	0.3005*	-9.8590
	Mean	16.48	19.22	22.05	19.25		
	S.E.±	1.38	2.49	1.53	1.85		
	CD at 5%	3.95	7.13	4.38	5.30		

*,** significant against pooled error at 5% and 1% levels, respectively

Table 11(b): Pooled analysis of variance for Genotype × Environment for weight of green pods per plant per picking (g) of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	2810.1411	140.5071**++
Environment + (G×E)	42	768.2963	18.2928**+
Environment (linear)	1	325.9506	325.9506**++
Genotype × Environment (linear)	20	283.2570	14.1628**
Pooled deviation	21	159.0887	7.5757**
Pooled error	126	419.2275	3.3272

*,** indicates significant pooled error at 5% and 1% levels, respectively.
+,++ significant against pooled deviation at 5% and 1% levels, respectively.

Table 12(a): Environmentwise performance and stability parameters for number of pods per peduncle of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	$(\overline{S}^2di)$
		E1	E2	E3			
1.	BCS-1	1.50	1.65	2.08	1.74	3.3375**	-0.0759
2.	Arka Garima	1.96	1.62	2.43	2.01	2.9955	0.1062*
3.	RCV-326	1.77	1.73	2.72	2.08	5.5564*	0.0351
4.	IVRCP-1	1.85	2.07	2.52	2.15	3.7653**	-0.0788
5.	RCV-395	2.09	2.05	2.36	2.17	1.6141*	-0.0660
6.	IIHR Sel. 11	1.90	1.94	2.14	1.99	1.3914**	-0.0787
7.	IIHR Sel. 16	2.22	1.97	2.06	2.08	-0.7713	-0.0586
8.	Konkan Safed	1.63	1.91	2.86	2.13	7.0133**	-0.0514
9.	Pusa Komal	1.34	1.81	2.37	1.84	5.6711**	-0.0792
10.	Pusa Dofasali	2.19	1.69	2.57	2.15	2.5731	0.2051**
11.	VS-15	2.22	1.94	1.95	2.04	-1.4019	-0.0619
12.	Arka Samruddhi	1.91	2.63	2.04	2.19	0.2737	0.2110**
13.	KLS-30	2.23	2.02	1.93	2.06	-1.6454	-0.0757
14.	Ajeet - 11	2.25	1.98	2.08	2.10	-0.7612	-0.0541
15.	BCP-3	2.18	2.13	1.80	2.04	-2.2234	-0.0737
16.	CHCP-2	1.79	1.88	1.44	1.70	-2.0925	-0.0471
17.	RCV-7	1.52	2.12	1.59	1.74	-0.0390	0.1296*
18.	Sel. 263	2.13	1.93	1.46	1.84	-3.7666	-0.0779
19.	IVRCP-2	1.73	2.84	2.00	2.19	0.7891	0.5762**
20.	CHCP-1	1.56	1.57	1.27	1.47	-1.7273	-0.0696
21.	Konkan Sadabahar	1.82	1.87	1.91	1.86	0.4481**	-0.0808
	Mean	1.90	1.97	2.08	1.98		
	S.E.±	0.18	0.19	0.12	0.16		
	CD at 5%	0.51	0.54	0.35	0.47		

*,** indicates significant at 5% and 1% levels, respectively.

Table 12(b): Pooled analysis of variance for Genotype × Environment for number of pods per peduncle of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	2.2824	0.1141**
Environment + (G×E)	42	5.0552	0.1204**
Environment (linear)	1	0.3435	0.3435**
Genotype × Environment (linear)	20	2.7794	0.1390**
Pooled deviation	21	1.9322	0.0920**
Pooled error	126	3.2888	0.0261

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

peduncle was highest in E_3 (2.08 pods per peduncle) followed by E_2 (1.97) and E_1 (1.90) conditions. The pooled mean was highest in Arka Samruddhi (2.19) for pods per peduncle followed by IVRCP-2 (2.19). The low in genotype CHCP-2 (1.70 pods/peduncle).

The regression coefficient was found to be highly significant in BCS-1, IVRCP-1, IIHR Sel. 11, Konkan Safed, Pusa Komal and Konkan Sadabahar. The genotypes RCV-326 and RCV-395 showed significant 'bi' values at 5 per cent level of significance. In remaining genotypes 'bi' value was non significant. Deviation from regression was highly significant in Pusa Dofasali, Arka Samruddhi and IVRCP-2, whereas RCV-7 and Arka Garima significant at 5 per cent level and remaining genotypes were non-significant for 'S^2di' values.

A high degree of variation exhibited among genotypes in this character Table 12 (b). The environment + (G × E), Environment (linear) and G × E (linear) was found to be significant against pooled error. The pooled deviation tested against pooled error found to be significant.

4.1.11 Pod length (cm)

The grand mean for pod length was 18.71 cm Table 13 (a). The length of pod was higher in E_3 (12.98 cm), E_2 (11.66 cm) and E_1 (10.98 cm) conditions over the pooled mean. The pooled mean was highest in VS-15 (24.94 cm) and lowest in Konkan Sadabahar (11.87 cm).

The regression coefficient was found to be significant in these genotypes except IIHR Sel. 16 and KLS-30. Deviation from regression was non significant for these genotypes.

Pooled analysis of variance was carried out to determine difference among genotypes, environments and genotype × environment interaction.

From the Table 13 (b), it is seen that the genotypic difference are highly significant. The influence of environment + (G × E) was also highly significant. This interaction was found to be made up of significant

Table 13(a): Environmentwise performance and stability parameters for pod length (cm) of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	$(\overline{S}^2di)$
		E1	E2	E3			
1.	BCS-1	20.06	21.33	27.33	22.91	1.8173**	-0.9549
2.	Arka Garima	20.37	19.04	23.37	20.93	0.9209*	1.0972
3.	RCV-326	17.70	17.60	21.57	18.95	1.0387**	-0.5788
4.	IVRCP-1	19.71	20.50	25.27	21.83	1.4047**	-0.9299
5.	RCV-395	15.90	16.99	24.00	18.96	2.0536**	-0.8717
6.	IIHR Sel. 11	15.97	16.96	22.50	18.48	1.6457**	-0.9340
7.	IIHR Sel. 16	16.02	16.29	14.83	15.72	-0.3414	-0.8162
8.	Konkan Safed	12.84	12.87	13.77	13.16	0.2441**	-0.9456
9.	Pusa Komal	15.43	16.48	19.37	17.09	0.9499**	-0.8895
10.	Pusa Dofasali	15.16	15.43	18.10	16.23	0.7563**	-0.9160
11.	VS-15	21.09	24.27	29.47	24.94	1.9313**	0.6775
12.	Arka Samruddhi	13.38	13.69	18.10	15.06	1.2272**	-0.7832
13.	KLS-30	20.51	20.87	17.93	19.77	-0.7191	-0.5593
14.	Ajeet - 11	17.65	17.58	19.13	18.12	0.4013**	-0.8888
15.	BCP-3	16.78	17.55	20.47	18.27	0.9092**	-0.9493
16.	CHCP-2	21.99	23.15	24.23	23.12	0.4892**	-0.6188
17.	RCV-7	15.01	16.49	17.63	16.38	0.5604*	-0.3582
18.	Sel. 263	16.86	16.91	21.27	18.35	1.1675**	-0.6271
19.	IVRCP-2	14.82	15.69	25.73	18.75	2.8238**	-0.2488
20.	CHCP-1	21.43	23.52	26.87	23.94	1.2513**	-0.2426
21.	Konkan Sadabahar	10.98	11.66	12.98	11.87	0.4678**	-0.8958
	Mean	17.13	17.85	21.14	18.71		
	S.E.±	0.60	0.59	0.51	0.56		
	CD at 5%	1.71	1.69	1.47	1.61		

*,** indicates significant at 5% and 1% levels, respectively.

Table 13(b): Pooled analysis of variance for Genotype × Environment for pod length (cm) of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	702.0256	35.1013**++
Environment + (G×E)	42	320.4442	7.6296**++
Environment (linear)	1	191.9826	191.9826**++
Genotype × Environment (linear)	20	120.6253	6.0313**++
Pooled deviation	21	7.8363	0.3732
Pooled error	126	38.8658	0.3085

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

influence of environment (linear) and G × E (linear). Highly significant genotypes indicated the extent of variability by the populations.

4.1.12 Biological yield (g)

The environment wise data on mean biological yield, regression coefficient (bi) and deviation from regression (S^2di) for the twenty-one genotypes of cowpea are given in Table 14 (a). The population mean for this trait under E_3 conditions was highest 36.59 g as compared to other two environments. The averages for biological yield were 36.59 g, 33.10 g and 30.63 g under environments E_3, E_2 and E_1 respectively.

The pooled mean for this trait ranged between 28.17 g (Konkan Sadabahar) to 36.13 g (VS-15). The top ranking genotype was VS-15 followed by Konkan Safed 36.13 g.

The regression coefficient found to be highly significant for all the genotypes. Deviation from regression i.e. the non-linear component was found to be non-significant for these genotypes.

Pooled analysis of variance for stability parameters in respect of biological yield is presented in Table 14 (b). The mean square due to genotype was highly significant against pooled deviation and pooled error. The mean squares due to Environment + (G × E), Environment (linear) and Genotype × Environment (linear) found to be highly significant against pooled error and pooled deviation. Pooled deviation was not significant.

4.1.13 Days to complete maturity

The data on environment wise for days to complete maturity, regression coefficient (bi) and deviation from the regression (S^2di) for the twenty-one genotypes of cowpea were given in Table 15 (a). The population mean over all the environments for days to compete maturity 86.92 days.

The duration for days to complete maturity was largest under E_3 (88.83 days) and shortest under E_1 (85.22 days). The wide range of

Table 14(a): Environmentwise performance and stability parameters for biological yield (g) of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S}^2di$)
		E1	E2	E3			
1.	BCS-1	31.46	34.28	38.88	34.87	1.2499**	-1.9917
2.	Arka Garima	28.47	31.57	35.74	31.93	1.2199**	-2.0318
3.	RCV-326	33.06	35.85	42.35	37.09	1.5806**	-1.2999
4.	IVRCP-1	30.42	33.57	35.48	33.16	0.8288**	-1.3027
5.	RCV-395	29.25	32.13	34.72	32.03	0.9078**	-1.7907
6.	IIHR Sel. 11	28.52	30.44	33.23	30.73	0.7907**	-2.0358
7.	IIHR Sel. 16	29.94	33.19	36.89	33.34	1.1602**	-1.9454
8.	Konkan Safed	32.14	34.88	41.40	36.14	1.5758**	-1.2389
9.	Pusa Komal	31.22	33.18	35.68	33.36	0.7459**	-2.0276
10.	Pusa Dofasali	31.68	33.72	36.20	33.86	0.7556**	-2.0182
11.	VS-15	31.93	35.31	41.18	36.14	1.5603**	-1.8983
12.	Arka Samruddhi	30.18	32.81	35.91	32.97	0.9581**	-1.9933
13.	KLS-30	31.31	33.72	36.91	33.98	0.9384**	-2.0313
14.	Ajeet - 11	31.32	32.45	36.01	33.26	0.8028**	-1.5922
15.	BCP-3	32.11	35.09	39.95	35.72	1.3201**	-1.9885
16.	CHCP-2	30.37	32.61	38.34	33.77	1.3576**	-1.2829
17.	RCV-7	31.09	32.48	36.05	33.21	0.8452**	-1.7440
18.	Sel. 263	30.42	32.91	35.01	32.78	0.7588**	-1.8074
19.	IVRCP-2	30.16	33.17	34.87	32.73	0.7701**	-1.3003
20.	CHCP-1	30.84	33.49	34.86	33.06	0.6567**	-1.3991
21.	Konkan Sadabahar	27.43	28.34	28.76	28.18	0.2165**	-1.9531
	Mean	30.63	33.10	36.59	33.44		
	S.E.±	0.63	0.74	1.06	0.82		
	CD at 5%	1.81	2.11	3.03	2.35		

*,** indicates significant at 5% and 1% levels, respectively.

Table 14(b): Pooled analysis of variance for Genotype × Environment for biological yield (g) of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	229.5469	11.4773**++
Environment+(G×E)	42	426.5415	10.1558**++
Environment (linear)	1	376.2562	376.2562**++
Genotype × Environment (linear)	20	44.1914	2.2096**++
Pooled deviation	21	6.0940	0.2902
Pooled error	126	82.8189	0.6573

*,** significant against pooled error at 5% and 1% levels, respectively.

+,++ significant against pooled deviation at 5% and 1% levels, respectively.

Table 15(a): Environmentwise performance and stability parameters for days to complete maturity of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S}^2di$)
		E1	E2	E3			
1.	BCS-1	88.52	91.01	93.33	90.95	1.3478**	-1.5510
2.	Arka Garima	85.01	85.84	89.06	86.64	1.1839**	-1.3673
3.	RCV-326	89.33	85.61	88.57	87.84	-0.0843	5.8980**
4.	IVRCP-1	89.23	86.37	89.82	88.48	0.2870	4.5219**
5.	RCV-395	88.27	88.58	89.02	88.63	0.2122**	-1.7735
6.	IIHR Sel. 11	89.76	87.40	90.24	89.13	0.2368	2.5128*
7.	IIHR Sel. 16	89.62	87.45	89.22	88.76	-0.0364	0.9029
8.	Konkan Safed	81.23	87.05	86.52	84.93	1.3621	7.3262**
9.	Pusa Komal	84.75	86.74	88.09	86.53	0.9261**	-1.4878
10.	Pusa Dofasali	88.55	88.27	90.40	89.07	0.5651*	-1.0933
11.	VS-15	87.71	91.98	91.93	90.54	1.1026	2.6353*
12.	Arka Samruddhi	86.00	86.64	88.44	87.03	0.7095**	-1.7039
13.	KLS-30	78.86	83.19	85.73	82.59	1.8974**	-0.0895
14.	Ajeet - 11	80.77	83.46	85.89	83.37	1.4342**	-1.4895
15.	BCP-3	83.37	87.09	89.86	86.77	1.8048**	-0.9129
16.	CHCP-2	84.72	86.47	88.31	86.50	1.0114**	-1.7068
17.	RCV-7	89.00	87.21	89.58	88.60	0.2436	0.8962
18.	Sel. 263	77.91	88.11	90.87	85.63	3.4979*	14.9682**
19.	IVRCP-2	85.98	91.03	93.31	90.11	2.0040**	1.2269
20.	CHCP-1	87.93	89.29	91.01	89.41	0.8733**	-1.7622
21.	Konkan Sadabahar	73.01	72.26	76.25	73.84	1.0004	0.9613
	Mean	85.22	86.72	88.83	86.92		
	S.E.±	0.66	1.04	0.47	0.77		
	CD at 5%	1.89	2.97	1.34	2.20		

*,** indicates significant at 5% and 1% levels, respectively.

Table 15(b): Pooled analysis of variance for Genotype × Environment for days to complete maturity of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	443.5853	22.1793**++
Environment + (G×E)	42	290.1710	6.9088**+
Environment (linear)	1	131.2122	131.2122**++
Genotype × Environment(linear)	20	94.8015	4.7401**
Pooled deviation	21	64.1574	3.0551**
Pooled error	126	72.1256	0.5724

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

variation was observed among the genotypes for this character. The range of performance was between 73.01 to 88.76 days under E_1, 72.26 to 91.98 days under E_2 and 76.25 to 93.33 days under E_3 conditions for days to complete maturity.

Among three stability parameters, the average duration for days to complete maturity was longest in BCS-1 (90.95 days) followed by VS-15 (90.54 days) and IVRCP-2 (90.10 days). The genotypes, Konkan Sadabahar (73.83 days) KLS-30 (82.59 days) were early in days to complete maturity.

The regression coefficient (bi) over environments was significant except RCV-326, IVRCP-1, IIHR Sel. 11, IIHR Sel. 16, Konkan Safed, VS-15 and RCV-7 and Konkan Sadabahar. While the deviation from regression (S^2di) was significant in genotypes *viz.,* RCV-326, IVRCP-1, IIHR Sel. 11, Konkan Safed, VS-15, and Sel. 263.

The days to complete maturity were highly significant among the genotypes against pooled error and deviation (Table 15 b). The contribution due to environment (linear) and, Environment + (G×E) was also highly significant. Genotype × Environment (linear) was highly significant against pooled error for this character. The pooled deviation was highly significant against pooled error for days to compete maturity.

4.1.14 Seed yield per plant (g)

The data on yield per plant under various environments and estimates of stability parameters are presented in Table 16 (a). The E_3 environment recorded the highest mean seed yield (13.0 g) followed by E_2

(12.70 g) environment and E_1(12.55 g) environment. The mean seed yield performance of RCV-326, VS-15, Konkan Safed and BCS-1 were higher among the genotypes. The seed yield per plant observed low in Konkan Sadabahar, IIHR Sel. 11 genotypes.

The regression coefficient over environments was highly significant in RCV — 7 and CHCP — 1. The genotypes KLS-30, IVRCP-2 and Konkan

Table 16(a): Environmentwise performance and stability parameters for seed yield per plant (g) of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S}^2$di)
		E1	E2	E3			
1.	BCS-1	14.22	14.29	13.34	13.95	-1.7590	-0.7543
2.	Arka Garima	11.53	11.72	11.67	11.64	0.2437	-0.8736
3.	RCV-326	15.62	15.52	15.47	15.54	-0.2926	-0.8834
4.	IVRCP-1	11.85	11.45	11.82	11.71	0.0149	-0.7868
5.	RCV-395	12.82	12.10	12.00	12.31	-1.4843	-0.7919
6.	IIHR Sel. 11	11.53	10.93	11.04	11.17	-0.8563	-0.7822
7.	IIHR Sel. 16	13.54	13.73	13.56	13.61	0.0101	-0.8621
8.	Konkan Safed	14.12	14.17	14.03	14.11	-0.1886	-0.8792
9.	Pusa Komal	12.90	12.69	12.18	12.59	-1.3950	-0.8777
10.	Pusa Dofasali	12.77	12.74	12.59	12.70	-0.3528	-0.8829
11.	VS-15	15.04	16.40	16.36	15.93	2.3676	-0.4683
12.	Arka Samruddhi	13.96	12.52	13.40	13.29	-0.8372	0.0788
13.	KLS-30	11.22	12.82	13.07	12.37	3.3953*	-0.4433
14.	Ajeet - 11	11.59	14.57	13.30	13.15	2.8396	2.4567**
15.	BCP-3	13.67	13.29	14.68	13.88	2.0949	-0.4543
16.	CHCP-2	13.67	12.07	14.16	13.30	1.2767	1.2804*
17.	RCV-7	12.06	12.15	12.59	12.26	1.0325**	-0.8718
18.	Sel. 263	11.69	11.22	12.39	11.77	1.4884	-0.4960
19.	IVRCP-2	10.35	12.34	12.87	11.85	4.6382*	-0.3298
20.	CHCP-1	12.32	12.98	14.10	13.13	3.4153**	-0.8773
21.	Konkan Sadabahar	7.00	7.03	8.40	7.47	2.7818*	-0.6748
	Mean	12.55	12.70	13.00	12.75		
	S.E.$\pm$	0.74	0.53	0.28	0.54		
	CD at 5%	2.12	1.52	0.80	1.55		

*,** indicates significant at 5% and 1% levels, respectively.

Table 16(b): Pooled analysis of variance for Genotype × Environment for seed yield per plant (g) of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	213.6892	10.6845**++
Environment +(G×E)	42	21.0320	0.5008*
Environment (linear)	1	2.8951	2.8951**+
Genotype × Environment (linear)	20	8.7400	0.4370
Pooled deviation	21	9.3969	0.4475
Pooled error	126	35.9622	0.2854

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels,

respectively Konkan Sadabahar found to be significant at 5 per cent level of significance. The remaining 'bi' values were non-significant. The third stability parameter 'S^2di' observed highly significant in Ajeet-11 genotype. While CHCP-2 showed significant value for 'S^2di' and remaining values were not significant for all the genotypes for this character.

4.1.15 100-Seed weight (g)

The mean over all environments was 11.35 g for weight of 100 seeds given in Table 17 (a). The pooled mean for 100 seed weight was highest in E_3 (11.47 g) followed by E_2 (11.37 g) and E_1 (11.33 g) environments.

Among three stability parameters, the average 100-seed weight was higher in VS-15 (16.01 g) followed by IVRCP-1 (14.18 g), BCS-1 (13.80 g), RCV-395 (13.37 g), Konkan Safed (12.64 g), Pusa Dofasali (11.77 g) and Sel. 263 (11.50 g) over the pooled mean.

The regression coefficient 'bi' values were highly significant in Konkan Sadabahar. While Sel. 263 and CHCP-1 were significant for 5 per cent level of significance. Whereas, third stability parameter (S^2di) values found to be significant for IVRCP-2 genotype at 5 per cent level. The remaining 'bi' and 'S^2di' values were found to be non-significant.

The differences among the genotypes in 100-seed weight were highly significant against pooled deviation and pooled error in Table 17 (b). The contribution of environments inclusive of G × E i.e. (E + G × E) to the total variation in 100-seed weight was not found to be considerable magnitude. The pooled deviation was not significant when tested against pooled error.

4.1.16 Harvest index (%)

The population means for harvest index and three stability parameters are given in Table 18 (a). The mean harvest index over the environments were (38.14 per cent) and 40.67, 38.25 and 35.49 per cent in

Table 17(a): Environmentwise performance and stability parameters for 100 seed weight (g) of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S}^2di$)
		E1	E2	E3			
1.	BCS-1	13.50	14.10	13.80	13.80	1.2231	-0.3075
2.	Arka Garima	9.46	9.25	9.38	9.36	-0.2646	-0.4523
3.	RCV-326	10.82	11.28	10.80	10.97	-0.9932	-0.3356
4.	IVRCP-1	14.72	13.77	14.06	14.18	-3.3456	-0.1228
5.	RCV-395	13.83	12.75	13.54	13.37	-0.3081	0.1458
6.	IIHR Sel. 11	10.92	10.53	10.54	10.66	-2.1672	-0.4265
7.	IIHR Sel. 16	10.38	11.08	11.38	10.95	6.4056*	-0.3758
8.	Konkan Safed	12.62	12.71	12.62	12.65	-0.1340	-0.4689
9.	Pusa Komal	10.66	10.95	10.87	10.83	1.1043	-0.4398
10.	Pusa Dofasali	12.01	11.32	11.99	11.77	1.0833	-0.1822
11.	VS-15	15.84	16.27	15.94	16.02	-0.0233	-0.3721
12.	Arka Samruddhi	10.32	10.92	10.25	10.50	-1.5919	-0.2319
13.	KLS-30	10.73	11.18	10.90	10.94	0.4624	-0.3756
14.	Ajeet - 11	9.64	10.28	9.82	9.91	0.2531	-0.2616
15.	BCP-3	11.53	10.81	11.48	11.27	0.9072	-0.1640
16.	CHCP-2	9.84	9.92	9.92	9.89	0.5086	-0.4716
17.	RCV-7	10.27	9.34	10.34	9.99	2.2020	0.0969
18.	Sel. 263	11.32	11.12	12.08	11.50	6.1861*	-0.3559
19.	IVRCP-2	10.69	12.25	11.01	11.31	-0.3190	0.8829*
20.	CHCP-1	11.20	11.43	11.54	11.39	2.2037*	-0.4628
21.	Konkan Sadabahar	7.65	7.55	8.62	7.94	7.6074**	-0.3766
	Mean	11.33	11.37	11.47	11.39		
	S.E.±	0.34	0.43	0.43	0.40		
	CD at 5%	0.98	1.23	1.21	1.14		

*,** indicates significant at 5% and 1% levels, respectively.

Table 17(b): Pooled analysis of variance for Genotype × Environment for 100 seed weight (g) of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	195.9533	9.7977**++
Environment + (G×E)	42	6.6852	0.1592
Environment (linear)	1	0.2189	0.2189
Genotype ×Environment (linear)	20	1.5720	0.0786
Pooled deviation	21	4.8943	0.2331

Pooled error	126	19.2721	0.1530

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

Table 18(a): Environmentwise performance and stability parameters for harvest index (%) of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S}^2$di)
		E1	E2	E3			
1.	BCS-1	45.19	41.70	34.33	40.41	2.1121**	-8.5287
2.	Arka Garima	40.88	37.31	32.83	37.01	1.5568**	-10.1937
3.	RCV-326	47.37	43.48	36.65	42.50	2.0819**	-9.3732
4.	IVRCP-1	38.93	34.05	33.44	35.47	1.0421*	-6.6744
5.	RCV-395	43.87	37.64	34.63	38.71	1.7684**	-7.7911
6.	IIHR Sel. 11	40.51	35.93	33.28	36.58	1.3879**	-9.2723
7.	IIHR Sel. 16	45.22	41.35	36.83	41.13	1.6234**	-10.2158
8.	Konkan Safed	43.95	40.66	34.03	39.55	1.9284**	-9.0101
9.	Pusa Komal	41.35	38.30	34.24	37.96	1.3770**	-10.1670
10.	Pusa Dofasali	40.28	37.82	34.80	37.63	1.0592**	-10.2103
11.	VS-15	47.17	46.44	39.77	44.46	1.4526**	-5.2429
12.	Arka Samruddhi	46.18	38.14	37.34	40.55	1.6768*	-0.0651
13.	KLS-30	35.86	38.03	35.49	36.46	0.0889	-6.5522
14.	Ajeet - 11	37.03	44.97	36.94	39.64	0.0846	32.1526**
15.	BCP-3	42.56	37.89	36.76	39.07	1.1049**	-7.6482
16.	CHCP-2	40.46	37.10	36.94	38.17	0.6668*	-8.2691
17.	RCV-7	38.81	37.42	34.92	37.05	0.7548**	-10.0919
18.	Sel. 263	38.50	34.08	35.54	36.04	0.5461	-4.0845
19.	IVRCP-2	34.31	37.22	36.89	36.14	-0.4842	-8.2762
20.	CHCP-1	40.01	38.76	40.45	39.74	-0.0959	-8.8141
21.	Konkan Sadabahar	25.57	24.87	29.25	26.56	-0.7326	-6.3058
	Mean	40.67	38.25	35.49	38.14		
	S.E.±	2.46	1.70	1.21	1.85		
	CD at 5%	7.03	4.85	3.46	5.27		

*,** indicates significant at 5% and 1% levels, respectively.

Table 18(b): Pooled analysis of variance for Genotype × Environment for harvest index (%) of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	733.5225	36.6761**++
Environment + (G×E)	42	558.8913	13.3069**++
Environment (linear)	1	281.5220	281.5220**++
Genotype × Environment (linear)	20	187.4248	9.3712**+
Pooled deviation	21	89.9445	4.2831
Pooled error	126	415.5328	3.2979

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

E_1, E_2 and E_3 environments respectively. VS-15 (44.46 per cent) and Konkan Sadabahar (26.56 per cent) showed the highest and lowest harvest index, respectively.

Mean harvest index over all genotypes and environments was observed to be 38.14 per cent.

The regression coefficient over environment was highly significant for BCS-1, Arka Garima, RCV-326, RCV-395, IIHR Sel. 11, IIHR Sel. 16, Konkan Safed, Pusa Komal, Pusa Dofasali, VS-15, BCP-3 and RCV-7, while, IVRCP-1, Arka Samruddhi and CHCP-2 were found to significant for 5 per cent level of significance. The remaining 'bi' and 'S^2di' were also found non-significant for all genotypes except for 'S^2di' *viz.,* Ajeet-11.

From the Table 18 (b), it is seen that the difference are highly significant for genotypes differences, Environment + (G × E) and Environment (linear). The Genotype × Environment (linear) was found to be highly significant against pooled error. The pooled deviation was non-significant against pooled error.

4.1.17 Yield Realization index (%)

The population mean of yield realization index over the environments was 23.78 per cent in Table 19 (a). The population mean was highest in E_3 (26.02 per cent) followed by E_2 (24.26 per cent) and E_1 (21.06

per cent) environmental conditions. The pooled mean of yield realization index was highest in IIHR Sel. 11 and lower in CHCP-1 (17.75 per cent).

The regression coefficient (bi) was highly significant for BCS-1, RCV-326, IIHR Sel. 11, Pusa Komal, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11 and IVRCP-2 and remaining were non-significant. The deviation from regression was highly significant in Arka Garima and remaining genotypes were non-significant for this trait.

The variation due to genotypes, E + (G × E) and Environment (linear) were highly significant against pooled error and pooled deviation.

Table 19(a): Environmentwise performance and stability parameters for yield realization index (%) of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S}^2di$)
		E1	E2	E3			
1.	BCS-1	17.51	25.82	25.70	23.01	1.7657**	-5.9523
2.	Arka Garima	20.32	19.09	31.59	23.67	1.9517	34.8879**
3.	RCV-326	23.39	26.04	29.72	26.38	1.2207**	-10.5667
4.	IVRCP-1	20.68	20.85	29.11	23.55	1.5019	6.0407
5.	RCV-395	21.32	28.38	26.56	25.42	1.1969	-3.0842
6.	IIHR Sel. 11	26.64	28.13	29.06	27.94	0.4849**	-11.8946
7.	IIHR Sel. 16	26.12	27.31	24.87	26.10	-0.1760	-9.3315
8.	Konkan Safed	25.28	28.85	27.21	27.11	0.4779	-8.3802
9.	Pusa Komal	19.34	25.12	27.61	24.03	1.6847**	-11.7661
10.	Pusa Dofasali	19.87	25.80	27.39	24.35	1.5579**	-11.1409
11.	VS-15	18.78	25.79	27.30	23.96	1.7743**	-10.4101
12.	Arka Samruddhi	18.17	23.85	24.76	22.26	1.3836**	-10.5686
13.	KLS-30	20.32	24.37	26.77	23.82	1.2964**	-11.8899
14.	Ajeet - 11	17.86	23.51	28.38	23.25	2.0801**	-11.0716
15.	BCP-3	21.54	22.94	22.29	22.26	0.1863	-11.3564
16.	CHCP-2	16.48	19.23	18.38	18.03	0.4392	-10.3952
17.	RCV-7	20.98	22.34	21.44	21.59	0.1327	-11.1598
18.	Sel. 263	19.59	23.11	21.54	21.41	0.4780	-8.5817
19.	IVRCP-2	22.47	27.37	27.41	25.75	1.0598**	-9.9795
20.	CHCP-1	17.38	16.85	19.05	17.76	0.2757	-10.2172
21.	Konkan Sadabahar	28.22	24.65	30.27	27.71	0.2280	3.5973
	Mean	21.06	24.26	26.02	23.78		
	S.E.±	1.98	2.00	2.04	1.99		
	CD at 5%	5.67	5.72	5.83	5.69		

*,** indicates significant at 5% and 1% levels, respectively.

Table 19(b): Pooled analysis of variance for Genotype × Environment for yield realization index (%) of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	445.2298	22.2615**++
Environment+(G×E)	42	504.2051	12.0049**+
Environment (linear)	1	265.4690	265.4690**++
Genotype × Environment (linear)	20	122.1013	6.1051
Pooled deviation	21	116.6348	5.5540
Pooled error	126	483.8472	3.8401

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

The Environment (linear) was found to be significant against pooled deviation at 5 per cent level of significance. The pooled deviation was not significant against pooled error for this character.

4.1.18 Number of green pods per plant

The data regarding mean number of green pods per plant under three environmental conditions and the stability parameters of the trait of twenty-one genotypes, of cowpea, under consideration are presented in Table 20 (a). The number of green pods under E_3 conditions was higher (13.90 pods) followed by E_2 (12.33 pods) and E_1 (10.17 pods) conditions. In general E_3 was found to be the most favourable environment. The range of green pods per plant was between 8.29 to 12.04 green pods under E_1 condition, 9.30 to 15.75 green pods under E_2 and 9.57 to 17.80 green pods under E_3 conditions.

The IVRCP-2 (14.51 pods) showed the higher number of green pods and CHCP-1 (9.48 pods) recorded the lowest green pods per plant. The regression coefficient was highly significant for BCS-1, RCV-326, IVRCP-1 RCV-395, IIHR Sel. 11, Konkan Safed, Pusa Komal, Pusa Dofasali, VS-15, KLS-30, Ajeet-11 and CHCP-2, whereas, significant for Arka Garima, IIHR Sel. 16, Arka Samruddhi, BCP-3, IVRCP-2 and CHCP-1 at 1% level of significance. The non-linear response (S^2di) was not significant for these genotypes except Arka Garima.

The pooled analysis of variance was carried out to determine difference among genotypes, environments and genotype × environment interaction. The difference among the genotypes, Environment + (Genotype × Environment), Environment (linear) and Genotype × Environment (liner) were highly significant for number of green pods per plant. The pooled deviation against pooled error was found to be significant at 5% level of significance.

Table 20(a): Environmentwise performance and stability parameters for number of green pods per plant of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S^2di}$)
		E1	E2	E3			
1.	BCS-1	8.29	12.26	13.90	11.48	1.5219**	-1.3276
2.	Arka Garima	8.66	9.30	15.40	11.12	1.7113*	5.4035**
3.	RCV-326	11.30	13.33	17.80	14.14	1.6905**	0.3379
4.	IVRCP-1	8.32	10.33	14.40	11.01	1.5844**	-0.1438
5.	RCV-395	9.66	12.80	14.50	12.32	1.3049**	-1.5929
6.	IIHR Sel. 11	9.99	12.20	13.30	11.83	0.8942**	-1.6103
7.	IIHR Sel. 16	10.32	12.20	12.20	11.57	0.5256*	-1.2540
8.	Konkan Safed	11.66	13.50	15.00	13.38	0.8912**	-1.6595
9.	Pusa Komal	9.66	13.96	16.08	13.23	1.7350**	-1.4479
10.	Pusa Dofasali	10.41	13.29	16.64	13.44	1.6470**	-1.3097
11.	VS-15	9.67	13.62	14.29	12.52	1.2735**	-0.5981
12.	Arka Samruddhi	9.67	15.08	15.19	13.31	1.5391*	1.5460
13.	KLS-30	10.78	12.51	14.07	12.45	0.8766**	-1.6443
14.	Ajeet - 11	9.29	12.51	15.30	12.36	1.6004**	-1.6178
15.	BCP-3	11.66	12.25	12.25	12.05	0.1663*	-1.6245
16.	CHCP-2	9.22	9.92	10.38	9.83	0.3129**	-1.6654
17.	RCV-7	11.27	11.90	11.67	11.61	0.1175	-1.5601
18.	Sel. 263	11.08	11.55	11.20	11.27	0.0425	-1.5605
19.	IVRCP-2	12.04	15.75	15.75	14.51	1.0372*	-0.0621
20.	CHCP-1	9.32	9.57	9.57	9.48	0.0685*	-1.6588
21.	Konkan Sadabahar	11.24	11.20	13.07	11.83	0.4591	-0.8693
	Mean	10.17	12.33	13.90	12.13		
	S.E.±	0.80	0.98	0.31	0.74		
	CD at 5%	2.27	2.80	0.89	2.12		

*,** indicates significant at 5% and 1% levels, respectively.

Table 20(b): Pooled analysis of variance for Genotype × Environment for number of green pods per plant of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	97.24528	4.862264**++
Environment +(G×E)	42	220.7953	5.25703**++
Environment (linear)	1	147.8064	147.8064**++
Genotype × Environment (linear)	20	53.92687	2.696343**++
Pooled deviation	21	19.06196	0.907712*
Pooled error	126	67.7411	0.537628

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

Table 21(a): Environmentwise performance and stability parameters for weight of green pods per plant (g) of cowpea.

Sr. No.	Genotypes	Environments			Pooled Mean	bi	($\overline{S}^2$di)
		E1	E2	E3			
1.	BCS-1	72.00	88.00	129.00	96.33	3.1957**	0.1409
2.	Arka Garima	86.00	83.00	92.00	87.00	0.3336	-87.2102
3.	RCV-326	69.00	77.00	86.00	77.33	0.9550**	-111.3183
4.	IVRCP-1	56.00	72.00	70.00	66.00	0.7920	-58.8967
5.	RCV-395	52.00	67.00	96.00	71.67	2.4684**	-75.6281
6.	IIHR Sel. 11	42.00	51.00	79.00	57.33	2.0736**	-47.6996
7.	IIHR Sel. 16	43.00	43.00	42.00	42.67	-0.0559	-111.4135
8.	Konkan Safed	39.00	36.00	43.00	39.33	0.2218	-94.7107
9.	Pusa Komal	40.20	39.08	53.60	44.29	0.7484	-69.7548
10.	Pusa Dofasali	40.20	49.13	63.65	50.99	1.3161**	-105.6846
11.	VS-15	93.80	122.83	125.07	113.90	1.7648*	3.7791
12.	Arka Samruddhi	31.27	33.50	45.78	36.85	0.8128**	-93.9832
13.	KLS-30	54.72	69.23	84.87	69.61	1.6939**	-111.1648
14.	Ajeet - 11	41.32	41.32	65.88	49.51	1.3733*	-7.8330
15.	BCP-3	68.83	60.67	61.83	63.78	-0.3961	-97.4070
16.	CHCP-2	63.00	58.33	64.17	61.83	0.0625	-93.1480
17.	RCV-7	33.83	72.33	51.33	52.50	1.0008	472.9874**
18.	Sel. 263	52.50	42.00	49.00	47.83	-0.2018	-60.8670
19.	IVRCP-2	47.83	78.17	61.83	62.61	0.8004	247.9469**
20.	CHCP-1	64.17	96.83	94.50	85.17	1.7148	87.0625
21.	Konkan Sadabahar	30.33	30.33	36.17	32.28	0.3261*	-105.7356
	Mean	53.38	62.42	71.18	62.32		
	S.E.±	4.50	8.21	5.08	6.10		
	CD at 5%	12.86	23.46	14.53	17.43		

*,** indicates significant at 5% and 1% levels, respectively.

Table 21(b): Pooled Analysis of variance for Genotype × Environment for weight of green pods per plant of cowpea.

Source of variation	d.f.	SS	MSS
Genotypes	20	26234.2864	1311.7143**++
Environment + (G×E)	42	7842.7141	186.7313**+
Environment (linear)	1	3325.0153	3325.0153**++
Genotype × Environment (linear)	20	2694.9434	134.7472**
Pooled deviation	21	1822.7554	86.7979**
Pooled error	126	4537.8072	36.0143

*,** significant against pooled error at 5% and 1% levels, respectively
+,++ significant against pooled deviation at 5% and 1% levels, respectively

4.1.19 Weight of green pods per plant (g)

The data on environment wise duration for weight of green pods per plant and three stability parameters are given in Table 21 (a). The weight of green pods was low in E_1 (53.38 g) and higher in E_3 (71.18 g) conditions.

Mean weight of green pods over all genotypes and environments was observed to be 62.32 g. The pooled means for each the genotypes showed considerable variations in weight of green pods per plant. The minimum weight of green pods was recorded in Konkan Sadabahar (32.28 g) and maximum in VS-15 (113.90 g).

The regression coefficient (bi) were highly significant in BCS-1, RCV-326, RCV-395, IIHR Sel. 11, Pusa Dofasali, Arka Samruddhi and KLS-30, whereas, significant at 5 per cent in VS-15, Ajeet-11 and Konkan Sadabahar. Remaining 'bi' value showed non-significant. The third stability parameter (S^2di) showed non-significant values except RCV-7 and IVRCP-2.

From Table 21 (b), it is seen that the genotypic differences are highly significant against pooled deviation and pooled error. The Environment + (G × E), Environment (linear) and Genotype × Environment (linear) showed highly significant against pooled error, whereas Environment + (G × E) and Environment (linear) significant against pooled deviation at 1% and 5% level of significance. The pooled deviation was found to be significant when tested against pooled error.

Inter relations between various traits for stability parameters

The association for the mean performance as well as two stability parameters 'bi' and 'S^2di' in respect of various traits was estimated through the coefficients of correlation's. The correlation coefficient in respect of various traits was calculated by using pooled mean of each genotype for every trait. The association between linear responses was computed by subjecting 'bi' values of various traits to correlation analysis and their interrelationship between non-linear components was estimated by subjecting values of nineteen traits to correlation analysis. The results on this aspect are given in Table 22 to 24.

Correlation for mean performance of various traits

Weight of green pods per plant showed positive and highly significant correlation with weight of green pods per plant per picking, pod length (cm) and 100 seed weight whereas number of compound leaves per plant, days to initiation of flowering, days to compete maturity, seed yield per plant (g) and harvest index (%) showed significant positive correlation with weight of green pods per plant, remaining characters showed either positive or negative but non-significant correlation with weight of green pods per plant. (Table 22)

Number green pods per plant showed positive and highly significant correlation with number of green pods per plant per picking, number of pods per peduncle and yield realization index (%). While, number of flowers per plant showed positive and significant correlation with number of green pods per plant, whereas, plant height (cm) showed negative highly significant correlation with number of green pods per plant and pod length (cm) showed negative significant correlation with number of green pods per plant. Yield realization index showed positive and highly significant correlation with number of green pods per plant per picking and number of pods per peduncle. While, plant height showed negative highly significant correlation with yield realization index and pod length showed negative significant correlation with yield realization index.

Harvest index (%) showed highly significant and positive correlation with days to initiation of flowering, number of flowers per plant, biological yield, days to complete maturity and seed yield per plant, while number of compound leaves per plant, weight of green pods per plant per picking, pod length and 100-seed weight (g) positive significant correlation with harvest index. 100-seed weight (g) showed highly significant and positive correlation with days to initiation of flowering, weight of green pods per plant per picking, days to complete maturity and seed yield per plant whereas number of compound leaves per plant, pod length (cm) and biological yield (g) showed significant positive association with 100-seed weight. Seed yield per plant (g) showed highly significant positive correlation with days to initiation of flowering, number of flowers per plant, biological yield (g) and days to compete maturity while weight of green pods per plant per picking showed significant positive correlation.

Days to compete maturity showed positive highly significant correlation with number of compound leaves per plant and days to initiation of flowering, whereas, number of flowers per plant, weight of green pods per plant per picking, pod length (cm) and biological yield (g) with days to complete maturity. Biological yield (g) showed positive and highly significant correlation with days to initiation of flowering and number of flowers per plant.

Pod length (cm) showed significant positive correlation with plant height (cm) and highly significant positive correlation with days to initiation of flowering and weight of green pods per plant per picking. Number of pods per peduncle showed highly significant negative correlation and number of green pods per plant per picking showed highly significant positive correlation with number of pods per peduncle. Weight of green pods per plant per picking (g) showed significant positive correlation with number of compound leaves per plant and days to initiation of flowering. Number of green pods per plant per picking showed highly significant negative correlation with plant height (cm) and significant positive correlation with number of flowers per plant.

Number of flowers per plant showed positive and highly significant correlation with days to initiation of flowering. Number of compound leaves per plant showed significant positive correlation with days to initiation of flowering. Number of inflorescence per plant showed significant positive correlation with number of branches per plant.

The character number of peduncles per plant had either positive or negative but non-significant correlation with all the characters studied.

Correlation for linear response of various traits

The linear component for weight of green pods per plant was positively and highly significantly correlated with weight of green pods per plant per picking and positively correlated with yield realization index, which is presented in Table 23. Number of green pods per plant for 'bi' values was positively and highly significantly correlated with number of flowers per plant, number of green pods per plant per picking, number of pods per peduncle and yield realization index, whereas, 100-seed weight (g) showed negative highly significant correlation and seed yield per plant showed significant negative correlation with number of green pods per plant. Yield realization index showed positive and highly significant correlation with number of green pods per plant per picking and positive significant correlation with weight of green pods per plant per picking. Yield realization index (%) showed negative and significant correlation with 100-seed weight.

The 'bi' value of harvest index (%) showed positive highly significant correlation with number of flowers per plant and biological yield while seed yield per plant showed negative highly significant correlation with harvest index.100-seed weight (g) showed negative highly significant correlation with number of green pods per plant per picking. Seed yield per plant showed highly significant negative correlation with number of flowers per plant and number of pods per peduncle while number of green pods per plant per picking showed negative significant correlation with seed yield per plant. The character days to complete maturity showed significant positive correlation with seed yield per plant. Days to compete maturity showed negative highly significant correlation with number of flowers per plant. Biological yield showed negative significant correlation with number of branches per plant.

Pod length (cm) showed negative significant correlation with days to initiation of flowering. Number of pods per peduncle showed highly significant positive correlation with number of flowers per plant and number of green pods per plant per picking while number of peduncles per plant showed highly significant negative correlation with number of pods per peduncles. Number of green pods per plant per picking for 'bi' value showed highly significant and positive correlation with number of flowers per plant. Number of inflorescence per plant showed negative significant correlation with plant height (cm). The number of compound leaves per plant had either positive or negative but non-significant correlation with all the characters studied.

Correlation for non-linear response of various traits

The non-linear components of weight of green pods per plant had positive and highly significant correlation with of weight of green pods per plant per picking and 100- seed weight (g), while, number of pods per peduncle had significant positive correlation with weight of green pods per plant (Table 24). Number of green pods per plant for S^2di was highly and positively correlated with number of green pods per plant per picking, pod length (cm) and yield realization index (%). Number of green pods per plant per picking had positive and highly significant correlation and pod length (cm) had positive significant correlation with yield realization index

(%). The S^2di value of harvest index (%) was highly and positively correlated with seed yield per plant (g). The S^2di for 100-seed weight had positive and highly significant correlation with weight of green pods per plant per picking (g) and number of pods per peduncle. The S^2di value of pod length was highly and positively correlated with number of green pods per plant per picking while number of pods per was positively and significantly correlated with weight of green pods per plant picking (g). The S^2di value of number of peduncles per plant had positively significant correlation with number of branches per plant.

The S^2di values for the characters plant height (cm), number of compound leaves per plant, number of inflorescence per plant, days to initiation of flowering, number of flowers per plant, biological yield (g) and days to complete maturity had either positive or negative but non-significant correlation with all the characters studied.

Table 22. Correlation for "Mean" values of various quantitative traits in cowpea.

Chara-cters	Plant height (cm) (X_1)	No. of bran-ches/plant (X_2)	No. of compou-nd leaves/plant (X_3)	No. of peduncles/plant (X_4)	No. of inflorescence /plant (X_5)	Days to initiati-on of flower-ing (X_6)	No. of flowers/plant (X_7)	No. of green pods /plant /picking (X_8)	Wt. of green pods /plant/picking (X_9)	No. of pods /pedun-cle (X_{19})	Pod length (cm) (X_{11})	Biologi-cal yield(g) (X_{12})	Days to complete maturity (X_{13})	Seed yield/plant (g) (X_{14})	100-seed weight (g) (X_{15})	Harvest index (%) (X_{16})	Yield Realization index (%) (X_{17})	No. of green pods /plant (X_{18})	Weight of green pods /plant (X_{19})
X_1	1.0000	0.0254	0.0542	0.1516	-0.0925	0.1540	-0.0566	-0.6472**	0.1398	-0.6700**	0.4826*	-0.0154	0.1370	0.1056	-0.0943	0.1202	-0.6979**	-0.6441**	0.2274
X_2		1.0000	0.1376	0.3127	0.4917*	0.2907	0.2085	0.0703	-0.1347	-0.0941	0.0466	-0.0039	0.3429	0.0965	-0.0564	0.1831	-0.0825	0.2148	-0.0983
X_3			1.0000	0.0694	0.4165	0.5198*	0.3969	0.2880	0.5483*	0.1886	0.3807	0.1715	0.6733**	0.3714	0.4318*	0.5121*	0.0328	0.0721	0.4985*
X_4				1.0000	0.3374	0.1935	0.4278	0.1825	0.0591	-0.3736	0.0659	0.3492	0.1569	0.2748	-0.0921	0.1971	-0.1227	0.2271	0.0617
X_5					1.0000	0.1896	0.2860	0.2442	-0.1494	0.0930	-0.1572	0.0007	0.3024	0.1008	-0.0592	0.1623	0.0489	0.2829	-0.1666
X_6						1.0000	0.5926**	0.1515	0.4712*	0.0130	0.5499**	0.6178**	0.8468**	0.7723**	0.6677**	0.8120**	-0.2537	0.1151	0.5011*
X_7							1.0000	0.5016*	0.2741	0.3014	0.2026	0.7233**	0.5425*	0.7392*	0.3698	0.7188**	-0.1678	0.4715*	0.2478
X_8								1.0000	0.0577	0.7388**	-0.3526	0.3223	0.1581	0.2787	0.2388	0.2747	0.7665**	0.8453**	-0.0663
X_9									1.0000	-0.1168	0.8175**	0.3820	0.5225*	0.4601*	0.5895**	0.4762*	-0.1221	-0.1807	0.9793**
X_{10}										1.0000	-0.3492	0.1331	0.0189	0.1024	0.1999	0.1143	0.6209**	0.6995**	-0.1949
X_{11}											1.0000	0.3127	0.5473*	0.4182	0.5011*	0.4325*	-0.5443*	-0.4600*	0.8669**
X_{12}												1.0000	0.4803*	0.9244**	0.5325*	0.7942**	-0.1675	0.2808	0.3961
X_{13}													1.0000	0.6231**	0.6003**	0.7058**	-0.2282	0.0187	0.5133*
X_{14}														1.0000	0.5538**	0.9605**	-0.2239	0.1947	0.4732*
X_{15}															1.0000	0.5375*	0.0091	0.0878	0.5780**
X_{16}																1.0000	-0.2138	0.1468	0.4754*
X_{17}																	1.0000	0.6224**	-0.2399
X_{18}																		1.0000	-0.2119
X_{19}																			1.0000

*,** Significant of 5% and 1 % level, respectively

Table 23. Correlation for "bi" values of various quantitative traits:

Character	Plant height (cm) (X_1)	No. of branches/ plant (X_2)	No. of leaves/ plant (X_3)	No. of peduncls/ plant (X_4)	No. of inflor/p lant (X_5)	Days to initiation of flowering (X_6)	No. of flowers / plant (X_7)	No. of green pods /plant /picking (X_8)	Wt. of green pods /plant/ picking (X_9)	No. of pods /peduncl e (X_{10})	Pod length (cm) (X_{11})	Biologic al yield (g) (X_{12})	Days to complete maturity (X_{13})	Seed yield/ plant (X_{14})	100- seed weight (g) (X_{15})	Harvest index (%) (X_{16})	Yield Realiza tion index (X_{17})	No. of green pods /plant (X_{18})	Weight of green pods /plant (X_{19})
X_1	1.0000	0.0221	-0.0705	0.0402	-0.5485*	-0.3254	-0.2923	-0.2293	-0.1109	-0.2077	0.0537	0.2005	-0.0348	0.1612	-0.1265	-0.1678	-0.1184	-0.2258	-0.1036
X_2		1.0000	-5.2249	-0.0750	-0.3484	-0.0437	-0.1664	-0.1446	-0.0477	-0.0531	-0.0617	-0.5185*	-0.0199	0.0001	0.1836	-0.3076	-0.1095	-0.1017	-0.0294
X_3			1.0000	0.2226	-0.0631	0.3487	0.3039	0.2609	-0.3163	0.2061	-0.1892	0.2332	0.0176	-0.3060	-0.1576	0.3325	0.1339	0.2104	-0.3577
X_4				1.0000	0.1666	0.1073	-0.3169	0.0059	-0.0258	-0.5700**	-0.1849	0.0168	0.2994	0.3385	-0.0722	-0.2131	0.2749	0.0349	-0.0105
X_5					1.0000	0.3882	0.1271	0.1658	0.1630	-0.0901	0.0539	-0.1760	-0.1459	-0.0311	0.0293	0.0515	0.1457	0.1526	0.1655
X_6						1.0000	0.1074	0.0837	-0.2640	0.0028	-0.4716*	-0.0216	0.0098	-0.2774	-0.0617	0.2142	-0.0028	0.0636	-0.2853
X_7							1.0000	0.7079**	0.2077	0.7615**	0.1669	0.3069	-0.6261**	-0.7294**	-0.3787	0.7159**	0.2666	0.6684**	0.1590
X_8								1.0000	0.4118	0.6857**	0.2426	0.2002	-0.3311	-0.5071*	-0.5836**	0.4982*	0.8575**	0.9937**	0.3903
X_9									1.0000	0.1834	0.3975	-0.0387	-0.2597	-0.2844	-0.3574	0.2316	0.4435*	0.3961	0.9954**
X_{10}										1.0000	0.1080	0.2173	-0.4167	-0.5958**	-0.4038	0.5237*	0.3538	0.6521**	0.1535
X_{11}											1.0000	-0.0362	0.0398	-0.0675	-0.3718	0.0909	0.2731	0.2403	0.3852
X_{12}												1.0000	-0.0788	-0.2410	-0.3578	0.6798**	0.1145	0.1629	-0.0652
X_{13}													1.0000	0.4809*	0.2792	-0.3977	0.0313	-0.3015	-0.2562
X_{14}														1.0000	0.2453	-0.8449**	-0.1925	-0.4605*	-0.2237
X_{15}															1.0000	-0.3706	-0.5274*	-0.5733**	-0.3501
X_{16}																1.0000	0.2247	0.4451*	0.1775
X_{17}																	1.0000	0.8799**	0.4468*
X_{18}																		1.0000	0.3813
X_{19}																			1.0000

*,** Significant of 5% and 1 % level, respectively.

Table 24. Correlation for "S^2di" values of various quantitative trait.

Chara -cters	Plant height (cm) (X_1)	No. of branches/ plant (X_2)	No. of compound leaves / plant (X_3)	No. of peduncles/ plant (X_4)	No. of inflorescence /plant (X_5)	Days to initiation of flowering (X_6)	No. of flowers/ plant (X_7)	No. of green pods /plant /picking (X_8)	Wt. of green pods /plant/ picking (X_9)	No. of pods /peduncle (X_{19})	Pod length (cm) (X_{11})	Biological yield(g) (X_{12})	Days to complete maturity (X_{13})	Seed yield/ plant (g) (X_{14})	100-seed weight (g) (X_{15})	Harvest index (%) (X_{16})	Yield Realization index (%) (X_{17})	No. of green pods /plant (X_{18})	Weight of green pods /plant (X_{19})
X_1	1.0000	0.1186	-0.2892	-0.1966	-0.1476	-0.1267	0.1643	-0.1539	-0.0122	-0.1320	0.0621	0.3773	-0.1913	0.3664	-0.2551	-0.0650	-0.0874	-0.1666	-0.0096
X_2		1.0000	0.1682	0.5305*	-0.2072	-0.1502	-0.0714	-0.1299	-0.2280	-0.1520	-0.1836	0.1594	0.0699	-0.0648	-0.3149	-0.1973	-0.1195	-0.1412	-0.2216
X_3			1.0000	0.1914	-0.0086	-0.0449	0.1581	-0.1519	-0.1805	0.0013	-0.3485	-0.1392	0.1195	-0.0736	-0.1798	0.0175	-0.2204	-0.1389	-0.1819
X_4				1.0000	-0.0898	0.3968	0.0034	0.3548	-0.1720	0.0271	0.3970	0.1507	0.2709	-0.1560	-0.2447	-0.1134	0.2247	0.3588	-0.1786
X_5					1.0000	-0.0563	0.1597	0.1429	-0.2257	-0.0867	-0.0278	-0.3052	-0.2327	0.1669	-0.1234	0.2683	0.3641	0.1560	-0.2167
X_6						1.0000	0.0595	0.1933	0.0143	0.3535	0.3719	0.1153	0.1280	0.0344	0.1425	-0.0169	-0.2022	0.2402	0.0145
X_7							1.0000	0.1716	-0.3036	0.1134	-0.2470	0.0794	-0.0629	-0.0745	-0.0205	-0.1016	0.1882	0.2007	-0.3059
X_8								1.0000	-0.1162	0.3230	0.6720**	-0.1224	-0.1048	-0.1364	-0.0344	-0.0986	0.8257**	0.9971**	-0.1225
X_9									1.0000	0.4513*	0.2334	0.2182	-0.0572	-0.0529	0.5769**	-0.0303	-0.1507	-0.1041	0.9988**
X_{10}										1.0000	0.2394	0.1692	-0.1268	-0.0128	0.7615**	-0.0840	0.0202	0.3691	0.4662*
X_{11}											1.0000	-0.0524	-0.0476	-0.1053	-0.0069	-0.1351	0.5438*	0.6638**	0.2241
X_{12}												1.0000	0.2792	0.2238	0.2417	0.0790	-0.1136	-0.1187	0.2167
X_{13}													1.0000	-0.2150	-0.0831	-0.0908	-0.0689	-0.1077	-0.0596
X_{14}														1.0000	-0.0149	0.8355**	-0.1962	-0.1254	-0.0420
X_{15}															1.0000	-0.0144	-0.1058	0.0015	0.5842**
X_{16}																1.0000	-0.1299	-0.0889	-0.0254
X_{17}																	1.0000	0.8017**	-0.1641
X_{18}																		1.0000	-0.1094
X_{19}																			1.0000

*,** Significant of 5% and 1 % level, respectively.

CHAPTER V

DISCUSSION

The general agreement among the breeders that, interaction of genotypes with environments has an important bearing on the breeding of better varieties. The choice of breeding programme is depend upon genotypes with their environmental interaction.

Genotype-environment interactions are of major consequence to the breeder in the process of evolution of improved varieties. Genotype-environment interaction is present whether varieties are pure lines, single crosses, double-crosses, top crosses, S_1 lines or any other material with which breeder is working. Stratification of the environment has been recommended to reduce the genotype-environment interaction.

The breeder has two objectives during crop improvement

1. To develop breeding material performing well in a particular environmental or locational situation with compromising significantly with its yield potential.
2. To develop breeding material with high yielding potential with the stable performance over seasons/locations/years.

To meet the requirement, it is imperative to use the extent of linear and non-linear component to select genotypes for desired performance. In crop like cowpea, it is more significant to select the parents critically for a particular object like developing a cultivar, which can be grown as 'all season genotype' in Konkan region because of seasonal variation, high rainfall during *kharif* and moisture scarcity. Following discussion on the stability parameter in cowpea is focused around above referred breeding strategy. Therefore, with a view to study the mean performance, the Genotype × Environment interaction and correlation among stability parameters, the studies were undertaken with genotype from wide geographical locations and genotypes collected from All India

Coordinated Project were tested over locations for higher yield performance. All these studied genotypes were vegetable types, tested along with Konkan Sadabahar, though released for seed yield, it has tender pods preferred for vegetable purpose under three different environments.

5.1 Nature and Extent of (G×E)

The mean sum of squares due to treatment was found to be significant for all nineteen characters. Therefore, stability studies were worked out for nineteen characters.

The performance of cultivars across different environments, which includes location and years are prerequisite to the breeders in two ways *viz.,* before selecting the parents to be included in evolving superior genotypes performing better under particular location with a specific purpose. Here location specifies the predictable performance of genotypes due to soil type, plant population interaction and various agronomic practices *viz.,* row spacing, planting dates and the rate of nutrient application. The response of genotype as a parent or the crossed material (hybrid) varies unpredictably during the interaction with factors those fluctuate consistently *viz.,* rainfall, temperature and relative humidity.

The variable productivity levels among environments in response of the genotypes provides the performance of genotype in response to stability over environments. The stability of fluctuations can be measured by undertaking the environmental stability of genotypes.

Therefore, there is no or minimal interaction between genotypes and environments, when the relative performance of genotypes remains relatively constant across environments.

When the mean square for pooled deviation is significant but mean square for genotype × environment (linear) is non-significant,

Table 25.Stability attributes of cowpea genotypes for 19 characters.

Sr. No.	Characters	Absence of G × E interaction	Presence of G × E interaction		
		'bi' non significant and 'S²di' non significant	'bi' significant and 'S²di' non significant	Both 'bi' and 'S²di' significant	'S²di' significant and'bi' non significant
1	2	3	4	5	6
1.	Plant height (cm)	BCS-1, IIHR-Sel-11, IIHR-Sel-16, Pusa Dofasali, KLS-30, Ajeet-11, BCP-3, Sel. 263	Arka Garima, RCV-326,IVRCP-1, RCV-395, Konkan Safed, Pusa Komal, VS-15, Arka Samruddhi, RCV-7CHCP-2, IVRCP-2, CHCP-1, Konkan Sadabahar	Nil	Nil
2.	Number of branches /plant	BCS-1, Arka Garima, RCV-326, IVRCP-1, IIHR-Sel-16, VS-15, Arka Samruddhi, KLS-30, BCP-3, CHCP-2, Konkan Sadabahar	RCV-395, IIHR-Sel-11, Pusa Dofasali, Ajeet-11, RCV-7, Sel. 263, IVRCP-2, CHCP-1	Pusa Komal	Konkan Safed
3.	Number of compound leaves / plant	Arka Samruddhi, RCV-7	BCS-1, Arka Garima, RCV-326, IVRCP-1, RCV-395, IIHR-Sel-16, Pusa Komal, Pusa Dofasali, VS-15, KLS-30, Ajeet-11,BCP-3, CHCP-2, Sel. 263, IVRCP-2, Sel. 263 ,CHCP-1,Konkan Sadabahar.	IIHR-Sel-11, Konkan Safed	Nil
4.	Number of peduncles /plant	BCS-1, Arka Garima, RCV-326, Pusa Komal, VS-15, Arka Samruddhi, RCV-7, IVRCP-2, Konkan Sadabahar	IVRCP-1, RCV-395, IIHR-Sel-11, IIHR-Sel-16, Pusa Dofasali, KLS-30, Ajeet-11, BCP-3, CHCP-2, Sel. 263, CHCP-1.	Nil	Konkan Safed

1	2	3	4	5	6
5.	Number of inflorescence/ plant	Konkan Safed, Pusa Komal, CHCP-2, IVRCP-2.	BCS-1, Arka Garima, RCV-326, IVRCP-1, IIHR-Sel-11, IIHR-Sel-16, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11, BCP-3, RCV-7, Sel. 263, CHCP-1, Konkan Sadabahar	Nil	Nil
6.	Days to initiation of flowering	Nil	BCS-1, Arka Garima, RCV-326, IVRCP-1, RCV-395, IIHR-Sel-11, IIHR-Sel-16, Konkan Safed, Pusa Komal, Pusa Dofasali, KLS-30, Ajeet-11, BCP-3, CHCP-2 RCV-7, Sel. 263, IVRCP-2, CHCP-1, Konkan Sadabahar	VS-15, Arka Samruddhi	Nil
7.	Number of flowers /plant	IVRCP-1, Pusa Dofasali, KLS-30, BCP-3, CHCP-2, RCV-7, Sel. 263, CHCP-1, IVRCP-2, Konkan Sadabahar	BCS-1, Arka Garima, RCV-326, RCV-395, IIHR-Sel-11, IIHR-Sel-16, Konkan Safed, Pusa Komal, VS-15, Ajeet-11	Nil	Arka Samruddhi
8.	Number of green pods /plant/picking	RCV-7, Sel. 263, Konkan Sadabahar	BCS-1, RCV-326, IVRCP-1, RCV-395, IIHR-Sel-11, IIHR-Sel-16, Konkan Safed, Pusa Komal, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11, CHCP-2, IVRCP-2, CHCP-1, BCP-3.	Arka Garima	Nil
9.	Weight of green/pods	Arka Garima, IVRCP-1, IIHR-Sel-11, IIHR-Sel-16, Pusa Komal, BCP-3,	BCS-1, RCV-326, RCV-395, IIHR-Sel-11, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11, Konkan	Nil	RCV-7, IVRCP-1

	/plant/picking	CHCP-2, Sel. 263, CHCP-1	Sadabahar		
10.	Number of pods/peduncle	IIHR-Sel-16, VS-15, KLS-30, Ajeet-11,BCP-3, CHCP-2, Sel. 263, CHCP-1	BCS-1, RCV-326, IVRCP-1, RCV-395, Konkan Safed, Pusa Komal, Konkan Sadabahar, IIHR-Sel-11.	Nil	Arka Garima, Pusa Dofasali, Arka Samruddhi, RCV-7, IVRCP-2
11.	Pod length (cm)	IIHR-Sel-16, KLS-30	BCS-1, Arka Garima, RCV-326, IVRCP-1, RCV-395, IIHR-Sel-11, Konkan Safed, Pusa Komal, Pusa Dofasali, VS-15, Arka Samruddhi, Ajeet-11, BCP-3, CHCP-2, RCV-7, Sel. 263, IVRCP-2, CHCP-1, Konkan Sadabahar	Nil	Nil
12.	Biological yield (g)	Nil	BCS-1, Arka Garima, RCV-326, IVRCP-1, RCV-395, IIHR-Sel-11, IIHR-Sel-16, Konkan Safed, Pusa Komal, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11, BCP-3, CHCP-2, RCV-7, Sel. 263, IVRCP-2, CHCP-1, Konkan Sadabahar.	Nil	Nil
13.	Days to complete maturity	IIHR-Sel-16, Konkan Sadabahar, RCV-7.	BCS-1, Arka Garima, RCV-395, Pusa Komal, Pusa Dofasali, Arka Samruddhi, KLS-30, Ajeet-11, BCP-3,	Sel. 263	RCV-326, IVRCP-1, IIHR-Sel-11,

			CHCP-2, IVRCP-2, CHCP-1		Konkan Safed,VS-15
1	**2**	**3**	**4**	**5**	**6**
14.	Seed yield /plant (g)	BCS-1, Arka Garima, RCV-326, IVRCP-1, RCV-395, IIHR-Sel-11, IIHR-Sel-16, Konkan Safed, Pusa Komal, Pusa Dofasali,VS-15, Arka Samruddhi,BCP-3, Sel. 263	KLS-30, RCV-7, IVRCP-2, CHCP-1, Konkan Sadabahar	Nil	Ajeet-11, CHCP-2
15.	100- Seed weight (g)	BCS-1, Arka Garima, RCV-326, RCV-7 IVRCP-1, RCV-395, IIHR-Sel-11, Konkan Safed, Pusa Komal, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11, BCP-3, CHCP-2,	IIHR-Sel-16, Sel. 263, CHCP-1, Konkan Sadabahar	Nil	IVRCP-2
17.	Yield realization index (%)	IVRCP-1, RCV-395, IIHR-Sel-16, Konkan Safed, BCP-3, CHCP-2, RCV-7, Sel. 263, CHCP-1, Konkan Sadabahar	BCS-1, RCV-326, IIHR-Sel-11, Pusa Komal, VS-15, Pusa Dofasali, Arka Samruddhi, KLS-30, Ajeet-11, IVRCP-2	Nil	Arka Garima
18.	Number of green pods/plant	RCV-7, Sel. 263, Konkan Sadabahar	BCS-1, RCV-326, IVRCP-1, RCV-395, IIHR-Sel-11, IIHR-Sel-16, Konkan Safed, Pusa Komal, Pusa Dofasali,VS-15, Pusa Dofasali,KLS-30, Ajeet-11,BCP-3, CHCP-2, IVRCP-2, CHCP-1	Arka Garima	Nil

19.	Weight of green pods/plant (g)	Arka Garima, IVRCP-1, Konkan Safed, IIHR-Sel-16, Pusa Komal, BCP-3, CHCP-2, Sel. 263, CHCP-1	BCS-1, RCV-326, RCV-395, IIHR-Sel-11, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11, Konkan Sadabahar	Nil	RCV-7, IVRCP-2

variation in the performance of genotypes is entirely unpredictable. On the other hand, significance of mean square for genotypes × environments (linear) is also significant, implies that part of variability is predictable in nature for the characters, *viz.,* number of branches per plant, days to initiation of flowering, number of compound leaves per plant, number of flowers per plant, number of green pods per plant per picking, weight of green pods per plant per picking, number of pods per peduncle, days to complete maturity, number of green pods per plant and weight of green pods per plant (g).

The experimental results are being discussed below

Pooled ANOVA for various traits (Table 3a to 21b) showed that mean character differences between genotypes for different characters were highly significant. This revealed the presence of genetic variability among genotypes included in the present investigation. Highly significant mean squares due to E +(G × E) were observed for characters *viz*., plant height, number of compound leaves per plant, number of peduncles per plant, number of inflorescence per plant, days to initiation of flowering, number of flowers per plant, number of green pods per plant per picking, weight of green pods per plant per picking (g), pod length (cm), biological yield (g), days to complete maturity, harvest index (%), yield realization index (%), number of green pods per plant and weight of green pods per plant (g) revealed that genotypes interacted considerably with environmental conditions prevailing during various seasons. A short portion of interaction was attributable to linear component in respect of all the characters *viz.,* plant height, number of branches per plant, number of compound leaves per plant, number of peduncles per plant, number of inflorescence per plant, days to initiation of flowering, number of flowers per plant, number of green pods per plant per picking, weight of green pods per plant per picking (g), pod length (cm), biological yield (g), days to complete maturity, seed yield per plant (g), harvest index (%), yield realization index (%), number of green pods per plant and weight of green pods per plant (g). The significant pooled deviation were observed for certain characters except plant height (cm), number of peduncles per plant, number of inflorescence per plant, pod length (cm), biological yield (g), seed yield per plant (g), 100-seed weight (g), harvest index (%) and yield realization index (%).

In general, considering mean performance of genotype in individual environment, it is observed that in *rabi* (E_3) environment most of characters showed high mean performance than (E_2) *late kharif* and (E_1) *summer* environment.

The examination of magnitude of "b'' and "S^2di" for individual genotypes also revealed that significant "bi" values of most of the traits contributed to substantial portion of linear component of interaction.

5.2 Stability for different characters

The seed yield as well as green pod yield being the most complex and polygenic characters, they respond very differently in various climatic factors. Therefore, the feasibility and elasticity of genotypes in response to environments as a whole needs to be studied and quantity in light of existing biometrical, analytical procedures. Such analysis with correlation, regression and genetic variation due to environmental factors can assess the response of genotypes with environment.

Linear "bi" and non-linear "S^2di" are the two stability parameters of individual genotypes, which is the base for classification of genotypes as per Table 25.

5.2.1 Plant height (cm)

Height in an important character needs to be studied critically in various environments as different environmental factors significantly affect this character (Birari *et al.* 1993, Sultana *et al.* 2001, Singh *et al.* 2003). In the present studies, the genotypes BCS-I, IIHR Sel. 11, IIHR Sel. 16, Pusa Dofasali, KLS-30, Ajeet-11, BCP-3 and Sel. 263 showed absence of (G×E) interaction. The linear component was significant in thirteen genotypes *viz.,* Arka Garima, RCV-326, IVRCP-1, RCV-395, Konkan Safed, Pusa Komal, VS-15, Arka Samruddhi, CHCP-2, RCV-7, IVRCP-2, CHCP-1 and Konkan Sadabahar. The S^2di values were not significant in all the genotypes (Table 25).

The higher significant 'bi' value observed in a Arka Garima, RCV-326, IVRCP-1, RCV-395, Konkan Safed, Pusa Komal, VS-15, Arka Samruddhi, CHCP-2, RCV-7, IVRCP-2 and Konkan Sadabahar indicating better plant height during favourable environment (E_3) whereas CHCP-1 has better plant height in E_2 environmental condition. Table 3(a). The non-linear component (S^2di) was non-significant in all the genotypes for plant height showed that the character in least affected by the environmental fluctuation. The genotypes RCV-326, IVRCP-1 and RCV-395 showed the values of 'bi' near unity indicating stable genotypes for plant height. The genotypes VS-15, CHCP-2, IVRCP-2 and CHCP-1 had high magnitude of 'bi' values suggesting the excellent performance in favourable environments (E_3). These results are in confirmation with those reported by Birari *et al*. (1993) that out of 7 genotypes of cowpea four genotypes was significant for 'bi' and 3 for 'S^2di' value for plant height. Sultana *et al*. (2001) estimated that out of 25 genotypes of green gram, 6 genotypes showed significant 'bi' value and three showed significant 'S^2di' value.

5.2.2 Number of branches per plant

Branches per plant have direct bearing on yield. The genotypes BCS-1, Arka Garima, RCV-326, IVRCP-1, IIHR Sel. 16, VS-15, Arka Samruddhi, KLS-30, BCP-3, CHCP-2 and Konkan Sadabahar exhibited absence of (G×E) interactions for number of branches per plant. (Table 25). The linear component (bi) was significant in RCV-395, IIHR Sel. 11, Pusa Dofasali, Ajeet-11, RCV-7, Sel. 263, IVRCP-2 and CHCP-1. The genotype Pusa Komal showed high (G ×E) interaction due to linear and non-linear components. The genotype Konkan Safed had significant 'S^2di' value.

The higher significant 'bi' value observed in RCV-395, IIHR Sel. 11, Pusa Komal, Pusa Dofasali, Ajeet-11, RCV-7, Sel. 263, IVRCP-2 and CHCP-1 indicating better number of branches per plant during favourable environments (E_3) is given in Table 4 (a). The non-linear component was non-significant in the genotypes except Konkan Safed and Pusa Komal. The none of the genotype was observed nearer to unity. The genotypes RCV-395, IIHR Sel. 11, Pusa Komal, Pusa Dofasali, Ajeet-11, CHCP-2, RCV-7, Sel. 263, IVRCP-2 and CHCP-1 showed higher 'bi' value than unity indicating good performance in favourable environment (E_3). The genotypes BCS-1 and VS-15 had lower linear component with non-significant non-linear component suggesting the better performance in poor environment (E_1) for this character. The 'S^2di' values were non-significant for genotypes except Konkan Safed and Pusa Komal indicating the little influence of the environment in expression of this character. This indicated that the character number of branches per plant do not vary much in different environment under study. Some findings of Sultana *et al.* (2001) estimated that out of 25 genotypes of green gram, 9 genotypes showed significant 'bi' value and only one genotype significant for 'S^2di' value for character number of branches per plant.

5.2.3 Number of compound leaves per plant

Leaf is the photosynthetic apparatus responsible for production of carbohydrates, which acts as energy for different plant processes. The genotypes *viz.*, Arka Samruddhi and RCV-7 exhibited absence of (G×E) interaction for number of compound leaves per plant (Table 25). The linear component 'bi' was significant in BCS-1, Arka Garima, RCV-326, IVRCP-1, RCV-395, IIHR Sel. 16, Pusa Komal, Pusa Dofasali, VS-15, KLS-30, Ajeet-11, BCP-3, CHCP-2, Sel. 263, IVRCP-2, CHCP-1 and Konkan Sadabahar genotypes. The genotypes *viz*., IIHR Sel. 11 and Konkan Safed showed high (G×E) interaction due to linear and non-linear components. The non-linear component (S^2di) was non-significant.

The results are depicted in Table 5 (a) showed that the genotype showed highly significant 'bi' value except Arka Samruddhi and RCV-7. The non-linear component was non-significant in the genotype except IIHR Sel. 11 and Konkan Safed for number of compound leaves per plant showed that the character in least affected by environmental fluctuations. The genotypes IIHR Sel. 11, Konkan Safed, Pusa Komal, KLS-30 and CHCP-2 showed the values of 'bi' nearer to unity indicating stable genotypes for number of compound leaves per plant. The genotypes Arka Garima, IVRCP-1 and Sel. 263 had high magnitude of significant 'bi' value suggesting the excellent performance in favourable environment (E_3). Similar results in cowpea was reported by Shikalgar (1996) that out of 12 genotypes of lablab bean only 3 genotypes showed significant results for non-linear component (S^2di) and remaining are non-significant for bi and (S^2di).

5.2.4 Number of peduncles per plant

Number of peduncles is one of the important yield contributing characters in cowpea, as it bears pods. The genotypes *viz.,* BCS-1, Arka Garima, RCV-326, Pusa Komal, VS-15, Arka Samruddhi, RCV-7, IVRCP-2 and Konkan Sadabahar had absence of (G × E) interaction for number of peduncles per plant. The linear component 'bi' was significant in genotypes *viz*., IVRCP-1, RCV-395, IIHR Sel. 11, IIHR Sel. 16, Pusa Dofasali, KLS-30, Ajeet-11, BCP-3, CHCP-2, Sel. 263 and CHCP-1. The Konkan Safed genotype showed significant value of non-linear component (S^2di).

The results on character number of peduncles per plant depicted in Table 6 (a) that the only genotype Konkan Safed showed non-significant 'bi' value but significant non-linear component. This indicated that number of peduncles per plant for Konkan Safed showed high degree of response in different environments. The genotypes Arka Garima, Arka Samruddhi and CHCP-1 indicating 'bi' value nearer to one and 'S^2di' value nearer zero, therefore these genotypes are most stable genotypes for this character. Remaining characters showed flexibility under different environmental conditions under study. This result was in confirmatory with that of Borale (1996). He studied 16 genotypes of cowpea and only 5 genotypes showed significant value for linear (bi) and non-linear (S^2di) components.

5.2.5 Number of inflorescence per plant

The character inflorescence per plant has proved its central importance in selecting for yield. The genotypes BCS-1, Arka Garima, RCV-326, IIHR Sel. 11, IVRCP-1, RCV-395, IIHR Sel. 16, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11, BCP-3, RCV-7, Sel. 263, CHCP-1 and Konkan Sadabahar were significant 'bi' values for number of inflorescence per plant. The genotypes *viz*., Konkan Safed, Pusa Komal, CHCP-2 and IVRCP-2 exhibited absence of (G×E) interaction. The S^2di values were not significant in all the genotypes (Table 25).

The high significant 'bi' values observed for the genotypes under study except Konkan Safed, Pusa Komal, IVRCP-2 and CHCP-2 indicating higher number of inflorescence per plant during favourable environment (E_3). The non-linear component was non-significant in all the genotypes showed that the character is least affected by the environmental fluctuations. The genotype IIHR Sel. 11 showed 'bi' value near unity indicating stable genotypes for this character. The remaining genotypes indicating this character is very much flexible under different environments under study. Similar trend was also observed by Shikalgar (1996) that all 12 genotypes of lablab bean showed significant ‘bi’ value except one Konkan Bhushan and only four-showed significant non-linear component.

5.2.6 Days to initiation of flowering

Days to first flowering initiation is the physiologically important plant character which in responsible for holding the proposed sink due to its early emergence in the younger age of the plant, where the physiological activities always exist at zenith of its performance.

The information on types of stability attributes is presented in Table 25 for this character. During the present studies, all genotypes were free from absence of (G×E) interaction. The linear component was significant in BCS-1, Arka Garima, RCV-326, IVRCP-1, RCV-395, IIHR Sel. 11, IIHR Sel. 16, Konkan Safed, Pusa Komal, Pusa Dofasali, KLS-30, Ajeet-11, BCP-3, CHCP-2, RCV-7, Sel. 263, IVRCP-2, CHCP-1 and Konkan Sadabahar genotypes. The VS-15 and Arka Samruddhi showed significant linear and non-linear components for this character (Table 25). The non-linear component was not significant in all the genotypes.

The higher significant 'bi' values observed for all the characters studied indicating better performance for this character during favourable environment. The non-linear component was non-significant in all the genotypes except VS-15 and Arka Samruddhi for the character days to initiation of flowering showed that the character is least affected by the environmental fluctuation. The genotypes RCV-326, IVRCP-1, RCV-395, IIHR Sel. 11, IIHR Sel. 16, Konkan Safed, Pusa Komal, Ajeet-11 and BCP-3 showed their 'bi' value near unity indicating stable genotypes for this character. The genotypes Arka Garima, Arka Samruddhi and KLS-30 can be selected as potential parents for developing the genotypes suitable for desirable environment as shown by their ‘bi’ value higher than unity. The genotypes BCS-1, VS-15, IVRCP-2 and CHCP-1 can be the better parents, as their ‘bi’ values were lesser than unity with non-significant non-linear component. Such genotypes could perform well in undesirable environments. These results are in confirmation with those reported by Birari *et al*. (1993) that all 7 genotypes showed significant “bi” values and ‘S^2di’ value except one genotype ACCC 216.

5.2.7 Number of flowers per plant

The sensitivity of this character to various environments is often related to the yield fluctuation of different genotypes in various environmental conditions. The genotypes *viz*., IVRCP-1, Pusa Dofasali, KLS-30, BCP-3, CHCP-2, RCV-7, Sel. 263, CHCP-1, IVRCP-2 and Konkan Sadabahar had absence of (G × E) interaction. The BCS-1, Arka Garima, RCV-326, RCV-395, IIHR Sel. 11, IIHR Sel. 16, Konkan Safed, Pusa Komal, VS-15 and Ajeet-11 were significant 'bi' values. The Arka Samruddhi genotype showed significant value of non-linear component (Table 25).

The genotypes BCS-1, Arka Garima, RCV-326, RCV-395, IIHR Sel. 11, IIHR Sel. 16, Konkan Safed, Pusa Komal, VS-15 and Ajeet-11 showed higher 'bi' value than unity indicating good performance in favourable environment (E_3). The genotypes KLS-30, Ajeet-11, BCP-3, CHCP-2, RCV-7, Sel. 263, CHCP-1 and Konkan Sadabahar had lower linear component with non-significant non-linear component suggesting the better performance in poor environment *viz.,* (E_1) and (E_2) for this character. The 'S^2di' values were non-significant for the genotypes except Arka Samruddhi indicating little influence of the environment in expression of this character. This indicated that the character number of flowers per plant do not vary much in different environment under study. Similar results in cowpea were reported by Shikalgar (1996) that 12 genotypes of lablab bean had significant S^2di value and non-significant ‘bi’ values for all genotypes.

5.2.8 Number of green pods per plant per picking

The number of green pods per plant per picking is important character, which ultimately determine yield of plant in vegetable type of cowpeas.

The genotypes RCV-7, Sel. 263 and Konkan Sadabahar had absence of G×E interaction. The seventeen genotypes showed significant 'bi' values *viz*., BCS-1, RCV-326, IVRCP-1, RCV-395, IIHR Sel. 11, IIHR Sel. 16, Konkan Safed, Pusa Komal, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11, BCP-3, CHCP-2, IVRCP-2 and CHCP-1 genotypes. The genotype Arka Garima showed significant linear and non-linear component. The non-linear component was not significant in all the genotypes. (Table 25).

The 'bi' values were significant and 'S^2di' values were non-significant for this character in genotypes except Arka Garima, RCV-7, IVRCP-2 and Konkan Sadabahar indicative of their major portion of (G × E) interaction. The genotype Arka Garima had significant 'bi' and S^2di values and 'bi' value much higher than unity indicating better performance of this genotype in favourable and poor environment for this character. The genotype RCV-7, Sel. 263 and Konkan Sadabahar had non-significant 'bi' value, which are lesser than unity suggesting that these genotypes will performs well in poor environment for the number of green pods per plant per picking. Similar trend was also observed by Kulkarni (1999) that all eight genotypes of asparagus bean for green pod yield showed significant ‘bi’ value and ‘S^2di’ value.

5.2.9 Weight of green pods per plant per picking

Weight of green pods per picking gives idea of the productivity of the plant for commercial application. The nine genotypes had absence of (G×E) interaction *viz.,* Arka Garima, IVRCP-1, IIHR Sel. 11, IIHR Sel. 16, Pusa Komal, BCP-3, CHCP-2, Sel. 263 and CHCP-1. The linear component significant in BCS-1, RCV-326, RCV-395, IIHR Sel. 11, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11 and Konkan Sadabahar genotypes. The non-linear component (S^2di) was non-significant (Table 25).

The 'bi' value nearer to unity was observed in a genotype RCV-326 indicating the overall stable performance in all environments under study. The genotypes BCS-1, RCV-395, IIHR Sel. 11 and KLS-30 showed higher 'bi' value than unity indicating good performance in favourable environments (E_3). The genotypes Arka Garima, IIHR Sel. 16, Konkan Safed, BCP-3, CHCP-2, Sel. 263 and Konkan Sadabahar had lower linear component with non-significant non-linear component suggesting the better performance in poor environment for this character.

The S^2di values were non-significant for genotypes except RCV-7 and IVRCP-2 indicating little influence of the environment in expression of this character. This indicated that the character weight of green pods per plant per picking do not vary much in different environments under study.

5.2.10 Number of pods per peduncle

The peduncles in quantitative character and yield of cowpea is also depend upon peduncle. The genotypes *viz.,* IIHR Sel.16, VS-15, KLS-30, Ajeet-11 BCP-3, CHCP-2, Sel. 263 and CHCP-1 were absence of (G×E) interaction. The genotypes *viz.,* BCS-1, RCV-326, IVRCP-1, RCV-395, Konkan Safed, Pusa Komal, Konkan Sadabahar and IIHR Sel. 11 had significant linear component. The five genotypes had significant "S^2di" values *viz.,* Arka Garima, Pusa Dofasali, Arka Samruddhi, RCV-7 and IVRCP-2 (Table 25).

The 'bi' values were significant and S^2di values were non-significant for the character number of pods per peduncle in genotypes BCS-1, RCV-326, IVRCP-1, RCV-395, IIHR Sel. 11, Konkan Safed, Pusa Komal and Konkan Sadabahar indicative of their major portion of (G×E) interaction Table 12 (a). The remaining genotypes had non-significant 'bi' values, which are not nearer to unity suggesting the non-stable performance of these genotypes over environments for this character. The genotypes RCV-7 and Konkan Sadabahar indicating lesser 'bi' value than unity indicating the genotypes may perform well under poor environmental conditions.

5.2.11 Pod length (cm)

Pod length is an accommodative vessel which reveals the space for the number of grains and its growth is a constrained area though it does not indicate relationship with the grains per pod or the size of the grains which had direct bearing on yield. The two genotypes *viz.,* IIHR Sel. 16 and KLS-30 showed absence of (G×E) interaction. The all genotypes showed significant "bi" values except *viz.,* IIHR Sel. 16 and KLS-30. The non-linear component was non-significant (Table 25).

The 'bi' values were highly significant in all genotypes except IIHR Sel. 16 indicating major portion of (G×E) interaction due to the linear environmental changes for this character Table 13 (a) and their predictable performance only under favourable environments. The non-linear components were non-significant which indicate that, the minimal environmental effects on the expression of this character facilitating the prediction of performance of these genotypes. The genotypes RCV-326, Pusa Komal, Arka Garima and BCP-3 were most stable for this character. The genotypes BCS-1, RCV-395, IIHR Sel. 11, VS-15 and IVRCP-2 can perform better in desirable environment as shown by their 'bi' value higher than the unity. Some findings of Kandasamy *et al*. (1985) that only one genotype of cowpea showed significant 'S^2di' value and remaining had non-significant 'bi' and 'S^2di value out of 10 genotypes. Also Dhakulkar (2003) reported all 8 genotype had significant 'bi' values and non-significant 'S^2di' value.

5.2.12 Biological yield (g)

Biological yield is a physiological important attribute and its partitioning is significant for the breeders in improvement of the crop for plant architecture. All genotypes showed the presence of (G×E) interaction on account of highly significant linear components for biological yield per plant (Table 25). All genotypes showed significant "bi" values and non-significant "S^2di" values (Table 25).

The 'bi' values were highly significant in all genotypes indicating major portion of (G×E) interaction due to the linear environmental changes for this character Table 14 (a) and their predictable performance only under favourable environments. The non-linear components were non-significant for all the genotypes studied indicated that, the minimal environmental effect on the expression of the character facilitating the prediction of performance of these genotypes. The genotypes RCV-395, Arka Samruddhi and KLS-30 were stable genotypes for this character. The genotype Konkan Safed and VS-15 can perform better in desirable environment (E_3) as their 'bi' values higher than the unity. The genotypes CHCP-1 and Konkan Sadabahar perform well in poor environmental conditions (E_1). These results are in confirmation with that of Dhakulkar (2003). He reported that all 8 genotypes of cowpea showed significant linear component and only two genotypes showed significant S^2di value.

5.2.13 Days to complete maturity

The character has with determinate and indeterminate types of plant. The (G×E) interaction was absent in three genotypes *viz.,* IIHR Sel-16, Konkan Sadabahar and RCV-7. The genotypes *viz.,* BCS-1, Arka Garima, RCV-395, Pusa Komal, Pusa Dofasali, Arka Samruddhi, KLS-30, Ajeet-11, BCP-3, CHCP-2, IVRCP-2 and CHCP-1 showed significant "bi" values indicating presence of (G×E) interaction. The genotype Sel. 263 indicated presence of linear and non-linear component. The non-linear component was significant in RCV-326, IVRCP-1, IIHR Sel. 11, Konkan Safed and VS-15 genotypes (Table 25).

The high significant 'bi' value observed in BCS-1, Arka Garima, RCV-395, Pusa Komal, Pusa Dofasali, Arka Samruddhi, KLS-30, Ajeet-11, BCP-3, CHCP-2, Sel. 263, IVRCP-2 and CHCP-1 indicating better days to complete maturity during favourable environment(E_3) Table 15 (a). Non-linear component was non significant in genotype except RCV-326, IVRCP-1, IIHR Sel. 11, Konkan Safed, VS-15 and Sel. 263 for days to complete maturity showed that the character is least affected by the environmental variations. The genotype Konkan Sadabahar showed 'bi' value near to unity and non-linear component near to zero indicating stable genotype for days to complete maturity. The genotypes RCV-326, IVRCP-1, IIHR Sel. 11, IIHR Sel. 16 and RCV-7 showed less magnitude of non-significant linear component Table 15 (a). These genotypes though not very stable over environments, they can resist environmental fluctuations considerably therefore can be ranked as desirable parents in improvement of days to compete maturity. The duration of complete maturity may be regarded as the most sensitive trait for complex (G×E) interaction. Similar trend was also observed by Dhakulkar (2003). He reported that only 3 genotypes showed significant 'S^2di' value and remaining genotypes showed non-significant 'bi' and 'S^2di' values

5.2.14 Seed yield per plant (g)

Yield being the most important character, which is governed, by various yield-contributing characters. The genotypes *viz.,* BCS-1, Arka Garima, RCV-326, IVRCP-1, RCV-395, IIHR Sel. 11, IIHR Sel. 16, Konkan Safed, Pusa Komal, Pusa Dofasali, VS-15, Arka Samruddhi, BCP-3 and Sel. 263 showed absence of G×E interaction. The "bi" values significant for the genotypes *viz.,* KLS-30, RCV-7, IVRCP-2, CHCP-1 and Konkan Sadabahar. The genotypes Ajeet-11 and CHCP-2 showed significant for non-linear component (Table 25).

The genotypes KLS-30 IVRCP-2, CHCP-1 and Konkan Sadabahar had significant 'bi' value above the unity indicative of well performance under favourable environments (E_3). The genotypes *viz.,* IVRCP-1 and Pusa Dofasali showed non-significant 'bi' value less than unity along with non-significant (S^2di) value suggests better performance under poor environment (E_1) for seed yield per plant whereas IIHR Sel. 16 and Konkan Safed in (E_2) environmental conditions. Some findings of Jindal *et al.* (1985), Thiyagarajan and Rajasekaran (1987), Manikannan *et al.* (2002) and Dhakulkar (2003) reported the estimates of stability parameters in various genotypes and environments on similar lines.

5.2.15 100 -Seed weight (g)

The test weight has a direct relevance with yield provided the grain size has positive relationship with test weight (Table 25). The genotypes *viz.,* BCS-1, Arka Garima, RCV-326, IVRCP-1, RCV-395, IIHR Sel. 11, Konkan Safed, Pusa Komal, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11, BCP-3, CHCP-2 and RCV-7 exhibited absence of (G×E) interaction. The linear component was significant for IIHR Sel. 16, Sel. 263, CHCP-1 and Konkan Sadabahar genotypes (Table 25). The genotype IVRCP -2 was significant for non-linear component (S^2di).

The non-linear component were non-significant in the genotypes except IIHR Sel. 11, Sel. 263, CHCP-1 and Konkan Sadabahar for this character indicated that the minimal environmental effects on the expression of this character, facilitating the performance prediction of this genotypes. The genotypes Pusa Komal, Pusa Dofasali and BCP-3 had 'bi' value near the unity and non-linear component near to the zero indicated their stable performance over environments under study. The genotypes IIHR Sel. 16, RCV-7, Sel. 263, Konkan Sadabahar and CHCP-1 can perform well in desirable environment (E_3) due to higher 'bi' value over unity. Similar result in cowpea was reported by Dhakulkar (2003). He studied 8 genotypes of cowpea and estimated that all genotypes showed significant 'bi' value and non-significant 'S^2di' values.

5.2.16 Harvest index (%)

The character harvest index has attracted the attention of the breeders as parameter for developing physiologically efficient genotypes. The genotypes KLS-30, Sel. 263, IVRCP-1, CHCP-1 and Konkan Sadabahar exhibited absence of (G×E) interaction. The fifteen genotypes showed significant 'bi' values *viz.,* BCS-1, Arka Garima, RCV-326, IVRCP-1, RCV-395, Konkan Safed, IIHR Sel. 11, IIHR Sel. 16, Pusa Komal, Pusa Dofasali, VS-15, Arka Samruddhi, BCP-3, CHCP-2 and RCV-7. The non-linear (S^2di) component was significant in Ajeet-11 genotype (Table 25).

The genotypes IVRCP-1, Pusa Dofasali and BCP-3 showed stable performance over environments as indicated by significant 'bi' values near unity. The genotypes BCS-1, Arka Garima, RCV-326, RCV-395, IIHR Sel. 16, Konkan Safed and Arka Samruddhi had high magnitude of significant 'bi' value suggesting the excellent performance in favourable environments. Birari *et al.* (1993) reported that out of seven genotypes of cowpea, five genotypes showed 'bi' value significant and all 'bi' and 'S^2di' values found to be non-significant.

5.2.17 Yield realization index (YRI) (%)

This yield realization index denotes the proportion of the number of flowers produced on the plant to the finally developed pods. The effect of environment can alter either the number of flowers per plant due to change in thermo and photosensitive units which have direct bearing on the development and retention of flowers on plant. Considerable flower drop affect the pods production significantly. Therefore, the physio- genetic efficiency of plant can be assessed by the higher proportion of realization of pods from the total number of flowers borne on the plant.

The genotypes *viz.,* IVRCP-1, RCV-395, IIHR Sel. 16, Konkan Safed, BCP-3, CHCP-2, RCV-7, Sel. 263, CHCP-1 and Konkan Sadabahar showed absence of (G×E) interaction (Table 25). The ten genotypes showed significant 'bi' values *viz.,* BCS-1, RCV-326, IIHR Sel. 11, Pusa Komal, VS-15, Pusa Dofasali, Arka Samruddhi, KLS-30, Ajeet-11 and IVRCP-2. The Arka Garima genotype exhibited significant in non-linear (S^2di) component.

The 'bi' values were highly significant in BCS-1, RCV-326, IIHR Sel. 11, Pusa Komal, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11 and IVRCP-2, this results suggest that the significant values of 'bi' much higher than unity made these genotypes perform well in desirable environments. The genotype IVRCP-2 showed 'bi' value nearer to unity indicating stable genotype under different environments. The genotypes IIHR Sel. 16, Ajeet-11 and RCV-7 showed non-significant 'bi' value much less than unity indicating that these genotypes could perform well under unfavourable environmental conditions. The last type of interaction is significant magnitude of non-linear component with non-significant 'bi' value was observed in Arka Garima, therefore, the yield realization index in this genotype had maximum interaction with environmental and also lacked the stability of the character. The studies indicated that yield realization index is a genetic character and different genotypes have differed in their ability for yield realization index. Some findings of Shikalgar (1996) are six genotypes of lablab bean showed significant 'bi' values and eight genotypes showed significant 'S^2di' values out of twelve genotypes.

5.2.18 Number of green pods per plant

The number of green pods per plant is important character, which ultimately determine yield of plant in vegetable type of cowpeas. The genotypes RCV-7, Sel. 263 and Konkan Sadabahar exhibited absence of (G×E) interaction. All genotypes showed significant 'bi' values except in genotypes *viz.,* Arka Garima, Sel. 263 and Konkan Sadabahar. The 'Arka Garima' showed significant linear and non-linear components for this character (Table 25). The S^2di values were not significant in all the genotypes.

The 'bi' values were significant and (S^2di) values were non-significant for this character in genotypes except Arka Garima, RCV-7, Sel. 263 and Konkan Sadabahar indicative of their major portion of (G×E) interaction. The genotype Arka Garima had significant 'bi' and (S^2di) values and the 'bi' value much higher than the unity indicating better performance of this genotype in favourable environment for this character. The genotypes IIHR Sel. 11, Konkan Safed and IVRCP-2 had significant 'bi' value near unity suggesting the stable performance of these genotypes over environments for number of green pods per plant. Similar trend was also observed by Kulkarni *et al*. (1999) studied eight genotypes of asparagus bean for green pod yield and estimated that all genotypes had significant 'S^2di' value and non-significant 'bi' value.

5.2.19 Weight of green pods per plant (g)

Weight of green pods per plant gives idea of the productivity of the plant for commercial application. The nine genotypes exhibited absence of (G×E) interaction *viz.,* Arka Garima, IVRCP-1, Konkan Safed, IIHR Sel. 16, Pusa Komal, BCP-3, CHCP-2, Sel. 263 and CHCP-1. The linear component (bi) significant in BCS-1, RCV-326, RCV-395, IIHR Sel. 11, Pusa Dofasali, VS-15, Arka Samruddhi, KLS-30, Ajeet-11 and Konkan Sadabahar genotypes. The 'S^2di' significant in RCV-7 and IVRCP-2 genotypes (Table 25).

The genotypes RCV-326 was the stable genotypes as showed by significant 'bi' value near unity Table 21 (a). The genotypes BCS-1, RCV-395, IIHR Sel. 11, VS-15, Arka Samruddhi and CHCP-1 produce relatively more weight of green pods per plant during favourable environments as shown by highly significant 'bi' value deviating positively from unity. The genotype Arka Garima, IIHR Sel. 16, Konkan Safed, BCP-3, CHCP-2 and Konkan Sadabahar showed 'bi' value lesser than unity and non-significant (S^2di) value indicated that these genotypes could perform well during unfavourable environments. The similar results were reported by Pujari (2003) in cowpea.

5.3 Interrelationship between various traits for stability parameter

Yield is a complex character governed by various physiological components, which are under control of the interplay of genetic and environmental factors. The expression of yield could be explained on the basis of compromises and compensations among the developmental pattern of various related characters (Allard and Bradshaw, 1964). The nature and extent of association between mean performance, linear component of interaction and deviation from the expected performance for various characters can reveal the compromises and compensations among yield determining attributes of cowpea could be related through their relationship for various stability parameters (Table 22 -24).

5.3.1 Associationship of yield with different characters

The results of correlation of various quantitative traits are discussed below from Table 22 -24. The weight of green pods per plant showed high relationship with weight of green pods per picking and yield realization index (%) at 'bi' values while it positively and significantly associated with weight of green pods per plant per picking, number of pods per peduncle and 100-seed weight for (S^2di) value. Also it showed positive and significant relationship with mean performance of number of compound leaves per plant, days to initiation of flowering, weight of green pods per plant per picking, pod length, days to complete maturity, seed yield per plant, 100-seed weight and harvest index (%).

The number of green pods per plant also showed its positive, highly significant association with number of green pods per plant per picking, yield realization index for linear component, non-linear component and mean performance, while it associated with plant height (cm), number of flowers per plant, number of pods per peduncle and pod length (cm) for mean performance and for significant 'bi' value with number of flowers per plant, number of pods per peduncle, seed yield per plant, 100-seed weight and harvest index.

The character yield realization index was significantly and positively associated with number of green pods per plant per picking for all the three stability parameters, while, it showed negative association with plant height for mean performance. Yield realization index showed positive significant association with number of pods per peduncle and negative association with pod length for mean performance, weight of green pods per plant per picking (positive and significant) and 100 seed weight (negative and significant) association for ‘bi’ values.

The character 100-seed weight showed its positive and significant association with number of compound leaves per plant, days to initiation of flowering, weight of green pods per plant per picking, pod length, biological yield, days to complete maturity and seed yield per plant for mean performance while it had shown negatively and highly significantly association with number of green pods per plant per picking for ‘bi’ values. 100-seed weight showed positively and significantly association with weight of green pods per picking and number of pods per peduncle for ‘S^2di’ values.

The character harvest index was positively associated with number of compound leaves per plant, days to initiation of flowering, number of flowers per plant, weight of green pods per plant per picking, pod length, biological yield, days to complete maturity, seed yield per plant and 100-seed weight for mean performance. It had shown positive significant association with number of flowers per plant, number of green pods per peduncle and biological yield for ‘bi’ values and showed negative association with seed yield per plant for ‘bi’ value. Harvest index showed positive significant association with seed yield per plant for ‘S^2di’ value.

Seed yield per plant showed positive significant association with days to initiation of flowering, number of flowers per plant, weight of green pods per plant per picking, biological yield and days to complete maturity for mean performance while associated negatively with number of flowers per plant, number of green pods per plant per picking for 'bi' value and associated positively with number of pods per peduncle and days to complete maturity for ‘bi’ value.

The character days to complete maturity was positively associated with number of compound leaves per plat, days to initiation of flowering, number of flowers per plant, weight of green pods per plant per picking, pod length and biological yield for mean performance and showed negatively and significantly association for 'bi' value with number of flowers per plant.

The character biological yield showed positively and significantly association with days to initiation of flowering and number of flowers per plant and negatively and significantly associated with number of branches per plant for 'bi' value.

Pod length showed positive and significantly association with plant height, days to initiation of flowering and weight of green pods per plant per picking while it had shown negative significant association with days to initiation of flowering for 'bi' value. Pod length was found to be positively and highly significantly associated with number of green pods per plant per picking at significant level for 'S^2di' value.

The character number of pods per peduncle revealed strong positively and significantly association with number of green pods per plant per picking and strong negative and highly significantly association with plant height for mean performance. It also showed positive relationship with number of flowers per plant, number of green pods per plant per picking however it showed negative relationship with number of peduncles per plant for 'bi' value. The number of pods per peduncle was found to be positively and significantly associated with weight of green pods per plant per picking for (S^2di) value.

Weight of green pods per plant per picking was positively associated with number of compound leaves per plant, days to initiation of flowering, whereas, number of green pods per plant per picking was negatively and highly significantly associated with plant height for mean performance. It also showed positively and highly significantly association for 'bi' value with number of flowers per plant.

The number of flowers per plant and number of compound leaves per plant were found to be positively associated with days to initiation of flowering for mean performance.

The trait number of inflorescence per plant was found to be positively and significantly associated with number of branches per plant for mean performance and negatively and significantly with plant height for 'bi' value. The number of peduncles per plant was found to be positively associated with number of branches per plant for S^2di.

The varieties *viz*., RCV-326, RCV-7, Arka Samruddhi, BCS-1, RCV-395, VS-15, KLS-30, IVRCP-1, BCP-3 and IVRCP-2 are found to be stable varieties for weight of green pods per plant (g) three environments under study. These varieties can be recommended for commercial cultivation under specific environments or these varieties can be used in crossing programme to develop high yielding stable genotypes in cowpea.

5.4 Promising stable genotypes

The stable genotypes having higher mean performance than the average of all varieties, linear component (bi) is at unity and non-linear component (S^2di) is non-significant i.e. zero. From present investigation, the genotypes, which are suitable for favourable climatic condition and unfavourable climatic conditions, are presented below in Table 26 and 27.

From Table 26 (a) showed that RCV-326 genotype had higher mean performance (77.33 g), linear component at unity (0.9550**) and non-linear component (S^2di) found to be non-significant. Therefore, this genotype could be regarded as stable for all three environments for weight of green pods per plant (g).

The genotypes having lower mean performance than of all varieties, linear component (bi) is near unity and non-linear component (S^2di) is non-significant then the genotype is poorly adapted to all the environments. From Table 26 (b) showed that RCV-7 and Arka Samruddhi genotypes had lower mean performance than all the varieties, linear component (bi) is unity and non-linear component (S^2di) is non-significant. Therefore these two genotypes poorly adapted to all the environments for weight of green pods per plant (g).

The genotypes having higher mean performance than all the varieties, linear component (bi) is greater than one and non-linear component found to be non-significant then these genotypes specifically

Table 26. Promising stable genotypes for weight of green pods per plant (g) in cowpea.

a) Stable genotype

Sr. No.	Stable genotype	High pooled mean + (bi=1) + (S^2di= Non-sig.)		
		High pooled mean	bi	S^2di
1.	RCV-326	77.33 (**5**)	0.9550**	-111.3183

(Figures in the parentheses are ranking of mean)

b) Genotypes poorly desirable for environments

Sr. No.	Genotypes	Lower pooled mean + (bi=1) + (S^2di= N.S.)				
		Pooled mean	bi		S^2di	
			Sig.	Non-sig	Sig.	Non-sig
1.	RCV-7	52.50 (**13**)	-	1.0008	472.98**	-
2.	Arka Samruddhi	36.85 (**20**)	0.8128**	-	-	-93.9832

(Figures in the parentheses are ranking of mean)

c) Genotypes desirable for favourable environments

Sr. No	Desired Genotypes	High pooled mean + (bi >1) + (S^2di = Sig. or Non-sig.)					Environment
		High mean	bi		S^2di		
			Sig.	Non-sig	Sig.	Non-sig	
1.	BCS-1	96.33 (**2**)	3.1957**	_	_	0.1409	E_3 (Rabi)
2.	RCV-395	71.67 (**6**)	2.4684**	_	_	-75.6281	E_3 (Rabi)
3.	VS-15	113.90 (**1**)	1.7648*	_	_	3.7791	E_3 (Rabi)
4.	KLS-30	69.61 (**7**)	1.6939**	_	_	-111.1648	E_3 (Rabi)

(Figures in the parentheses are ranking of mean)

d) Genotypes desirable for unfavourable environments

Sr. No	Desired Genotypes	High pooled mean + (bi <1) + (S^2di = Sig. or Non-sig.)					Environment
		High mean	bi		S^2di		
			Sig.	Non-sig	Sig.	Non-sig	
1.	IVRCP-1	66.00 (**8**)	_	0.7920	_	-58.8967	E_2 (Late kharif)
2.	BCP-3	63.78 (**9**)	_	-0.3961	_	-97.4070	E_1 (Summer)
3.	IVRCP-2	62.61 (**10**)	_	0.8004	247.9469**	_	E_2 (Late kharif)

(Figures in the parentheses are ranking of mean)

desirable to favourable environments. From above Table 26 (c) showed that genotypes BCS-1, RCV-395, VS-15 and KLS-30 had higher mean performance, linear component (bi) greater than one and non-linear component (S^2di) is non-significant therefore genotypes found to be specifically desirable to favourable environments (E_3) i.e. below average stability.

The genotypes with linear component (bi) lesser than unity do not respond favourable to improved environmental conditions and hence could be regarded as specifically desirable to poor environments when their mean performance is more than average of all varieties. From Table 26 (d) showed that IVRCP-1, BCP-3, and IVRCP-2 genotypes desirable for unfavourable environments E_2, E_1 and E_2 respectively.

The genotype whose mean performance in higher than all the varieties, the linear component (bi) is at unity and non-linear component (S^2di) approaching to zero then the genotype is found to be stable for the environment. But no genotype found to be fulfilling the criteria of stable genotype for seed yield per plant (g).

The genotype having lower mean performance than all the varieties, linear component (bi) is unity and non-linear component (S2di) is zero then the genotype is poorly desirable to all the environments. From Table 27 (b) showed that RCV-7 is poorly desirable to all the environments.

The genotypes having high mean performance than all the genotypes, linear component (bi) greater than one and non-linear component found to be non-significant then the genotypes desirable for favourable environments. From table 27 (c) showed that CHCP-1 found to be desirable to favourable environment E_3 (*rabi*).

The genotypes with linear component (bi) lesser than unity do not respond favourably to improved environmental conditions and hence could be regarded as specifically desirable to unfavourable environments when their mean performance is more than average of all the varieties.

Table 27. Promising genotypes for seed yield per plant (g) in cowpea.

b) Genotype poorly desirable for environments

Sr. No	Desired Genotypes	Lower pooled mean + (bi =1) + (S^2di = Sig. or Non-Sig)					Environment
		High mean	bi		S^2di		
			Sig.	Non-sig	Sig.	Non-sig	
1.	RCV-7	12.26 (**15**)	1.0325**	-	-	-0.8718	E_3 (Rabi)

(Figures in the parentheses are ranking of mean)

c) Genotypes desirable for favourable environments

Sr. No.	Desired Genotypes	High pooled mean + (bi >1) + (S^2di = Sig. or Non Sig)					Environment
		High mean	bi		S^2di		
			Sig.	Non-sig	Sig.	Non-sig	
1.	CHCP-1	13.13 (**10**)	3.4153 **	-	-	-0.8773	E_3 (Rabi)

(Figures in the parentheses are ranking of mean)

d) Genotypes desirable for unfavourable environments

Sr. No	Desired Genotypes	High pooled mean + (bi <1) + (S^2di = Sig./N.S.)					Environments
		Pooled mean	bi		S^2di		
			Sig.	Non-sig	Sig.	Non-sig	
1.	BCS-1	13.95 (**4**)	-	-1.7590	-	-0.7543	E_2 (Late kharif)
2.	RCV-326	15.54 (**2**)	-	-0.2926	-	-0.8834	E_1 (Summer)
3.	IIHR Sel-16	13.61 (**6**)	-	0.0101	-	-0.8692	E_2 (Late kharif)
4.	Konkan Safed	14.11 (**3**)	-	-0.1886	-	-0.8792	E_2 (Late kharif)
5.	Arka Samruddhi	13.29 (**8**)	-	-0.8372	-	0.0788	E_1 (Summer)

(Figures in the parentheses are ranking of mean)

From Table 27(d) showed that BCS-1, RCV-326, IIHR Sel. 16, Konkan Safed and Arka Samruddhi genotypes desirable for unfavourable environments E_2, E_1, E_2, E_2 and E_1 respectively.

Performance of twenty-one genotypes of cowpea in three different environments is presented in a graphical form. The abscissa (X axis) is marked with environmental indices and the ordinate (Y-axis) with weight of green pods per plant (g) and seed yield per plant (g). Expected yield of a variety is plotted against corresponding environmental indices, which gives regression line for a genotype. In this way, regression line for all the genotypes were investigated and are plotted in graph.

Figure 1. shows stability performance of twenty-one genotypes of cowpea in three different environments for weight of green pods per plant (g). The first environmental index is negative and has a large value (-8.9437). Hence, it is most unfavourable environment. Environment 3 appears to be the most favourable environments followed by environment 2. Genotype VS-15 has not only given better performance in favourable environments but also perform well in poorest environment. On the other hand, yield levels of genotype BCS-1 have increased with the improvement in environment. While, the genotypes, Arka Garima given almost constant yields in poor as well as better environmental conditions. Expected values of weight of green pods per plant (g) and environmental indices is given in Table 28 (a) and 28 (b).

Figure 2. shows stability performance of twenty-one genotypes of cowpea in three different environments for seed yield per plant (g). The

first environmental index is negative and has a large value (-0.2486). Hence, it is most unfavourable environment. Environment 3 appears to be the most favourable environments followed by environment 2. Genotype VS-15 has not only given better performance in favourable environments but also perform well in poorest environment. On the other hand, yield levels of genotype BCP-3 have increased with the improvement in environment. While, the genotype, IIHR Sel. 16 given almost constant yields in poor as well as better environmental conditions. Expected values of seed yield per plant (g) and environmental indices are given in Table 29 (a) and 29 (b).

Table 28(a) Expected values of green pods per plant (g) of twenty-one genotypes in three environments.

Sr.No.	Genotypes	E_1	E_2	E_3
1.	BCS-1	67.7525	96.6301	124.6174
2.	Arka Garima	84.0161	87.0310	89.9530
3.	RCV-326	68.7923	77.4220	85.7857
4.	IVRCP-1	58.9168	66.0735	73.0096
5.	RCV-395	49.5904	71.8959	93.5137
6.	IIHR Sel. 11	38.7881	57.5259	75.6860
7.	IIHR Sel. 16	43.1666	42.6615	42.1719
8.	Konkan Safed	37.3493	39.3539	41.2968
9.	Pusa Komal	37.6010	44.3639	50.9184
10.	Pusa Dofasali	39.2239	51.1167	62.6428
11.	VS-15	98.1161	114.0639	129.5200
12.	Arka Samruddhi	29.5807	36.9255	44.0438
13.	KLS-30	54.4561	69.7628	84.5978
14.	Ajeet - 11	37.2236	49.6331	61.6600
15.	BCP-3	67.3202	63.7410	60.2721
16.	CHCP-2	61.2745	61.8391	62.3863
17.	RCV-7	43.5490	52.5929	61.3581
18.	Sel. 263	49.6382	47.8146	46.0472
19.	IVRCP-2	55.4528	62.6854	69.6951
20.	CHCP-1	69.8303	85.3259	100.3438
21.	Konkan Sadabahar	29.3614	32.3081	35.1638

Table 28(b) Environmental indices

Environments	Environmental index
E_1	-8.9437
E_2	0.0929
E_3	8.8508

Table 29(a) Expected values of seed yield per plant (g) of twenty-one genotypes in three environments.

Sr.No.	Genotypes	E_1	E_2	E_3
1.	BCS-1	14.3884	13.9967	13.4682
2.	Arka Garima	11.5816	11.6359	11.7091
3.	RCV-326	15.6094	15.5443	15.4563
4.	IVRCP-1	11.7041	11.7074	11.7119
5.	RCV-395	12.6746	12.3440	11.8980
6.	IIHR Sel. 11	11.3807	11.1900	10.9327
7.	IIHR Sel. 16	13.6097	13.6120	13.6150
8.	Konkan Safed	14.1569	14.1149	14.0582
9.	Pusa Komal	12.9346	12.6239	12.2048
10.	Pusa Dofasali	12.7877	12.7091	12.6031
11.	VS-15	15.3447	15.8720	16.5834
12.	Arka Samruddhi	13.5015	13.3150	13.0635
13.	KLS-30	11.5269	12.2831	13.3033
14.	Ajeet - 11	12.4473	13.0797	13.9329
15.	BCP-3	13.3603	13.8268	14.4563
16.	CHCP-2	12.9792	13.2636	13.6472
17.	RCV-7	12.0077	12.2377	12.5479
18.	Sel. 263	11.3988	11.7303	12.1775
19.	IVRCP-2	10.6979	11.7309	13.1245
20.	CHCP-1	12.2842	13.0448	14.0710
21.	Konkan Sadabahar	6.7828	7.4023	8.2382

Table 29(b) Environmental indices

Environments	Environmental index
E_1	-0.2486
E_2	-0.0259
E_3	0.2746

CHAPTER VI

SUMMARY AND CONCLUSION

Cowpea (*Vigna unguiculata* (L.) Walp) has its important place in daily diet of the people. Among the pulse crops, cowpea is more cosmopolitan and grown in most of the regions of India. The response of cowpea genotypes to differential performance was emphasized for recommendation of particular variety/genotype in relation to a particular environment. Secondly, the stable genotypes/varieties can be recommended as parents in future breeding programme for generating the breeding material either suitable for a particular environment or a particular stable genotype suitable over environments.

The present investigations entitled 'Genotype × Environment' interaction in cowpea (*Vigna unguiculata* (L.) Walp) was undertaken at the Botany Research Farm, College of Agriculture, Dapoli during *summer* 2004, *late kharif* 2004 and *rabi* 2004. The experiment was conducted with three replications in randomized block design with twenty-one cowpea genotypes and three environments, which are given in Table 30.

Table 30. Sowing dates

Environments	Season	Period
E_1	*Summer*	4 –2-2004 to 30-4-2004
E_2	*Late kharif*	5-10-2004 to 9-1-2005
E_3	*Rabi*	18-11-2004 to 20-2-2005

The stability parameters were estimated in twenty-one genotypes of cowpea for green pod yield and its eighteen important components *viz.*, plant height (cm), number of branches per plant, number of compound leaves per plant, number of peduncles per plant, number of inflorescence per plant, days to initiation of flowering, number of flowers per plant, number of green pods per plant per picking, weight of green pods per plant per picking (g), number of pods per peduncle, pod length (cm), biological yield (g), days to complete maturity, seed yield per plant (g), 100-seed weight (g), harvest index (%), yield realization index (%), number of green pods per plant and weight of green pods per plant (g). The nature and extent of Genotype × Environment interactions were ascertained in the above investigations. The genotypes were identified with desired response of varying environmental conditions. The correlation coefficient was worked out among various attributes.

1. The mean sum of squares due to treatment was found to be significant for all nineteen characters. Therefore, stability studied was worked out for nineteen characters.

2. The twenty-one genotypes differed significantly in their response for all the nineteen characters. The genotypes were tested genetically divers in respect of all the characters studied as evidenced by significant genotypic mean squares.

2.1 The differential effect of environment for genotypes was found to be significant as indicated by significant environment (linear) mean sum of squares for eighteen characters except 100-seed weight.

2.2 The mean sum of square due to environment plus genotype × environment was significant suggesting the presence of G × E interactions for eighteen characters except 100-seed weight.

2.3 The significant genotype × environment (linear) interaction for all characters except seed yield per plant (g), 100-seed weight (g) and yield realization index (%) indicated that differences among the regression coefficient pertaining to various genotypes on the environmental mean were real for the characters.

2.4 The absence of (G×E) interaction was observed among the genotypes under study indicating their wider adaptability with average stability for the characters except days to initiation of flowering and biological yield (g).

2.5 Both linear and non-linear components of genotype × environment interactions were significant for certain characters, while non-linear component was observed in all the characters.

3. An appropriate structure for environmentwise performance and stability parameters presented in Table 3(a) to 21 (b). From these tables it could be seen that E_3 (*rabi*) was desirable environment for all characters except number of peduncles per plant, days to initiation of flowering and harvest index (%).

4. On the basis of pooled mean performance of the green pods yield and seed yield (g), the E_3 (*rabi*) environment has been considered as favourable environment followed by E_2 (*late kharif*) and then E_1 (*summer*).

5. For the characters weight of green pods per plant, the mean performance of genotypes in different environments, it is observed that in E_1 (*summer*) environment, genotype VS-15 produce maximum weight of green pods per plant (93.80 g) followed by Arka Garima (86.00 g) while genotype Konkan Sadabahar produced lowest weight of green pods per plant (30.33 g). In E_2 environment VS-15 produced maximum weight of green pods per plant (122.83 g) followed by CHCP-1 (96.83g) while Konkan Sadabahar recorded lowest weight of green pods per plant (30.33 g) and in E_3 environment genotype BCS-1 produced maximum weight of green pods per plant (129.00 g) followed by VS-15 (125.07 g) and genotype Konkan Sadabahar recorded lowest weight of green pods per plant (36.17 g).

5.1 Considering the criteria of stable genotype, the genotype for weight of green pods per plant RCV-326 found to be stable genotype as its high mean performance, linear component (bi) is near to unity and non-linear component is non-significant.

5.2 The genotype RCV-7 and Arka Samruddhi was found to be poorly adapted for environments with considering their lower mean performance, linear component (bi) is near unity and non-linear component (S^2di) is non-significant.

5.3 The genotypes BCS-1, RCV-395, VS-15 and KLS-30 was found to be desirable for favourable environment E_3 (*rabi*) with linear component (bi) greater than one and non-linear (S^2di) found to be non-significant.

5.4 The genotypes IVRCP-1, BCP-3 and IVRCP-2 was found to be desirable for unfavourable environments *viz.*, E_1, E_2 (*summer*, *late kharif*) with linear component lesser than one and non-linear (S^2di) found to be non-significant

6. For the characters seed yield per plant (g), the mean performance of genotypes in different environments, it is observed that in E_1 (*summer*) environment, genotype RCV-326 produced maximum yield (15.62 g) followed by VS-15 (15.04 g), while, in E_2 and E_3 environment genotype VS-15 recorded higher seed yield per plant 16.40 g and 16.36 g respectively followed by RCV-326 (15.52 g) and (15.47 g) respectively. The genotype Konkan Sadabahar recorded lowest seed yield in all the three environments *viz.*, 7.00 g , 7.03 g and 8.40 g respectively.

6.1 No genotype found to be fulfilling the criteria of stable genotype for seed yield per plant (g).

6.2 The genotype RCV-7 was found to be poorly adapted for all the environments with considering lower mean performance, linear component (bi) is near unity and non-linear component (S^2di) is non-significant.

6.3 The genotype CHCP-1 was found to be desirable for favourable environment E_3 (*rabi*) with linear component greater than one and non-linear (S^2di) found to be non-significant.

6.4 The genotypes BCS-1, RCV-326, IIHR Sel. 16, Konkan Safed and Arka Samruddhi were found to be desirable for unfavourable environments *viz.*, E_1, E_2 (*summer*, *late kharif*) with linear component lesser than one and non-linear (S^2di) found to be non-significant

It is concluded that the twenty-one genotypes of cowpea were studied for phenotypic stability and yield performance under three environmental conditions during *summer* - 2004 (E_1), *late kharif* - 2004 (E_2) and *rabi* 2004 (E_3) for nineteen morphological and yield contributing characters for green pod yield and seed yield with considering the high mean performance, linear component (bi) and non-linear component (S^2di). Based on these three stability parameters, RCV-326 found to be stable for green pod yield in all three environmental conditions, while the genotypes RCV-7 and Arka Samruddhi found to be poorly desirable for environments, the genotypes BCS-1, RCV-395, VS-15 and KLS-30 found to be desirable for favourable environment (*rabi*) and the genotypes IVRCP-1, BCP-3 and IVRCP-2 found to be desirable for unfavourable environments *viz.*, E_1, E_2 (*summer*, *late kharif*) for green pods yield.

These stable genotypes can be recommended as high performing varieties under specific environmental conditions. The genotypes can be served as potential parents for developing high yielding, stable varieties after hybridization.

LITERATURE CITED

Acharya, S. and Singh, L.N. (1979). G x E interaction for quality attributes in cowpeas *Forage Res*. **5**: 147-50.

Allard, R.W. and Bradshaw, A. D. (1964). Implication of genotype-environmental interactions in plant breeding. *Crop Sci*.,**4**:503-8.

Anonymous (1992). Crop and Season Report of Maharashtra State Government of Maharashtra Pub.

Apte, U.B. and Jadhav, B.B. (2000) constrains and strategies for increasing productivity of Arid Legumes in Konkan Region. Paper presented and abstract published at the National Symposium on 'Arid legumes for food, Nutrition security and promotion of trade' at CCS, Haryana Agricultural University, Hissar during May, 15-16, 2002.

Asfaw, A., Yadav O.P. and Tomar, Y.S. (2004). Stability for grain yield in black gram. *Legume Res*. **27**(1): 42-47.

Bejiga, G., Tsegaye, S. and Tullu, A. (1992). Performance and stability of some chickpea (*Cicer arietinum* L.) varieties in Ethiopia. *Crop Res.* **5**(3): 478-484.

Birari, D.S., Birari, S.P. and Jamadagni, B.M. (1993). Stability analysis of promising genotypes of cowpea (*Vigna unguiculata*). *Indian J. Agric. Sci.* **63**(2):103-6.

Cisse, N. (2001). Genotype × row spacing and environment interaction of cowpea in semi-arid zones. *Afric. Crop Sci. J.,* **9** (2): 359-367.

Dabholkar, A.R. (1937). Elements of Biometrical Genetics. Revised Edn. 1999. Concept publishing company, New Delhi, pp-379-421.

Dhakulkar, S. J. (2003). Stability analysis in cowpea (*Vigna unguiculata* (L.) Walp). M.Sc. (Agri). Thesis submitted to Dr. B. S. K. K. V. Dapoli. (Unpublished).

Eberhart, S.A. and Russell, W.A. (1966). Stability parameters for comparing varieties. *Crop Sci.* **6**: 36-40.

Hemanthkumar, M. and Hussain Sahab, K. (2003). Phenotypic stability for grain and fodder yields in Pearl millet. *J Res. ANGRAU.* **31**(4): 39-42.

Henry, A. (2001). Genotype × Environment Interaction for Seed Yield Mothbean Germplasm. *Curr. Agric.* vol. **25**, No. 1-2, 85-89.

Henry, A. and Kackar, N.L. (2001). Studies on phenotypic stability in clusterbean under late sown conditions. *Curr. Agric.* Vol. **25**, No. (1-2), 103-105.

Henry, A. and Kackar, N.L. (2002). Phenotypic stability in mothbean. *Curr. Agric.* Vol. **26**, 1-2, 71-73.

Holkar, S., Mishra, V.K. and Billore, S.D. (1991). Phenotypic stability of seed yield in Pigeon pea (*Cajanus cajan* L. Mill.) under dryland conditions. *Crop Res.* **4**(2): 247-252.

Hunsigi, G. and Krishna, K.R. (1998). Science of field crop production. I[st] Edn. 1998, Oxford and IBH publishing Co. PVT. LTD. New Delhi, pp-

Jahagirdar, J.E., Makne, V.G., Kapre, P.R. and Ghodke, M.K. (1994). Stability analysis in summer Mungbean. *J. Maharashtra Agric. Univ.,* **19**(2): 283-284.

Jain, K.C., Pandya, B.P. and Pande, K. (1984). Stability of yield components of chickpea genotypes. *Indian J. Genet.,* **44** (1) : 159-163.

Kandasamy, G., Rajasekaran, S. and Kadambavanasundaram, M. (1985). Studies on stability for yield component characters and correlation of stability parameters in cowpea (*Vigna unguiculata* (L.) Walp). *Madras Agric. J.* **72** (1): 9-15.

Katiyar, P.R. (1988). Component compensation for stability of yield in Urd bean at high altitudes. *Indian J. Genet.,* **48** (2) : 225-233.

Kavitha, R., Khatri, R.S., Sangwan, R.S., Henry, A., Kumar, D. and Singh, N.B. (2003). Stability analysis for grain yield in cowpea. Proceeding of National Symposium on Arid Legumes, for food nutrition security and promotion of trade, Hisar, India. *Advances in arid legumes research*., (379-382).

Khatri, R.S., Kavitha, R., Sangwan, R.S., Henry, A., Kumar, D. and Singh, N.B. (2003). Stability analysis for test weight in cowpea. Proceeding of National Symposium on Arid Legumes, for food nutrition security and promotion of trade, Hisar, India. *Advances in arid legumes research*., 376-378.

Kulkarni, P.J. and Birari, S.P. (1999). Stability studies for green pod yield in Asparagus bean. *J. Maharashtra Agric. Univ.,* **24** (3): 313-314.

Mandal, N. and Dana, I. (1994). Phenotypic stability in fodder cowpea. *Environment and Ecology,* **12** (2): 487-488.

Manikannan, C., Jebaraj, S. and Ashok, S. (2002). Stability analysis for seed yield and its components in urdbean (*Vigna mungo* (L.) Hepper). *Madras Agric. J.* **89** (10-12): 706-708.

Manivannan, N., Murugesan, S., Ramamoorthi, N. and Nadarajan, N. (1997). Phenotypic stability for seed yield in black gram. *Madras Agric. J.* **84** (11-12): 652-653.

Minal Ghangurde, (1999). Genetic studies on biomass partitioning in lablab bean (*Lablab purpurcus* (L.) Sweet). M.Sc. (Agri). Thesis submitted to Dr. B. S. K. K. V. Dapoli. (Unpublished).

Murugan, E., Manivannan, N., Viswanathan, P.L. and Nadarajan, N. (1997). Stability on seed yield in Pigeon pea. *Madras Agric. J.,* **84** (11-12): 686-687.

Panse, V.G. and Sukhatme, P.V. (1954). Statistical methods for Agril. Workers. 4th Edn. 1985, ICAR, New Delhi.

Parab, P. J. (1988). Genotype × environment interaction in moth bean (*Vigna acontifolia* (Jacq.) Marechal). M.Sc. (Agri). Thesis submitted to Dr. B. S. K. K. V. Dapoli. (Unpublished).

Patil, H.S. and Narkhede, B.N. (1989). Stability analysis for pod length and seeds/pod in green gram. *J. Maharashtra Agric. Univ.,* **14** (2): 146-148.

Pujari, M.M., Tewari, V. and Sinha, B.B. (2003). Phenotypic stability for pod characters in cowpea. *Ann. Agric. Res.* New series Vol. **24** (2): 358-361.

Raje, R.S. and Rao, S.K. (2004). Stability analysis for seed yield in mungbean. (*Vigna radiata* (L.) Wilczek). *Legume Res*., **27** (1): 11-18.

Rao, C.M. and Rao, K.Y. (2004). Stability analysis in Chickpea (*Cicer arietinum* L.). *Legume Res*., **27** (4): 235-242.

Rao, K.Y., Durga, K.K., Murthy, S.S. and Reddy, D.M. (2004). Stability for yield in Mungbean (*Vigna radiata* (L.) Hepper). *Legume Res*., **27** (1): 77-78.

Renganayaki, K. (1995). Phenotypic stability in Mungbean. *Madras Agric. J.,* 82(6-8) : 425- 427.

Saini, M.L., Jhorar, B.S. and Solanki, K.R. (1979). Genotype × Environment interactions for green fodder yield in clusterbean. *Forage Res*. **5:** pp 185-188.

Sarma, R.N., Roy, A., Borthakur, A. and Sarma, S.K (1993). Phenotypic stability for grain yield in Rajmah (*Phaseolus vulgaris* L.).*Ann. Agric. Res.* **14** (3): 339-341.

Senapathi, B.K. and Roy, K. (1991). Stability analysis for pod yield and maturity of groundnut. *Crop Res*. **4** (2): 253-257.

Sharma, T.R. and Sharma, J.K. (2000). Stability for green pod yield in garden pea (*Pisum sativum). Indian Journal of Agricultural Sciences* **70** (1): 40-1.

Shikalgar, Y.B. (1996). Studies on Genotype × environment interaction in lablab bean (*Lablab purpurcus* (L.) Sweet). M.Sc. (Agri). Thesis submitted to Dr. B. S. K. K. V. Dapoli.(Unpublished).

Singh, C (1983). Modern Techniques of raising field crops. Published by Mohan Primilani for oxford and IBH Co. Pvt. Ltd., pp: 237

Singh, R.C., Henry, A., Kumar, D. and Singh, N.B. (2003). Stability of cowpea lines under weather conditions of semiarid region. Proceeding of National Symposium on Arid Legumes, for food nutrition security and promotion of trade, Hisar, India. *Advances in arid legumes research*., 383-386.

Singh, R. K. and Choudhary, B. D. (1977). Biometrical methods in quantitative genetic analysis, Kalyani publishers, New Delhi, pp: 253-280.

Singh, S.R. (1988). Cowpea, an important food legume for the tropics. *Indian J. Pulses Res.* **1** (1) : 27-33.

Sood, B.C. and Saini, G.C. (1989). Stability for yield and maturity in mash (*Vigna mungo* (L.) Hepper). *Indian J. Genet.,* **49** (3) : 309-311.

Sood, O.P., Sood, V.K., Anand, D. and Kalia, N.R. (1999). Phenotypic stability for yield and maturity in soybean (*Glycine max*) in mid-hills of Himachal Pradesh. *Indian Journal of Agricultural Sciences.,* **69** (7) : 536-7.

Sulochana, K.A. and Peter, K.V. (1987). Phenotypic stability in cowpea. *Indian Journal of Agricultural Sciences.,* **57** (6) : 425-26.

Sultana, R., Duplay, S. and Sreedhar, N. (2001). Genotype-Environment interaction and stability performance in green gram (*Vigna radiata* (L.) Wilczek). The *Andhra Agric. J.* **48** (3-4): 196-204.

Thakur, H.L., Gupta, J.C., Kalia, N.R., Verma. S. and Sharma, K.C. (2001). Phenotypic stability for green yield and maturity in french bean (*Phaseolus vulgaris). Indian J. Agric. Sci.,* **71** (11): 721-2.

Thaware, B.L., Birari, S.P. and Jamadagni, B.M. (1991). Genotype × Environment interaction for forage yield in cowpea. *J. Maharashtra Agric. univ.*, **16** (1): 43-44.

Thiyagarajan, K. and Rajasekaran, S. (1991). Stability of days to maturity in cowpea. *Indian J. Pulses Res.* **4** (1): 87-88.

Viswanathan, P.L. and Nandarajan, N. (1996). Genotype × environment interaction for grain yield in cowpea. *Madras Agric. J.*, **83** (11): 707-708.