

**GENETIC VARIABILITY, CORRELATION AND PATH
COEFFICIENT ANALYSIS IN DIVERSE GENOTYPES OF COWPEA
[VIGNA UNGUICULATA (L.) WALP.]**



THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF

Master of Science (Agriculture)

In

Horticulture

Supervisor

Prof. Anil K. Singh

Submitted by

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Dedicated to
My Beloved Parents

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Sir

I feel great pleasure in forwarding the thesis entitled “**Genetic variability, correlation and path coefficient analysis in diverse genotypes of cowpea [*Vigna unguiculata* (L.) Walp.]**” of Miss Sunita, Id. No.: H-14131, submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE** from Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

I certify that the work has been carried out solely by **Ms. Sunita** under my supervision and guidance and her findings and data presented herein are to the best of my knowledge and belief genuine and original and no part of the work has been submitted for any other degree or distinction.

Yours faithfully

(Anil K. Singh)
Supervisor

Forwarded

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CHAPTER I

INTRODUCTION

Vegetables are rich and comparatively cheaper source of vitamins. The importance of vegetable crops in India can be judged from the fact that the majority of Indian population is vegetarian. India produces the largest variety of vegetables. Consumption of vegetable provides taste, palatability, increases appetite and provides fiber for digestion and prevent constipation. They also play key role in neutralizing the acids produced during digestion of pretentious and fatty foods and also provide valuable roughages which help in movement of food in intestine. Some of the leguminous vegetables are good sources of proteins, vitamins and carbohydrates.

Cowpea [*Vigna unguiculata* (L.) Walp.], belongs to family Fabaceae. Cowpea is also known as black-eyed pea, kaffir pea, China pea, southern bean, asparagus bean, snake bean, yard long bean and catjang bean. It is also known internationally as lubia, niebe coupe or frijol. However, they are all species of [*Vigna unguiculata* (L.) Walp.], which in older reference may be identified as [*Vigna sinensis* (L.) Walp.] Quinn, 1999. There are mainly two types of cowpeas growing in India for grain and vegetable purposes. Generally grain type cowpea varieties produce short pods with more number of seeds and mature early whereas vegetable type varieties produce long pods with less number of seeds and mature late and the pods remain tender and soft for longer period. Cowpea is generally grown in marginal land with little or no inputs and therefore the yield is very low.

It is an annual herb with a strong principal root and many spreading lateral roots in surface soil. The root system having largest nodules is more extensive than those of soybean. *Bradyrhizobium* spp. are the specific symbiotic nodular bacteria. Growth forms vary and may be erect, trailing, climbing or bushy, usually indeterminate under favourable conditions. Leaves are alternate and trifoliate usually dark green. The first pair of them is simple and opposite. Stems are striate, smooth or slightly hairy, sometimes tinged with purple. Generally, cowpea grows in areas of low rainfall as high rainfall lead to crop failure. Many of the cowpea phenotype exhibit

heat induced suppression of floral bud development, which result in two weeks delay in flowering when plant are found in very hot field environment under long days (Ehlers and Hall, 1997). A mean temperature of 27⁰C is optimum for pod formation and seed yield, though; it performs better in region with rainfall of 250-100mm per annum. Loamy soil is considered the best for the cultivation of cowpea with a pH value of 6-7 for optimum growth. Varieties with shorter maturity dates are available for gardeners with a less lengthy summary. Cowpea is called as vegetable meat due to high amount of protein in grain with better biological value on dry weight basis. On dry weight basis, cowpea grain contains 23.4 per cent protein, 1.8 per cent fat and 60.3 per cent carbohydrates and it is rich source of calcium and iron (Gupta, 1988). Apart from this, cowpea forms excellent forage and it gives a heavy vegetative growth and covers the ground so well that it checks the soil erosion. As a leguminous crop, it fixes about 70-240kg/ha of nitrogen per annum. Cowpea is mainly grown in tropical and subtropical regions in the world for vegetable and seed purpose and to lesser extent as a fodder crop (Rangel *et al.*, 2004).

The essentiality of increase in productivity is the present challenge to the crop improvement field. The present day cultivars exhibit lower productivity, non synchronous flowering and fruiting, unresponsive to high doses of inputs like fertilizers, irrigation, tillage *etc.*, unsuitability of the various cropping systems, lodging and shattering susceptible, long duration, complete or partial absence of genetic resistance to major insect pest and diseases like mosaic virus, rust, powdery mildew and bacterial blight which cause considerable damage and very poor harvest indices. Development of cultivars with early maturity, acceptable grain quality, resistance to some important diseases and pests has significantly increased the yield and cultivated area (Ehlers and Hall, 2007). Understanding of the genetic variability of cowpea is important to design and accelerate conventional breeding programmes. Collection, characterization and evaluation of available cowpea germplasm, quantification of the magnitude of diversity and classification into groups facilitate identification of genetic variability that enables breeders to select traits of interest for an improvement programme. Information on the nature and degree of genetic diversity would assist plant breeders in choosing the best genotypes as parents for hybridization (Souza and Sorrells, 2005). Yield being a complex trait, is influenced by

many other important yield contributing characters controlled by polygenes and also environmental factors. Better knowledge of the genetic similarity of breeding materials could help to maintain genetic diversity and sustain long term selection gain. Research on evaluation and genetic improvement on cowpea is very limited. Increasing major components of grain yield such as pods/plant, pod length, seeds/pod and seed size will allow improving cowpea yield potential (Carnide *et al.*, 2007). Use of morphological descriptors in sequential fashion is useful and convenient to discriminate the different varieties (Joshi *et al.*, 2003). Characterization can be done by using morphological and chemical characteristics. Morphological descriptors have traditional significance and one can immediately access on the spot without the need of equipment. Keeping these aspects in view, the present study entitled, **“Genetic variability, correlation and path coefficient analysis in diverse genotypes of cowpea [*Vigna unguiculata* (L.) Walp.]”** was undertaken with the following objectives:

- To study the nature and magnitude of association between seed yield and its component traits.
- To assess the extent of genetic variability for quantitative traits.
- To assess the magnitude of genetic divergence and to classify the genotypes under different groups on genetic distance.



CHAPTER II

REVIEW OF LITERATURE

Vegetables are rich and comparatively cheaper source of vitamins. The importance of cowpea [*Vigna unguiculata* (L.) Walp.] is one of the important leguminous crops, which belongs to family Fabaceae. It is primarily originated in West Africa. Since, limited availability of high productive varieties with good plant types and lack of short duration varieties with higher resistance to diseases, are the major hindrance to increase the production. The collection of information based on these factors will be useful to crop improvement activities.

The review of literature is presented under following sub headings.

- 2.1 Analysis of variance
- 2.2 Mean performance of genotypes
- 2.3 Parameters of variability
- 2.4 Correlation coefficient
- 2.5 Path coefficient analysis

2.1 Analysis of variance

Mehta *et al.* (2014) studied the genetic variability in M_2 and M_3 generation. Analysis of variance in M_2 and M_3 population showed significant differences among the treatments for all the twelve genotype for their yield and its attributing characters under study except protein per cent. For all the characters under study in both the generations, phenotypic coefficient of variation was higher in magnitude than genotypic coefficient of variation. High GCV as well as PCV was obtained in M_2 and M_3 generation for traits number of primary branches per plant, protein percent, yield per plant and hundred seed weight.

Rana *et al.* (2014) were collected cowpea genotypes from different places in the country and evaluated for different horticultural traits for genetic variation, character association. Genetic diversity was measured among the genotypes through

D₂ statistics. All the eight characters under study differed significantly among the genotypes. Association studies revealed that genotypic correlation coefficients were higher than their phenotypic correlation coefficients in most of the cases. From the correlation and path analysis, it can be concluded that emphasis should be given on number of pods per plant and pod weight for selecting high yielding genotypes. Based on the degree of mean performance the genotypes were grouped into seven clusters. The top three characters which contributed most towards the mean performance were number of seeds per pod, pod yield per plant and pod weight.

Venkatesan *et al.*(2003)evaluated twenty genotypes of cowpea for variability, for 12 traits (number of days to first flower, length of plant, number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, pod yield per plant, pod length, number of seeds per pod, 100 seed weight, seed yield per plant, and dry matter production). Significant variation among the genotypes was evident for all the traits. The greatest variation was recorded for length of plant.

Arora *et al.*(2003)evaluated ten diverse genotypes of cowpea for 8 morphological characters (hypocotyl length, epicotyl length, seedling height, length and diameter of first pair of true leaves, petiole length of first trifoliate leaf and fresh and dry weight of seedlings) at seedling stage.

Nigude *et al.* (2004) studied the variability, correlation and path coefficients in 45 cowpea genotypes. The genotypic (GCV) and phenotypic coefficients of variation (PCV) were higher for length of plant, grain yield per plant and number of pods per plant. The magnitude of PCV was higher than GCV for all the characters studied. In broad sense was higher for all the charactersexcept number of seeds per pod.

Zargar *et al.* (2005) evaluatedthirty-two genotypes of cowpea for variability, for seven traits (days to 50% flowering, length of plant (cm), number of pods/plant, pod length (cm), number of seeds/pod, seed yield (g)/plot and 100-seed weight). Significant variation among the genotypes was evident for all the traits. A good variation was recorded for seed yield/plot, 100-seed weight, length of plant, number of pods per plant, number of seeds per pod and pod length. The magnitude of the phenotypic coefficient of variation (PCV) was higher than that of the genotypic coefficient of variation (GCV) for all the traits studied. High GCV and PCV were

recorded for length of plant, number of pods per plant, seed yield per plot and 100 seed weight. High coupled with high genetic gain was observed for length of plant (96.39 and 90.78%), number of pods per plant (67.84 and 38.39%), seed yield per plot (175.02 and 122.83%) and 100 seed weight (37.40 and 39.34%).

Nkouannessiet *al.* (2005) found that the magnitude of the phenotypic coefficient of variation (PCV) was higher than that of the genotypic coefficient of variation (GCV). High GCV, PCV were recorded for length of plant and dry matter production. Length of plant, number of pods per plant, pod length, 100 seed weight, seed yield, and dry matter production were characterized by very high.

Girishet *al.* (2006) evaluated one hundred genotypes of cowpea for variability, for eleven quantitative characters. Wide range of variability was observed for most quantitative characters. Length of plant and seed yield showed highest phenotypic and genotypic variance, while primary and secondary branches showed lowest variances. The magnitude of Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), (h_2) and (GA) was high for seed yield per plant, number of pods per plant and length of plant. Days to first flower opening, days to 50% flowering and days to maturity were recorded low.

2.2 Mean performance of genotypes

Adewaleet *al.* (2010) studied the grain yield components of eleven cowpea genotypes to understand the sensitivity of the quantitative traits to heterogeneous environments. Significant genotypic variation in pod length was only in 2007. 100 seed weight and pod yield were significantly influenced by the effect of genotype, year and their interactions. Seeds per pod, 100 seed weight and pod length had fairly high relative genetic gain resulting from high GCV, PCV and repeatability; indicating their low sensitivity to G x E.

Aswathiet *al.* (2015) carried out an investigation with seeds of ten cowpea varieties to study the mean performance of the varieties with respect to storability and seed quality parameters. The seeds were evaluated for four seed quality parameters *viz.*, germination, speed of germination, seedling vigour index I and seedling vigour index II and diversity was assessed using Mahalanobis D_2 analysis after ten months of

storage under ambient conditions. There was significant variation for the quality aspects related to storage. Variety KashiKanchan had a germination of 61.67 per cent after ten months of storage. On the basis of D_2 values the genotypes were grouped into four clusters. Cluster I was the largest containing four varieties (Lola, VellayaniJyothika, Vyjayanthi and Anaswara). The maximum inter-cluster distance was recorded between clusters I and IV (Hridya and Bhagyalakshmi). The maximum intra-cluster distance was found in cluster IV followed by I. Varieties Kanakamony and KashiKanchan grouped in cluster II and Kairali and Sreya in cluster III.

Badheet *al.* (2015) concluded based on D_2 statistic, the forty genotypes of cowpea from different geographical origin was grouped into six clusters indicating wider genetic diversity. The clustering pattern indicated the absence of relationship between genetic diversity and geographical origin of genotypes. Intercrossing among them would lead to upgrade genetic base in the base population and opportunities to obtain high heterotic effects. It will be helpful to recover desirable transgressive segregants and wide spectrum of variability in subsequent generations. Estimation of the degree of the mean performance between biological populations and computation of relevant contributions of different components to the total mean performance is done completely by Mahalanobis's generalized distance estimated by D_2 statistic (Nair and Mukharjee, 1960 and Mourya and Singh, 1977). Nair and Mukharjee (1960) were the pioneers to use D_2 statistic as measure of mean performance in the field of plant breeding for classification of teak plants.

Renganayaki and Rangasamy (1991) analyzed the Mung bean (*Vignaradiata*), black gram (*Vignamungo*) and cowpea (*Vigna unguiculata*) using the Mahalanobis D_2 value and revealed that the genotypes of the *Vignaradiata*, *V. mungo* and *V. unguiculata* were regrouped in seven, five and four clusters respectively and also concluded that hundred seed weight, pod length and seed yield contributed most towards mean performance.

Santoshet *al.* (1997) reported mean performance of cowpea under two different environments using Mahalanobis D_2 statistics that length of the main branch, hundred seed weight and pod length were the most important characters to affect divergence.

Sharma and Misra (1997) revealed that days to 50 % flowering, length of plant, pods per peduncle and harvest index contributed most towards mean performance; seed yield had a high positive phenotypic correlation with pods per peduncle, number of seeds per pod and harvest index.

Bakiyaraniet *al.* (2000) concluded that mean performance for physiological traits like single plant yield, harvest index and earliness in flowering together accounted for 80 % of the total mean performance in cowpea.

Borah and Khan (2002) revealed on mean performance in fodder cowpea. Sixty cowpea cultivars were grouped into 10 clusters. Dry matter yield, green fodder yield and length of plant were recorded highest contribution to total mean performance. These traits could be good criterion for the selection of parents in hybridization programme.

Ushakumari *et al.* (2002) reported that contribution towards mean performance was recorded for length of plant (22.69%), seeds per pod (17.63%), number of branches (16.82%), number of pods per cluster (15.27%) and pod length (13.47%) in cowpea.

Bhardwaj *et al.* (2014) were conducted field experiment in the *Kharif* 2012 to estimate genetic variability, correlation and path co-efficient studies in sixty genotypes of cowpea were evaluated for eleven morphological traits *viz.*, length of plant, leaf length, leaf diameter, number of branches, stem girth, number of leaves, number of pods, seeds per pod, pod weight, 100 seed weight and seed yield per plant. The high range of variability was observed for length of plant (117.2-261.5), number of leaves (194-568), pod weight (10-105) and seed yield per plant (3.12-225.05) while rest of the traits showed medium range of variability. The highest value of PCV (Phenotypic coefficient of variation) and GCV (Genotypic coefficient of variation) were recorded for seed yield per plant (108.91, 108.86) followed by number of pods (66.12, 65.05), pod weight (49.1, 48.37) and 100 seed weight (28.88, 27.92). In general, the genotypic correlation coefficients were higher in magnitude than the phenotypic correlation coefficients. Seed yield per plant was highly significant and positively correlated with number of pods per plant (0.92, 0.90), pod weight (0.90,

0.89), 100 seed weight (0.57, 0.55), leaf length (0.56, 0.90), leaf diameter (0.27, 0.11) and seeds per pod (0.22, 0.14), respectively.

Dhanwaniet *et al.* (2014) studied on twenty two genotypes of cowpea and revealed significant differences among the genotypes for all the characters except for number of branches per plant, number of pods per plant and number of clusters per plant. The character seed yield per plot registered the highest magnitude of GCV (75.702) and PCV (78.275). The highest estimate was recorded for the characters days to 50% flowering (99.89%) followed by hydration capacity (99.74%), days to maturity (99.63%), 100 seed weight (99.34%), seed volume (99.19%), swelling capacity (98.15%), swelling index (96.09%), seed density (94.02%), seed yield per plot (93.54%), hydration index (82.48%) and pod length (76.94%). However, among them only days to maturity, seed volume, swelling capacity, swelling index and seed yield per plot were having high.

Tajaneet *et al.* (2014) conducted an experiment on 44 genotypes of cowpea for green forage yield per plant, dry matter yield per plant, length of plant at 50 per cent flowering, branches per plant. Correlation studies stressed the importance of characters, *viz.*, dry matter yield per plant, days to 50 per cent flowering, length of plant at 50 per cent flowering, leaf: stem ratio and number of leaves per plant.

Aswathi *et al.* (2015) studied the mean performance of the ten cowpea varieties with respect to storability and seed quality parameters. The seeds were evaluated for seed quality parameters, *viz.*, germination and speed of germination. There was significant variation for the quality aspects related to storage. Variety KashiKanchan had a germination of 61.67 per cent after ten months of storage.

2.3 Parameters of variability

Viswanatha *et al.* (2015) carried out with a set of 196 cowpea genotypes and analysis of variance revealed significant differences among the genotypes tested for all the nine characters, justifying the selection of genotypes for the study. The genotypes exhibited considerable amount of genetic variation for all the characters and it indicated the good scope for selection of suitable basic material for further

improvement. PCV values were of higher magnitude than GCV for all the characters under study.

Meena *et al.* (2015) evaluated 72 genotypes of cowpea to estimate genetic variability, of ten quantitative characters. Analysis of variance revealed highly significant difference among genotypes for all the characters indicated that considerable amount of genetic variability was present in the experimental material which can be exploited for improvement of seed yield in cowpea. Genotypic and phenotypic variance were recorded highest for length of plant (358.69, 378.69) followed by pod wall proportion (38.30, 41.27) and lowest for primary branches per plant (0.30, 0.50).

Muranaka *et al.* (2016) carried out an experiment and found wide genetic variation and strong correlations among crude protein, Fe and Zn contents suggest the possibility of improving the concentrations of these nutritional factors.

Kapoor *et al.* (2000) revealed that the number of seeds per pod and 100 seed weight were the main contributing characters towards the seed yield. Pod length contributed indirectly towards seed yield via the number of seeds per pod and 100 seed weight in the study involved 160 genotypes of cowpea. The direct effect of pod yields on grain yield and genotypic correlation between pod yield and grain yield were almost equal (Neema and Palanisamy, 2001) and they also reported that the highest positive direct effect on grain yield was recorded by pod yield and the lowest by pod length. The indirect effect was maximum for pod length via pod yield.

2.3.1 Length of plant

Most of the reports on genetic variability showed a wide range of variability for length of plant with moderate to high and high, based on studies varying number of genotypes and there were few reports based on the segregating material. A report showed moderate and moderate (Patil and Patil, 1986). Rangaiah and Nehru (1998) indicated low (5.61%) with 6%. However, Selviet *et al.* (1994) revealed that high (99.89%) with moderate GCV and PCV values.

Kumar *et al.* (2002) reported for green fodder yield per plant, number of days to 50% flowering, length of plant and dry fodder yield per plant in the study involved five

cultivars. In general, genotypic coefficient of variation was found to be higher than the corresponding phenotypic coefficient of variation for this character.

2.3.2 Number of branches

This character is highly variable and highly heritable. Most of the reports indicated moderate to high with low. A moderately high with moderate value of was reported by Mehta and Zaveri (1999), while Rangaiah and Nehru (1998) reported low to moderate estimates for number of branches with very low in cowpea. In 1994, Madhusudhan reported high heritable values of 96.21 per cent in F_1 materials, while in 1997, Balraju reported that, low (14.2%) for this trait. Many reports indicated that low to high ranging from 0.6 (Apteet *et al.*, 1987) to 13.43 (Balraju, 1997). Apteet *et al.* (1987) reported moderate GCV (17.39%) and high PCV (79.18%) for the character while Rangaiah and Nehru (1998) reported high GCV and PCV.

2.1.3 Number of clusters per plant

Many reports indicated high phenotypic and genotypic coefficient values with regard to number of clusters per plant. Most of the segregating populations showed high estimates for both. (Rangaiah *et al.*, 1999) reported moderate to high for number of clusters per plant in cowpea. Sarvamangala (2004) revealed moderate to high GCV and PCV with number of clusters.

2.3.4 Days to 50% flowering

Most of the reports indicated higher, lower, lower values of genotypic and phenotypic coefficient of variation and three reports indicated lower. The ranged from 4.7 per cent (Thiyagarajan, 1989) to 92.39 per cent (Marangappanavar, 1984). Sarvamangala (2004) revealed high for this character.

2.3.5 Days to maturity

Reports on days to maturity indicated high, two of them were based on F_1 generations (Patil and Patil, 1986). One report based on 50 genotypes another report based on 49 pure lines (Patil and Baviskar, 1987) and other three reports indicated low.

Sarvamangala (2004) showed high heritability for this character by studying 50 genotypes, reported low GCV, PCV and high with low GAM for this character by studying 50 genotypes.

2.3.6 Number of pods per plant

Jagadishmurthy (1986) stated high phenotypic and genotypic variation, and expected by studying F_2 population and showed that number of pods per plant was the major yield contributing character. High with high has been reported for this character in cowpea (Mehta and Zaveri, 1999). Reports based on segregating populations (Rangaiah and Nehru, 1998) and one study of limited genotypes indicated that, this trait is highly variable one. In 1999 Sharma showed moderate variability based on 42 genotypes. Mathur (1995) reported very high (98.0%) with extremely high GCV and PCV (103.93%) values. Sarvamangala (2004) reported moderate to high GCV and PCV based on 50 genotypes.

2.3.7 Pod length

High for this character is very much fruitful during selection programme. In 1989, Dharmalingam and Vanasundaram reported high variability in pod length. Some reports indicated that high estimates of both. The lowest being 7.84 (Mathur, 1995) and the highest being 58.23 (Rangaiah and Nehru, 1998) for GCV. Mathur (1995) found high associated with low yield.

2.3.8 Number of seeds per pod

Number of seeds per pod is most contributing trait for the yield. The number of seeds per pod is highly variable character and moderately heritable in cowpea. ranged from 31.3 per cent (Selvam *et al.*, 2000) to 98.8 per cent (Tyagi *et al.*, 2000) based on studies of 24 and 50 cowpea genotypes, respectively. Mathur (1995) observed a high coupled with low. Low to moderate has been reported by Rangaiah and Nehru (1999) and Selvam *et al.* (2000). While Selvi *et al.* (1994), Backiyarani and Nadarajan (1996) and Selvam *et al.* (2000) reported moderate GCV and PCV for the character.

2.3.9 Hundred seed weight

This character is most related to yield which showed high estimates of GCV, in all pulse crops. In general low to moderate variability was observed for this character of hundred seed weight ranged from 14.47% (Rangaiah and Nehru, 1999) to 99.2% (Selviet *al.*, 1994). High with low was reported by Gowda *et al.* (1991) and Backiyarani and Nandarajan (1996).

Analyzing diverse genotypes, Sharma (1999) reported moderate. Low to moderate coupled with relatively higher was observed and it was supported by the findings of Gowda *et al.* (1991), Rangaiah and Nehru, (1998) Tyagi *et al.* (2000) and Selvam *et al.* (2000).

2.3.10 Seed yield per hectare

Seed yield is an ultimate product of any selection or breeding programme. Most of reports indicated fairly higher estimates of (Selviet *al.*, 1994; Mathur, 1995 and Tyagi *et al.*, 2000). Mehta and Zaveri (1999) observed high for seed yield, based on their studies on segregating material while Mathur (1995) in a variability study, among F_2 population recorded high GCV and PCV for this character.

The estimates of seed yield per plant varied from 18.34 to 99.8 per cent (Tyagi *et al.*, 2000). Some reports indicated higher estimates of (Biradare *et al.*, 1993; Selvi 1994; Mathur, 1995 and Tyagi *et al.*, 2000). High for seed yield based on segregating material was observed by Mehta and Zaveri (1999), while Mathur (1995) recorded high GCV and PCV for seed yield by studying F_2 population. High genotypic and phenotypic coefficient of variability and for seed yield per plant was reported by Dharmalingam and Kadambavan Sundaram (1989).

Kumari *et al.* (2003) revealed high genetic gain for seed yield per plant, number of pods and number of clusters per plant by studying 50 cowpea genotypes.

2.3.11 Yield attributing characters

Fernandez and Miller (1985) studied four determinate and indeterminate cowpea cultivars and reported five cultivars differed significantly for yield, biomass and nitrogen fixation. The biomass and seed yield were more in indeterminate

cultivars with inoculation and harvest index was found to be more in determinate types.

Diagaet *al.* (2011) found that pod dry weight and grain yield was significantly correlated with root and shoot dry weights. If vegetative growth is profuse, it had negative effect on grain yield and resulting reduction of harvest index.

Kumari *et al.* (2003) reported significant genetic variation for most of the traits by studying genetic variation and correlation analysis in 50 cowpea genotypes. The phenotypic coefficient of variation (PCV) was higher than the corresponding genetic coefficient of variation (GCV). GCV and PCV values were highest for days to flowering and maturity, number of clusters and pods per plant, 100 seed weight and seed yield per plant.

2.4 Correlation coefficient

The relationship between various plant characters gives the measurement of correlation coefficients, which will give an indication for breeders. The extent of observed relationship between two characters is known as simple, total phenotypic correlation. Environmental correlation is the measure of environmental influence on the covariance between the two characters in question. Patil *et al.* (1989) reported that the grain yield was highly correlated with pods per plant, 100 seed weight, clusters per plant, pod length and days to 50% flowering based on diallele cross involving ten diverse indigenous lines and varieties of cowpea.

Birader *et al.* (1996) reported strong correlation between pod weight per plant and seed yield, pod length and number of seeds per pod, number of clusters and number of pods per plant and pod weight per plant. Gowda (1996) revealed a positive and significant association of seed yield with number of pods per plant, number of seeds per pod and 100 seed weight and also found a significant and negative association with 100 seed weight and number of seeds per plant. Singh and Singh (1977) revealed that number of clusters per plant, number of seeds per pod and total biomass made greatest direct contribution to seed yield in 45 cowpea genotypes. Vardhan and Savithamma (1998) reported a very high positive association of green pod yield with pods per plant.

Rangaiah *et al.* (1999) reported that total seed weight was positively and significantly associated with all the traits, except length of plant and pod weight made the greatest contribution towards yield per plant in both crosses. Length of plant, number of pods per plant and number of seeds per pod showed significant and positive association with hundred seed weight indicating that more number of pods gives more number of seeds and also observed a positive association of pod length with length of plant, number of branches per plant and number of pods per plant.

Belhekar *et al.* (2003) revealed that by studying F_2 generation, the seed yield per plant exhibited positive and significant correlation with length of plant, number of flowers per plant, first pod maturity, complete maturity, number of pods per plant and 100 seed weight both at the phenotypic and genotypic levels. However, it showed a negative and significant correlation with the number of pods per peduncle and seed index.

Venkatesan *et al.* (2003) stated that the numbers of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant and pod yield were positively correlated with seed yield at the genetic and phenotypic levels by studying correlation and path analysis in 20 genotypes of cowpea. The magnitude of genetic correlation was higher than that of phenotypic correlation. The number of clusters per plant was positively associated with number of branches per plant, number of pods per cluster and number of pods per plant, but was negatively correlated with number of days to flowering, 100 seed weight, and dry matter production. The number of branches per plant and number of pods per cluster exhibited few significant associations with the other traits. Based on the above reviews, it is clear that number of pods per plant, number of seeds per pod, 100 seed weight and pod length have positive significant association with yield. These characters can be considered during selection for yield improvement.

2.5 Path coefficient analysis

Vardhan and Savithramma (2010) studied path coefficient analysis for green pod yield per plant in 29 accessions of cowpea and concluded that green pods per plant, pod length, pods per plant, pod length, pod diameter and number of primary branches were major traits contributing to yield.

The performance of different genotypes in varying environments might be vary over season, year and locations. Study of these aspects would be more important to select highly adaptable genotypes. Viswanathan and Nadarajan (1996) evaluated thirteen genotypes in three environments. Two of them showed average response to changes in environmental conditions with higher mean yields and one is specially suited for the unfavourable growing season.

Kulkarni and Birari (1999) studied six genotypes of asparagus bean and two hybrids of cowpea [*Vigna unguiculata*(L.) Walp.] for yield components and revealed that one variety performed best under different environments, while yields of the other genotypes were not very stable.

Lopes *et al.* (2000) revealed that high genetic variation for most of the studied traits of cowpea and the presence of high genotype environment interaction for pod length and seed yield was detected.

Cisse (2001) stated that the most productive genotypes could be identified through concomitant selection for yield in high productivity environments and for harvest index in low productivity conditions by evaluating ten genotypes.

Chattopadhyay *et al.* (2001) evaluated twenty cowpea genotypes for stability in yield and its components such as number of pods per plant, pod length and pod weight and revealed that the significant genotype and environment interaction was observed for all characters except pod length.

Siddique and Gupta (1991) observed a significant correlation of seed yield per plant with days to 50% flowering, days to maturity, number of clusters per plant and number pods per plant. Oseni *et al.* (1992) revealed that there is a positive correlation between seed yield and pods per plant, between days to flowering and 100 seed weight. While, negative correlations were observed between days flowering and seed yield and between 100 seed weight, seed yield, days to flowering, 100 seed weight, days, days to pod filling and pod length were the major components contributing to yield.

Altinbas and Sepetoglu (1993) conducted an experiment and correlated with pods per plant, seeds per pod and number of branches per plant. Both days to

flowering and maturity had no influence on seed yield, 100 seed weight was negatively and significantly associated with pods per plant and seeds per pod.

Sawant (1994) found that the seed yield was significantly and positively correlated with branches per plant, inflorescence per plant, pods per plant, pod length, seeds per pod, 100 seed weight and harvest index.

Tamilselvan and Das (1994) reported that the number of clusters, number of pods per plant and 100 seed weight should be used as a selection criterion in the development of high yielding genotypes of cowpea.

Shiddique and Gupta (1991) reported that pods per plant, 100 seed weight and seeds per pod as the most important yield attributing characters.

Oseniet *al.* (1992) concluded through path analysis that the major components contributing to seed yield were days flowering, 100 seed weight, days to pod filling and pod length.

Altinbas (1993) revealed by path analysis study that the most important yield component was number of pods per plant affecting the yield through path analysis, whereas Sawant (1994) revealed by the path analysis that pods per plant had the highest positive direct effect on seed yield followed by 100 seed weight, seeds per pods, days to flowering, inflorescence per plant, harvest index per plant and pod length.

Biraderet *al.* (1996) reported that strong correlation between pod weight per plant and seed yield, pod length and number of seeds per pod, number of clusters and number of pods per plant and pod weight per plant.

Gowda (1996) revealed that a positive and significant association of seed yield with number of pods per plant, number of seeds per pod and 100 seed weight and also found a significant and negative association with 100 seed weight and number of seeds per plant. Singh and Singh (1997) revealed that number of clusters per plant, number of seeds per pod and total biomass made greatest direct contribution to seed yield in 45 cowpea genotypes.

Vardhan and Savithramma (1998) reported a very high positive association of green pod yield with pods per plant. Rangaiah *et al.* (1999) recorded that total seed weight was positively and significantly associated with all the traits except length of plant and pod weight made the greatest contribution towards yield per plant in both crosses. Length of plant, number of pods per plant and number of seeds per pod showed significant and positive association with hundred seed weight indicating that more number of pods gives more number of seeds and also observed a positive association of pod length with length of plant, number of branches per plant and number of pods per plant.

Mehta and Zaveriet *al.*(1999) reported moderate to high for number of clusters per plant in cowpea. Sarvamangala (2004) revealed moderate to high GCV and PCV with number of clusters. Many reports indicated high phenotypic and genotypic coefficient values with regard to number of clusters per plant. Most of the segregating populations showed high estimates for both.

Selvamet *al.* (2000) concluded that number of seeds per pod is most contributing trait for the yield. The number of seeds per pod is highly variable character and moderately heritable in cowpea ranged from 31.3 percent based on studies of 24 and 50 cowpea genotypes and observed a high coupled with low.

Tyagiet *al.*(2000) concluded that those characters are most related to yield which showed high estimates of GCV in all pulse crops. In general low to moderate seed yield is an ultimate product of any selection or breeding programme. Most of reports indicated fairly higher estimates of (Selviet *al.*, 1994; Mathur, 1995 and Tyagiet *al.*, 2000). Mehta and Zaveri (1999) observed high value for the seed yield, based on their studies on segregating material while Mathur (1995) in a variability study among F₂ population recorded high GCV and PCV for this character.

Kumar *et al.* (2002) reported high for green fodder yield per plant, number of days to 50% flowering, length of plant and dry fodder yield per plant in the study involved five cultivars. In general, genotypic coefficient of variation was found to be higher than the corresponding phenotypic coefficient of variation for this character.

Kalaiyarasi and Palanisamy (2002) stated that number of seeds per pod, number of pods per plant, crude protein content and length of plant had high positive direct effects on seed yield while pod length, hundred seed weight, number of branches per plant and crude fibre content had negative direct effects on seed yield in the F₃ population of cowpea. Pod length and hundred seed weight had positive indirect effects on seed yield through number of pods.

Kumari *et al.* (2003) revealed that high and genetic gain for seed yield per plant, number of pods and number of clusters per plant by studying 50 cowpea genotype.

Venkatesan *et al.* (2003) stated that the number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant and pod yield was positively correlated with seed yield at the genetic and phenotypic levels by studying correlation and path analysis in 20 genotypes of cowpea. The magnitude of genetic correlation was higher than that of phenotypic correlation. The number of clusters per plant was positively associated with number of branches per plant, number of pods per cluster and number of pods per plant, but it was negatively correlated with number of days to flowering, 100 seed weight, and dry matter production. The number of branches per plant and number of pods per cluster exhibited few significant associations with the other traits. Based on the above reviews it is clear that number of pods per plant, number of seeds per pod, 100 seed weight and pod length having positive significant association with yield. These characters can be considered during selection for yield improvement.

Bezerra *et al.* (2005) showed that plant habits and growth have direct influence on the response of cowpea to population management because of the observed decrease in grain production per plant, as a consequence of the increased plant population per hectare, which occurs to a lesser degree in the erect than in the climbing genotypes.

Cardoso *et al.* (1997) stated that the plant architecture and the production system have an influence in determining the arrangement of more adequate plant number to efficiently take advantage of the production factors and maximize the production potential of the cultivar.

Jagadishmurthy *et al.* (2007) stated high phenotypic and genotypic variation, and expected by studying F₂ population and showed that number of pods per plant was the major yield contributing character. High with high has been reported for this character in cowpea.

Yousaf and Sarwar (2008) concluded that stable performance of cowpea genotypes across contrasting environments is essential for the successful selection of stable and high yielding varieties.

Ahmed *et al.* (2005) studied on cowpea and found that combination of genotypes stability with high yield is an important criteria for selecting high yielding and stable genotypes. Therefore, a number of techniques that simultaneously coupled with high yield and stability of performance have been proposed.

Dumet *et al.* (2008) and Musvosvi (2009) found that cowpea is a self-pollinating plant species that is cultivated worldwide (Maheet *et al.*, 1994; Musvosvi, 2009). Due to its drought tolerance and ability to grow on poor-quality soils, it is one of the most important food and/or forage legumes in the semi-arid tropics. The crop enhances soil fertility through biological nitrogen fixation.

Mathur *et al.* (2009) High for this character pod length is very much fruitful during selection programme. Sundaram (2001) reported high variability in pod length. Some reports indicated high estimates of both. The lowest being 7.84 (Mathur, 2009) and the highest being 58.23 (Sundaram, 2001).

Patil *et al.* (2002) reported that pods per plant, 100 seed weight and seeds per pod had greatest positive direct effect on yield.



CHAPTER III

MATERIALS AND METHODS

The present experiment “**Genetic variability, correlation and path coefficient analysis in diverse genotypes of cowpea [*Vigna unguiculata*(L.) Walp.]**” was carried out during 2015 at the Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The detail of materials used and methodology adopted in the experiment are given below.

3.1 Location

The Horticulture Research Farm (Institute of Agricultural Sciences, B.H.U.) is situated in South-Eastern part of Varanasi city at 25° 15' North latitude and 83° 03' East longitude at an elevation of 129.23 m above the mean sea level.

3.2 Climatic condition

Varanasi is situated in the eastern part of Uttar Pradesh and lies in the centre of north alluvial plain on the left side of river the Ganges and enjoys a humid subtropical climate with large variation in summer and winter temperature *i.e.*, extreme of hot weather in summer and cold in winter. On the basis of available knowledge, the climatic conditions of this area for an entire year are divided into three parts.

Summer season : March to third week of June

Rainy season : Last week of June to October and

Winter season : From November to February

The mean annual rainfall is about 850-1100 mm. The major portion of precipitation about 85 to 90% is received during July to September.

3.3 Climate and weather during crop season

The mean maximum temperature during experimentation was 34.9 °C (April) and mean minimum temperature was 7.8 °C (January). The mean relative humidity was maximum during the month of January (96%) and minimum during the month of May (33%).

During the period of study, meteorological observations were recorded from meteorological observatory of All India Coordinated Research Project for Dry-land Agriculture, situated at Agricultural Research Farm, Banaras Hindu University and the meteorological data recorded during investigation period is presented in Table: 3.3.1.

Table 3.3.1 Weekly Meteorological Data 2015.

Week No.	Month & date	Rainfall (mm)	Temperature (°C)		R.H. (%)		Wind speed (km/hr)	Sunshine hours	Evaporation rate
			Max.	Min.	Mor.	Eve.			
1	June 04-10	0.0	42.6	2.2	59	35	3.3	8.0	6.7
2	11-17	9.0	38.7	28.3	73	46	5.1	7.2	6.3
3	18-24	0.2	36.6	29.8	67	60	7.0	7.5	6.5
4	25-01	192.2	33.1	25.4	86	77	5.1	4.8	4.4
5	July 02-08	30.5	32.9	27.1	81	66	5.6	6.0	5.7
6	09-15	105.1	32.2	26.9	85	78	5.8	4.4	3.5
7	16-22	146.8	31.5	26.6	90	77	4.0	3.3	3.4
8	23-29	54.0	33.2	26.4	85	64	5.0	6.2	5.1
9	30-05	81.2	31.6	25.4	86	69	5.0	4.8	1.4
10	Aug 06-12	18.6	34.0	26.7	85	67	1.9	5.2	4.2
11	13-19	116.3	32.7	27.1	89	77	4.2	6.0	4.4
12	20-26	49.5	33.2	25.7	87	72	6.4	5.9	4.9
13	27-02	42.2	33.4	26.7	90	74	3.0	4.5	3.6
14	Sep 03-09	0.0	34.6	26.3	80	59	4.0	8.8	4.2
15	10-16	0.0	24.6	27.5	86	64	3.1	7.3	3.7
16	17-23	11.9	31.1	26.9	87	66	5.0	6.9	4.3
17	24-30	0.0	33.3	23.8	80	54	3.4	8.8	3.2
18	Oct 01-07	0.0	34.0	22.8	83	51	1.3	9.0	3.0
19	08-14	0.0	33.5	22.0	82	52	1.8	8.6	3.2
20	15-21	0.0	33.0	21.8	79	59	1.5	8.0	3.1

21	22-28	0.0	32.1	19.0	88	56	0.3	8.3	2.7
22	29-04	23.0	28.0	16.6	93	82	1.4	5.2	2.0
23	Nov 05-11	0.0	30.6	18.6	89	49	0.8	5.7	2.6
24	12-18	0.0	30.4	16.6	89	40	1.8	7.6	2.5
25	19-25	0.0	28.7	16.2	90	49	0.7	4.4	1.4
26	26-02	0.0	28.4	17.2	86	53	1.1	4.3	2.1
27	Dec 03-09	0.8	24.6	14.8	93	62	1.0	2.2	1.4
28	10-16	0.0	22.7	11.4	92	56	2.6	3.7	1.5
29	17-23	0.0	22.0	8.2	91	43	1.5	3.8	1.4
30	24-31	0.0	22.8	8.0	82	37	2.5	5.4	1.6

Source: Agriculture Research Farm, IAS, BHU, Varanasi

3.4 Experimental site

A homogeneous piece of land was selected from the composite block of the experimental farm, keeping in view the irrigation facilities and gradient of the soil.

3.5 Experimental material

In the present experiment nineteen genotype of cowpea [*Vigna unguiculata*(L.)Walp.] were under taken (Table 3.5.1) which were obtained from the Indian Institute of Horticulture Research Farm, Varanasi.

Table 3.5.1 Name of the genotypes of cowpea and their sources.

Genotype number	Name of the genotypes	Sources
L ₁	KashiGauri	IIVR, Varanasi
L ₂	KashiShyamal	IIVR, Varanasi
L ₃	KashiKanchan	IIVR, Varanasi
L ₄	KashiSudha	IIVR, Varanasi
L ₅	EC-390226	IIVR, Varanasi
L ₆	KashiNidhi	IIVR, Varanasi
L ₇	KashiUnnati	IIVR, Varanasi

L ₈	IC-202804	IIVR, Varanasi
L ₉	IC-201097	IIVR, Varanasi
L ₁₀	IC-202858	IIVR, Varanasi
L ₁₁	IC-209711	IIVR, Varanasi
L ₁₂	EC-1738	IIVR, Varanasi
L ₁₃	IC-39095	IIVR, Varanasi
L ₁₄	IC-37587	IIVR, Varanasi
L ₁₅	EC-30590	IIVR, Varanasi
L ₁₆	IC-307095	IIVR, Varanasi
L ₁₇	EC-37588	IIVR, Varanasi
L ₁₈	EC-390211	IIVR, Varanasi
L ₁₉	EC-110598	IIVR, Varanasi

3.6 Cultivation operation

3.6.1 Soil and field preparation

After deciding the experimental field, the field was irrigated to have optimum level of moisture condition. First, deep ploughing was done with disc plough and subsequent light ploughings were done with cultivator followed by planking. Then the required area was marked and 57 plots were prepared according to the layout plan.

3.6.2 Fertilizer application

Fertilizers was applied at the rate of 100 kg/ha nitrogen, 60 kg/ha phosphorus, 50 kg/ha potassium to the soil at the time of sowing. The complete dose of phosphorus and potassium fertilizer and one-third dose of nitrogenous fertilizers broadcasted in each plot in equal amount as basal dose before sowing. The remaining dose of nitrogenous fertilizers applied in two split doses.

3.6.3 Selection of seed and sowing time

Pure and healthy seeds of each genotype were collected before sowing. The seeds were soaked in water for 24 hours to get good germination. The distance between plants to plant was 20 cm and row to row 60 cm. The sowing was done on 15th June 2015.

3.6.4 Intercultural operation

The experimental plot was irrigated during the cropping period depends upon the rain and field moisture. Weeding was done four times according to the requirement of maintain uninterrupted growth of the crop.

3.6.5 Selection of plant for observation

In a field experiment, detail study of the entire population is rather difficult. Since all the plants get identical environment, *i.e.* some plants from the population were randomly selected for detailed investigation, then three plants were selected at random in each plot and tagged for identification.

3.7 Experimental design and layout

(A) Experimental design

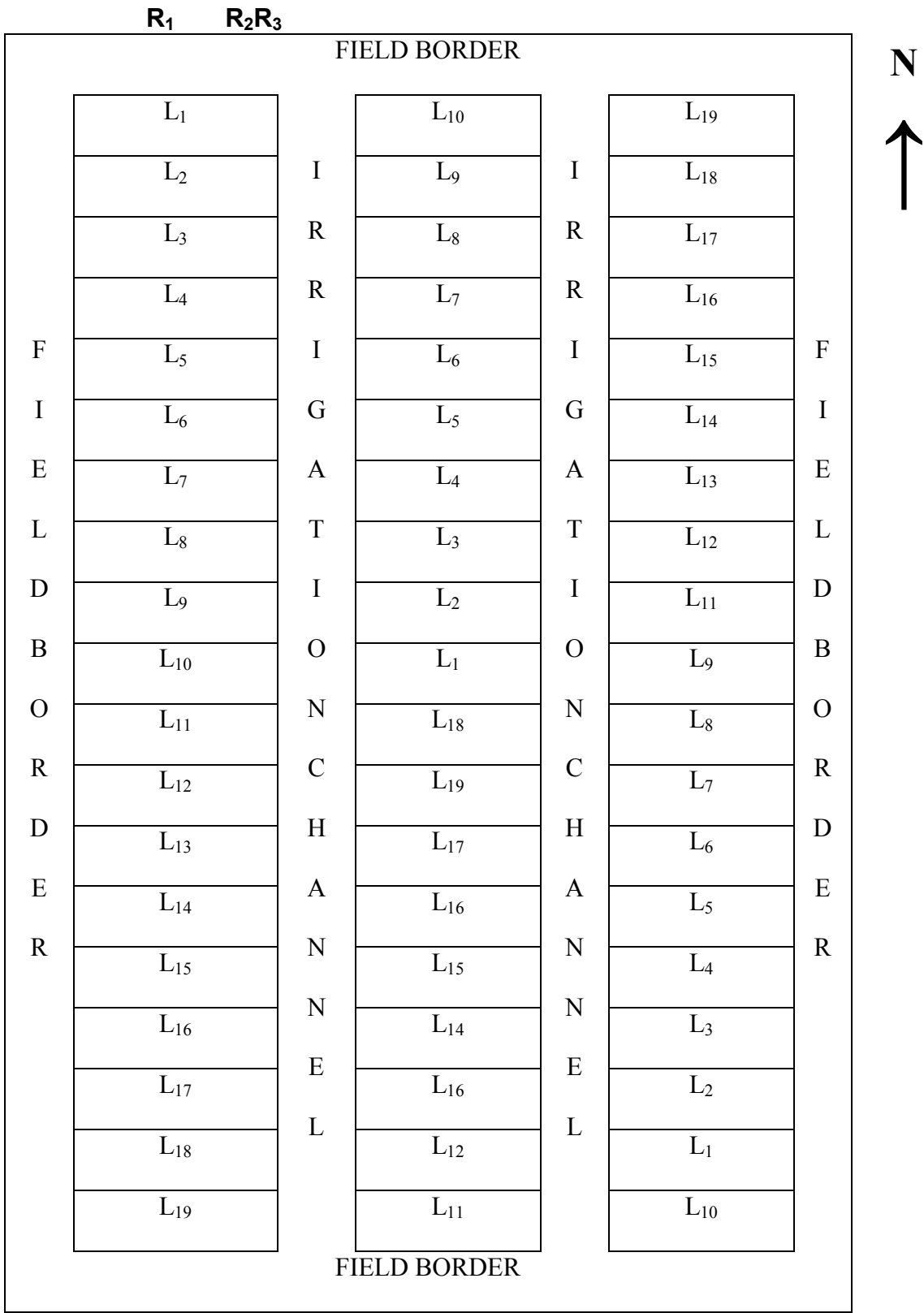
The experiment was laid out in randomized block design with three replications. The experiment was conducted at Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The plan of layout is given in Fig. No.1. the details of layout are as under.

(B) Details of the layout plan

(1)	Experimental design	RBD
(2)	Number of genotypes	19
(3)	Number of replications	3
(4)	Total number of plots	$3 \times 19 = 57$
(5)	Size of plot	$3 \times 3 \text{sqm}$

- | | | |
|------|--------------------|---------------------------------------|
| (6) | Field border | 1m |
| (7) | Block border | 1m |
| (8) | Main channel | 1m |
| (9) | Sub-channel | 1m |
| (10) | Date of sowing | 20 June, 2015 |
| (11) | Spacing: | Plant to plant 20cm |
| | Row to row | 60cm |
| (12) | Fertilizers | |
| | Nitrogen | 100 kg/h |
| | Phosphorus | 60 kg/h |
| | Potassium | 50 kg/h |
| (13) | Irrigation | 3 |
| (14) | Date of harvesting | From 20 July to 18 th Aug. |

3.8 Layout of experiment



3.9 Observations recorded

The technique of random sampling was adopted for recording the observations of various quantitative characters of cowpea. Three plants of each treatment from each replication were selected at random at the time of recording the data on various characters. Data of three plants were averaged replication wise and mean data was used for statistical analysis. Recommended package of practices were followed to raise a healthy crop.

3.9.1. Days to germination of 1st seedling

Number of days were counted from the date of sowing to the date of 1st seedling germination in the sown seeds of a plot of each treatment in each of the replication and averaged.

3.9.2. Days to 50% germination

Number of days were counted from the date of sowing to the date of 50% germination in the plants of a plot of each treatment in each of the replication and averaged.

3.9.3. Days to four leaf stage

Number of days were counted from the date of sowing to the date of four leaf emergence in the plants of a plot of each treatment in each of the replication and averaged.

3.9.4. Number of primary branches per plant

Total number of primary branches were counted at early stage of plant of a plot of each treatment in each of the replication and averaged.

3.9.5. Days to 1st flowering

Number of days to 1st flowering was counted from the date of sowing to the date of 1st flower blooming in the plants of the plot of each treatment in each of the replication and averaged.

3.9.6. Days to 50% flowering

Number of days to 50% flowering was counted from the date of sowing to the date of flower blooming in 50% of the plants of the plot for each treatment in each of the replication and averaged.

3.9.7. Number of pods per plant

3.9.8. Plant length (cm)

The length of the main stem of the plants from the ground level to the growing tip (terminal bud) was measured with the help of a meter scale in centimeter at flowering. Plant length was obtained from the average of five randomly selected observational plants at flowering.

3.9.9. Days to 1st pod emergence

Number of days were counted from the day of sowing to the date of 1st pod emergence of the plants of a plot for each treatment in each of the replication and averaged.

3.9.10. Number of flowers per plant

The total number of flowers from the three randomly selected plants was counted and their average value was counted at maturity.

3.9.11. Number of pods per plant

The total number of pods from the three randomly selected plants was counted and their average value was counted at maturity.

3.9.12. Green pod length (cm)

Randomly five pods were selected from each selected plants and their length was measured in cm.

3.9.13. Dry pod length (cm)

Lengths of dry pods were measured from the pod which was already selected for green pod length measurement.

3.9.14. Green pod diameter (cm)

Randomly five pods were selected from each selected plants and their diameter was measured in cm. The average was worked out for recording the pod diameter.

3.9.15. Pod weight (g)

The weights of randomly selected five pods were taken from each genotype per replication and average value was calculated to obtain the average pod weight in gram.

3.9.16. Number of seeds per pod

The fully matured seeds from each pod of the selected plants were harvested and threshed separately and weight of the seed was recorded with help of electronic balance. The average was worked out for recording the seed yield per plant in gram.

3.9.17.100 Seed weight (g)

The 100 seeds of each genotype in each replication were taken after seed extraction from dried pod and weighing was done and expressed in gram.

3.9.18. Pod yield per plant (kg)

Pod yield per plant was calculated after last picking. Its average was taken and expressed in kilogram.

3.9.19. Pod yield per hectare (q/ha)

As per spacing of plants from row to row and plant to plant, calculated total number of plant per hectare and it was multiplied with pod yield per plant in each genotypes and expressed in quintal.

3.9.20. Seedyield per hectare (q/ha)

As per spacing of plants from row to row and plant to plant, calculated total number of plant per hectare and it was multiplied with seed yield per plant in each genotypes and expressed in quintal.

3.9.21. Protein content (%)

The protein content was analyzed by using kjeldahl's method their average value was recorded.

3.9.22. Chlorophyll content (SPAD reading)

The SPAD reading of chlorophyll content measuring instrument chlorophyll meter and their average value was recorded.

3.9.23. TSS (⁰brix)

TSS (⁰brix) of green pods was recorded by using hand refractometer and their average value was recorded.

3.10. Statistical and biometrical analysis

The mean values of data obtained from the field were subjected to following statistical analysis.

- 3.1 Analysis of variance
- 3.2 Mean performance of genotypes
- 3.3 Parameters of variability
- 3.4 Correlation coefficient
- 3.5 Path coefficient analysis

3.10.1 Analysis of variance

Difference between nineteen genotype for different characters were tested for significance according to procedure given Panse and Sukhatame (1954). This also facilitates in dividing the total variance into phenotypic, genotypic and environmental

variance. Phenotypic, genotypic and environmental coefficient of variability was calculated as per method proposed by Burton (1952). The skeleton of ANOVA is given below.

Table 3.10.1 Skeleton of Analysis of variance (ANOVA)

Source	df	SS	MSS	F Value(calculated)
replication	(r-1)	SSr	$\frac{SSr}{r-1} = MSR$	$\frac{MST}{MSE}$
treatment	(t-1)	SSt	$\frac{SSt}{t-1} = MST$	
error	(r-1)(t-1)	SSe	$\frac{SSe}{(t-1)(r-1)} = MSE$	
Total	(rt-1)	TSS		

Where,

r = number of replications

df = degree of freedom

SSt = treatment sum of square

TSS = Total sum of square

MSR = replication mean sum of square

Test of significance

t = number of treatments

SSr = replication sum of square

SSe = error sum of square

MST = treatment mean sum of square

MSE = error mean sum of square

If the variance ratio (or) F-calculated value [V_t/EMS] of treatment was greater than the F-table value at 5% and 1% level of significance, the variance between treatments was considered to be significant. If the F-calculated value is less than F-tabulated value, the differences between treatments were considered to be non-significant.

3.10.2 Genetic variability

3.10.2.1 Mean

The mean is the average value of the character in a sample *i.e.*, mean value is determined by dividing the total number by corresponding number of observation.

$$\text{Mean} = \frac{\text{Sum of all observation}}{\text{Number of observation}}$$

$$\text{Mean } \bar{X} = \frac{\sum x}{N}$$

Where,

$\sum x$ = Sum of all observations for each character in each replications

N = Corresponding number of observation

3.10.2.2 Range

It was taken as the difference between the highest and lowest mean value for each character. It is the simple measure of variability and gives an idea of the dispersion or spread of the observations in sample.

$$\text{Range} = X_n - X_1$$

Where,

X_n = Highest mean value of character

X_1 = Lowest mean value of character

3.10.2.3 Component of variance

It is defined as the average of the square deviation from the mean or it is the square of the standard deviation. It is an effective measure of variability which permits partitioning of various components.

(a) Genotypic variance

The genotypic variance (VG or σ^2_g) is variance due to the genotype present in the population. This was calculated by the formula suggested by Burton (1952).

$$\sigma^2_g = \frac{MS_t - EMS}{\text{Number of replication}}$$

Where,

MS_t = Mean sum of squares due to treatment

EMS = Error mean sum of squares

(b) Phenotypic variance

Phenotypic variance (VP or σ^2_p) denotes the total variance present in a population for particular character and is calculated by following formula.

Phenotypic variance (σ^2_p) = Genotypic variance + Error variance.

3.10.2.4 Standard error of mean (SEM)

Standard error of mean was cultivate by following formula

$$SEM = \sqrt{\frac{2EMS}{r}}$$

3.8.2.5 Critical differences (CD)

The critical difference was calculated by following formula

$$CD = \sqrt{\frac{2EMS}{r}} \times t \text{ value}$$

Where,

tvalue = table value at error degree of freedom at 5% level of significance

r = Number of replication

EMS = Error mean sum of squares

Significant 'F' value indicates that there is significant difference among the treatment. But to compare any two particular treatments, it is tested against CD value.

3.10.2.6 Coefficient of variation (CV)

A measurement of variance which is independent of the unit of measurement is provided by the standard deviation expressed as percentage of mean. This is known as ccoefficient of variation (CV).

$$CV (\%) = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

The phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) was calculated by the formula given by Burton (1952).

$$(a) \quad PCV (\%) = \frac{\text{Phenotypic standard deviation}}{\text{Grand Mean}} \times 100$$

$$= \frac{\sqrt{VP}}{\bar{X}} \times 100$$

$$(b) \quad GCV (\%) = \frac{\text{Genotypic standard deviation}}{\text{Grand Mean}} \times 100$$

$$= \frac{\sqrt{VG}}{\bar{X}} \times 100$$

3.11 Heritability (broad sense)

Heritability in bread sense was calculates using the formula suggested by Burton and Devane (1953).

$$h^2 = \frac{VG}{VP} \times 100$$

Where,

h^2 = Heritability

$VG (\sigma^2g)$ = genotypic variance

$VP (\sigma^2p)$ = phenotypic variance

Heritability (%) = Heritability coefficient $\times 100$

3.12 Genetic advance

Improvement in the mean genotype value of selected plants over the parental population is known as genetic advance. The genetic advance *i.e.*, the expected genetic seed was worked out by using the formula suggested by Johnson *et al.* (1955).

$$\begin{aligned} \text{G.A.} &= \frac{\sigma^2_g}{\sigma^2_p} k. \sigma_p \\ &= h^2. K. \sigma_p \end{aligned}$$

Where,

$$\begin{aligned} h^2 &= \text{Heritability coefficient} \\ K &= \text{Selection differential standard units which is 2.06 for 5\% selection intensity} \\ \sigma_p &= \text{Phenotypic standard deviation} \\ \text{G.A.} &= \text{Genetics advance} \end{aligned}$$

Genetic advance as percent of mean (GA % M)

It was calculated by the following formula:

$$\text{Genetic Advance as Percentage of Mean} = \left(\frac{GA}{\bar{X}} \right) \times 100$$

GA = Genetic advance

$\bar{X}$ = Mean of character

3.13 Correlation

(a) Correlation coefficient

Correlation coefficient, represented as 'r' was used to measure the association between two attributes and this was computed in terms of genotypic and phenotypic correlation coefficient based on variance and covariance which are given below:

i. Genotypic correlation coefficient

Genotypic correlation coefficient was calculated by the following formula

$$r_g(x,y) = \frac{\text{Genotypic covariance of x and y}}{\sqrt{\text{Genotypic var.}(x) \cdot \text{Genotypic var.}(y)}}$$

Where,

$r_g(x,y)$ = Genotypic correlation coefficient between x and y

ii. Phenotypic correlation coefficient

It was calculated by the following formula:

$$r_g(x,y) = \frac{\text{Phenotypic covariance of x and y}}{\sqrt{\text{Phenotypic var.}(x) \cdot \text{Phenotypic var.}(y)}}$$

Where,

$r_g(x,y)$ = Phenotypic correlation coefficient between x and y

iii. Test of significance

The significance of correlation coefficient was tested with the help of ‘r’ value (statistical table by Fisher and Yates) at n-2 degree of freedom at 5% and/or 1% level of significance. If the calculated value of correlation coefficient is greater than the tabulated value of ‘r’ at n-2 degree of freedom, the correlation was considered to be significant, where ‘n’ is number of treatment.

3.14 Path analysis

Wright (1921) defined the path coefficient as “the ratio of the deviation when all causes are constant, except three in question, the variability of which kept in changed”. It is simply a standardized partial regression coefficient and measures the direct influence of three variable upon another and permits the separation of the correlation coefficient into component of direct and indirect effect. The use of the method requires a cause and effect situation among variables (Dewey and Lu, 1959).

3.14.1 Causal system

The causal system indicates mutual association as measured by correlation coefficient and the direct influences as measured by path coefficient. The path coefficients were obtained by solving the simultaneous equations which express the basic relationship between correlation coefficient and path coefficient by Dewey and Lu (1959).

3.14.2 Computation of direct effects

In order to estimate the direct effects of different component traits, first a path diagram was constructed using the estimates of correlation coefficients. With the help of the path diagram simultaneous equations are developed as follows:

$$r_{x_1y} = P_{x_1y} + r_{x_1x_2}P_{x_2y} + r_{x_1x_3}P_{x_3y} + \dots + r_{x_1x_9}P_{x_9y}$$

$$r_{x_2y} = r_{x_2x_1}P_{x_1y} + P_{x_2y} + r_{x_2x_3}P_{x_3y} + \dots + r_{x_2x_9}P_{x_9y}$$

$$\dots$$

$$r_{x_9y} = r_{x_9x_1}P_{x_1y} + r_{x_9x_2}P_{x_2y} + r_{x_9x_3}P_{x_3y} + \dots + P_{x_9y}$$

Where,

r_{x_iy} = Correlation between x_{ith} component trait and yield

P_{x_iy} = Path coefficient between the x_{ith} trait and yield

$r_{x_ix_j}$ = Coefficient of correlation between i^{th} and j^{th} characters

The P_{x_iy} is the estimated direct effect of variable x_i on Y (yield).

3.14.3 Computation of indirect effects

The indirect effect of a character *via*, another causal factor was obtained by multiplying the correlation coefficient between the two factors with the direct effect (*i.e.* path coefficient) of the later upon effect.



CHAPTER IV

EXPERIMENTAL FINDINGS

The present investigation entitled “**Genetic variability, correlation and path coefficient analysis in diverse genotypes of cowpea [*Vigna unguiculata* (L.) Walp.]**” was carried out during 2015. The experiment was conducted at the Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.), India.

The productivity of cowpea is very low due to non-availability of high yielding varieties with good plant types and resistance to diseases. It is a major hindrance to the breeders for further research. An attempt was made to identify such varieties, having high yields with good plant types and resistance to diseases. The results obtained from the investigations on quantitative and qualitative characters related to yield and yield contributing characters and disease resistance are presented in the following sub headings.

- 4.1 Analysis of variance
- 4.2 Mean performance of genotypes
- 4.3 Parameters of variability
- 4.4 Correlation coefficient
- 4.5 Path coefficient analysis

4.1 Analysis of variance

The analysis of variance for different characters. The result showed significant difference for twenty three characters under study among nineteen genotypes of cowpea. These characters were days to germination of 1st seedling, days to 50% germination, days to four emergence stage, number of primary branches per plant, days to first flowering, length of plant at flowering, days to 50% flowering, number of flowers per plant, days to first pod emergence, number of pods per plant, green pod length, dry pod length, diameter of pod, weight of pods, number of seeds per

pod, seed index (weight of 100 seed), yield of green pod per ha, yield of seed per ha, protein content (%), TSS (°Brix) and chlorophyll content (SPAD reading).

4.2 Mean performance of genotype

The mean value of 23 characters of 19 genotypes of cowpea have been presented in Table 4.2

4.2.1 Days to 1st seedling germination

It is apparent from the data pertaining to days to 1st seedling germination presented in Table 4.2.1 and graphically represented in Fig. 4.2.1 showed significant effect on germination of 1st seedling due to various genotypes. Genotypes KashiKanchan, KashiSudha and KashiUnnati (3.00 days) were earliest in producing 1st seedling which were statistically at par with genotype KashiShyamal (3.67 days) and significant to all other genotypes. Genotypes EC-390211 resulted in late germination of seedling (6.67 days) which was at par with EC-37588 genotype (6.08 days). Value of genotype ranged from 3.00 days to 6.67 days.

4.2.2 Days to 50% germination

Various genotypes showed significant effect on days to 50% germination of seedling data presented in Table 4.2.1 and graphically represented in Fig. 4.2.1. Genotypes KashiKanchan and KashiSudha earliest (3.33 days) in producing 50% germination which were statistically at par with genotype KashiShyamal, KashiNidhi and IC-202804 (4.33 days) and significant to all other genotype. Genotype EC-390211 took longest time of 50% germination of seedling (7.00 days) which was at par with KashiGauri (6.33 days), IC-209711 (6.67 days), EC-1738 (6.33 days), EC-30590 (6.67 days), EC-110598 (6.33 days) and EC-110598 (6.33 days). The value of genotypes ranged between 3.33 days to 7.00 days.

4.2.3 Days to four leaf emergence

It is apparent from the data pertaining to days to four leaf emergence presented in Table 4.2.1 and graphically represented in Fig. 4.2.1 showed significant effect on days to four leaf emergence due to various genotypes. The genotype KashiKanchan (7.00 days) was the earliest in producing four leaf emergence followed by Kashi

Table 4.2.1 Performance of genotypes for days to first seedling germination, days to 50% germination and days to four leaf stage

S. No.	Variety	Days to 1st seedling germination	Days to 50% germination	Days to four leaf stage
1	KashiGauri	5.67	6.33	8.67
2	KashiShyamal	3.67	4.33	8.00
3	KashiKanchan	3.00	3.33	7.00
4	Kashiudha	3.00	3.33	8.00
5	EC-390226	4.00	5.33	9.67
6	KashiNidhi	4.00	4.33	9.67
7	KashiUnnati	3.00	5.00	9.67
8	IC-202804	4.67	4.33	9.33
9	IC-201097	4.33	4.67	10.33
10	IC-202858	5.67	5.33	9.33
11	IC-209711	5.67	6.67	10.33
12	EC-1738	4.67	6.33	9.67
13	IC-39095	4.67	5.67	9.33
14	IC-37587	4.67	5.33	10.67
15	EC-30590	5.33	6.67	10.67
16	IC-307095	5.67	5.33	10.67
17	EC-37588	6.00	6.33	11.67
18	EC-390211	6.67	7.00	10.67
19	EC-110598	5.67	6.33	10.67
	C.D. at 5%	0.887	0.984	0.982

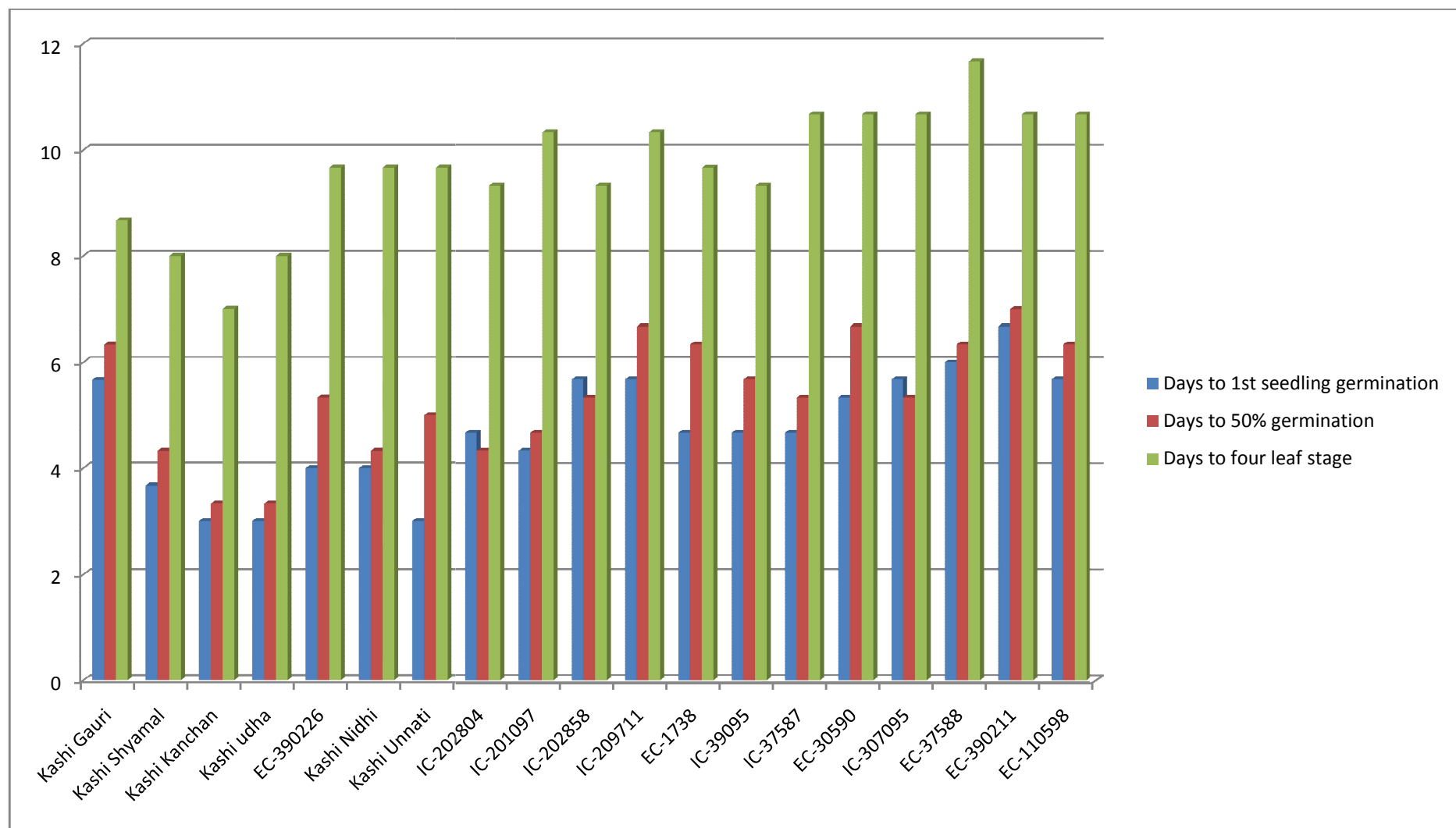


Fig. 4.2.1 Performance of genotypes for days to first seedling germination, days to 50% germination and days to four leaf stage

Sudha (8.00 days) and KashiShyamal (8.20 days). These genotype were statistically at par with each other and significant to all other genotype. The genotype EC-37588 (11.67 days) took longest time of for four leaf stage. The value of other genotypes ranged between 7.00 days to 11.67 days.

4.2.4 Number of primary branches per plant

Various genotypes showed significant effect on number of primary branches per plant presented in Table 4.2.2 and graphically represented in Fig. 4.2.2. The genotype KashiSudha, KashiUnnati and EC-390226 (4.00) were producing maximum number of primary branches per plant followed by KashiNidhi (3.67) KashiShyamal (3.33). These genotype were statistically at par with each other and significant to all other genotypes whereas, the genotypes EC-110598 and IC-307095 (2.67) took minimum number of primary branches per plant and were significantly at par with each other. The value of other genotypes ranged between 2.67 to 4.00.

4.2.5 Days to 1st flowering

Various genotypes showed significant effect on days to 1st flowering presented in Table 4.2.2 and graphically represented in Fig. 4.2.2. The genotype KashiUnnati was the earliest in producing 1st flower with 30.33 days, followed by KashiShyamal (43.00 days) and KashiSudha (43.00 days). These genotype were statistically at par with each other and significant to all other genotypes whereas, the genotype EC-110598 took longest time of 58.65 days for 1st flowering. The value of other genotypes ranged between 30.33 days to 58.65 days.

4.2.6 Days to 50% flowering

From the data presented in Table 4.2.2 and graphically represented in Fig. 4.2.2 showed significant effect on days to 50% flowering. The genotype KashiUnnati was the earliest in producing 50% flowering with 35.33 days, followed by KashiSudha (46.00 days), KashiShyamal (46.00 days) and KashiKanchan (46.67 days). These genotype were statistically at par with each other and significant to all other genotypes whereas, the genotype EC-110598 (66.00 days) resulted in late flowering which was at par with EC-37588 (64.00 days). The value of days to 50% flowering other genotypes ranged between 35.33 days to 66.00 days.

Table 4.2.2 Performance of genotypes for no. of primary branches/plant, days to first flowering and days to 50% flowering

S. No.	Variety	No. of primary branches/plant	Days to first flowering	Days to 50% flowering
1	KashiGauri	3.00	40.00	43.67
2	KashiShyamal	3.33	43.00	46.00
3	KashiKanchan	3.00	42.33	46.67
4	KashiSudha	4.00	43.00	46.00
5	EC-390226	4.00	46.33	50.00
6	KashiNidhi	3.67	45.33	46.00
7	KashiUnnati	4.00	30.33	35.33
8	IC-202804	3.00	47.00	52.67
9	IC-201097	3.00	45.00	49.00
10	IC-202858	3.00	46.67	48.67
11	IC-209711	3.00	46.00	52.33
12	EC-1738	3.00	49.33	56.00
13	IC-39095	3.00	49.67	58.33
14	IC-37587	2.67	52.67	60.33
15	EC-30590	3.00	53.00	60.33
16	IC-307095	3.00	55.00	62.00
17	EC-37588	3.00	54.67	64.00
18	EC-390211	3.00	55.33	63.00
19	EC-110598	2.67	58.67	66.00
	C.D. at 5%	0.412	4.308	1.693

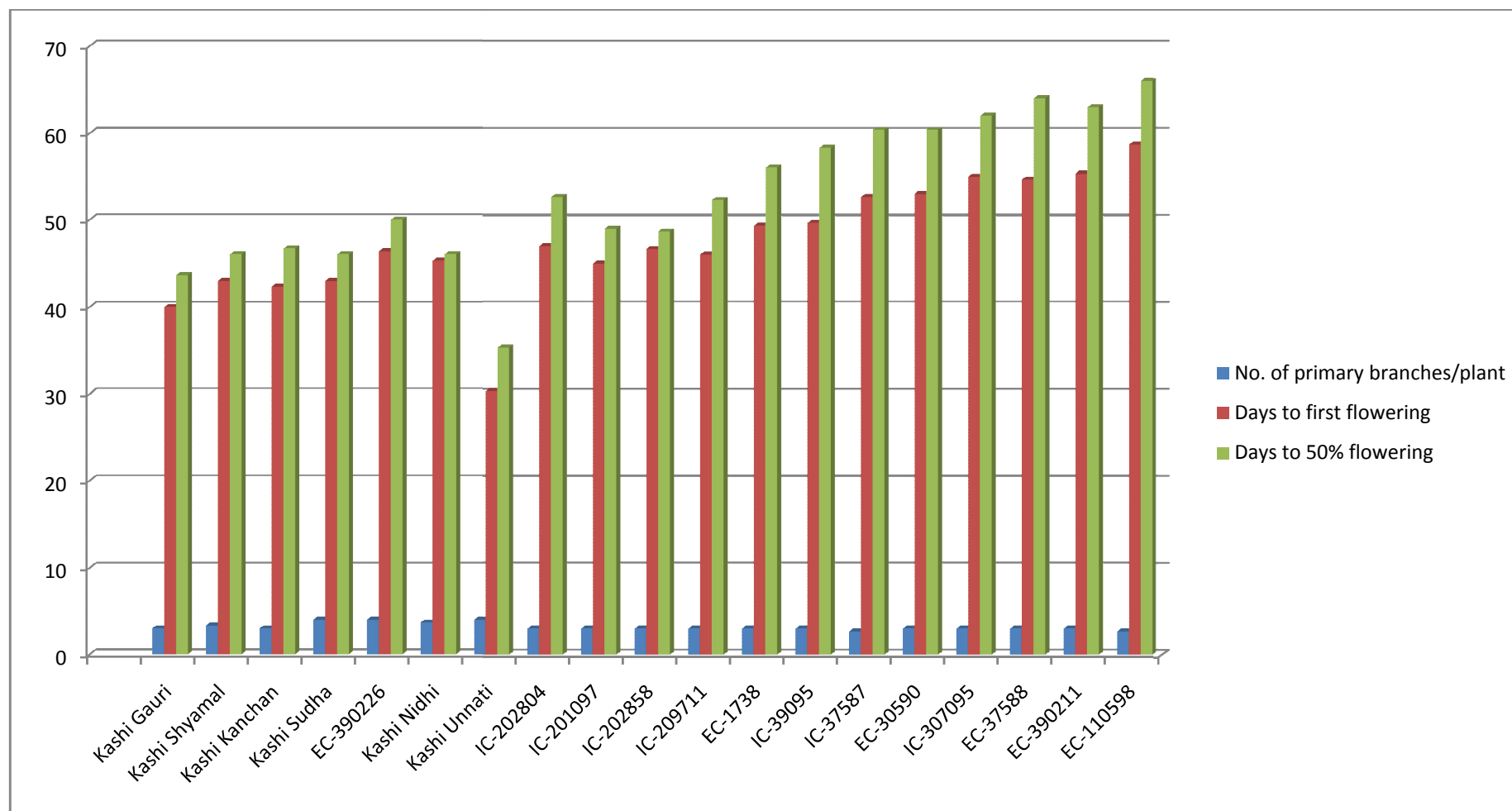


Figure 4.2.2 Performance of genotypes for no. of primary branches/plant, days to first flowering and days to 50% flowering

4.2.7 Length of Plant

Various genotypes showed significant effect on length of plant data presented in Table 4.2.3 and graphically represented in Fig. 4.2.3. Genotype KashiSudha exhibited maximum length of plant (77.67 cm) which was statistically at par to genotypes KashiUnnati (73.00 cm), EC-37588 (72.33 cm), EC-30590 (71.76 cm), EC-1738 (71.67 cm), IC-209711 (79.67 cm) and significant to all other genotypes. Minimum length was recorded with genotype KashiGauri (48.67 cm) followed by genotype KashiKanchan (54.00 cm), KashiShyamal (55.00 cm), EC-390226 (57.33 cm) and KashiNidhi (58.00 cm). The value of length of plant ranged between 48.67 cm to 77.67 cm.

4.2.8 Days to 1st pod emergence

It is apparent from the data pertaining to days to 1st pod emergence presented in data presented in Table 4.2.3 and graphically represented in Fig. 4.2.3. The genotype KashiUnnati was the earliest in producing 1st pod emergence with 36.67 days, followed by KashiNidhi (48.00 days) and KashiGauri (42.67 days). These were statistically at par with each other and significant to all other genotypes whereas, the genotype EC-110598 took longest time of 62.00 days for 1st pod emergence. The value of other genotypes ranged between 36.67 days to 62.00 days.

4.2.9 Number of flowers per plant

Data presented in Table 4.2.4 and graphically represented in Fig. 4.2.4 showed significant effect on number of flower per plant. The maximum 49.33 flower were recorded in genotype KashiShyamal followed by KashiGauri (49.00) and KashiUnnati (48.00) were statistically at par with each other and significant to all other genotypes. The genotype EC-37588 was recorded minimum no. of flowers with a value of 42.00 flowers. The value of number of flower per plant of rest of genotypes ranged between 42.00 to 49.33 flowers.

4.2.10 Number of pods per plant

It is apparent from the data pertaining to number of pods per plant presented in Table 4.2.4 and graphically represented in Fig. 4.2.4. The maximum 22.00 pods were

Table 4.2.3 Performance of genotypes for plant length at flowering time and days to first pod emergence

S. No.	Variety	Plant length at flowering time (cm)	Days to first pod emergence
1	KashiGauri	48.67	42.67
2	KashiShyamal	55.00	45.67
3	KashiKanchan	54.00	44.57
4	KashiSudha	77.67	46.67
5	EC-390226	57.33	49.33
6	KashiNidhi	58.00	48.00
7	KashiUnnati	73.00	36.67
8	IC-202804	66.33	50.33
9	IC-201097	66.00	48.67
10	IC-202858	69.33	48.67
11	IC-209711	70.67	49.00
12	EC-1738	71.67	52.33
13	IC-39095	68.00	53.00
14	IC-37587	67.33	56.00
15	EC-30590	71.67	56.00
16	IC-307095	68.00	57.67
17	EC-37588	72.33	57.67
18	EC-390211	68.33	58.33
19	EC-110598	65.67	62.00
	C.D. at 5%	8.821	1.778

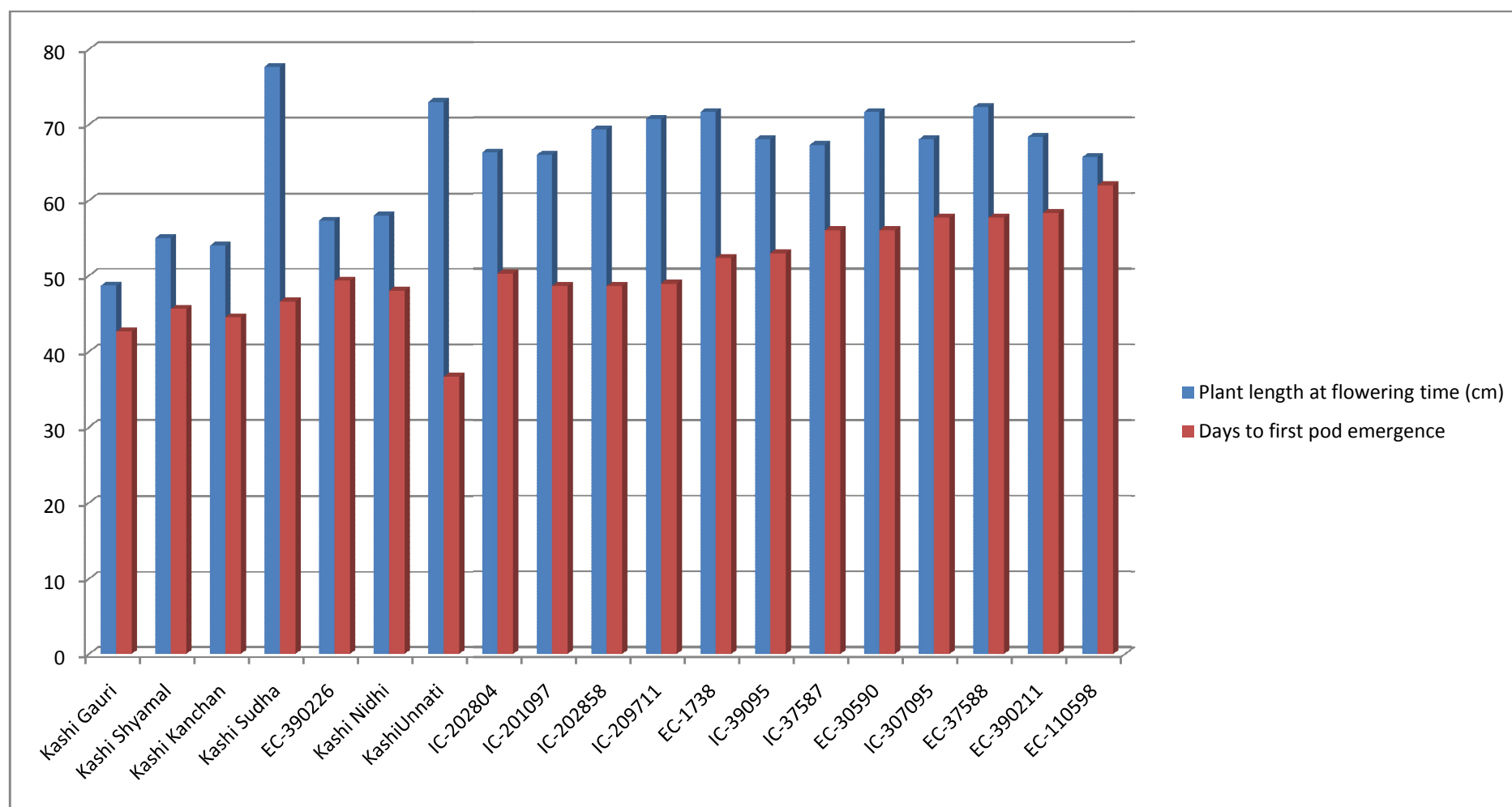


Figure 4.2.3 Performance of genotypes for plant length at flowering time and days to first pod emergence

Table 4.2.4 Performance of genotypes for no. of flowers and pods per plant

S. No.	Variety	No of flowers per plant	No of pods per plant
1	KashiGauri	49.00	22.00
2	KashiShyamal	49.33	15.67
3	KashiKanchan	47.00	17.33
4	KashiSudha	46.67	12.67
5	EC-390226	40.33	16.67
6	KashiNidhi	47.00	13.33
7	KashiUnnati	48.00	14.67
8	IC-202804	44.00	16.33
9	IC-201097	32.33	12.33
10	IC-202858	28.33	10.00
11	IC-209711	26.67	13.33
12	EC-1738	28.67	4.67
13	IC-39095	28.67	4.33
14	IC-37587	23.67	5.00
15	EC-30590	25.00	2.00
16	IC-307095	26.00	3.67
17	EC-37588	22.67	2.00
18	EC-390211	30.33	3.67
19	EC-110598	27.33	4.00
C.D. at 5%		3.314	2.554

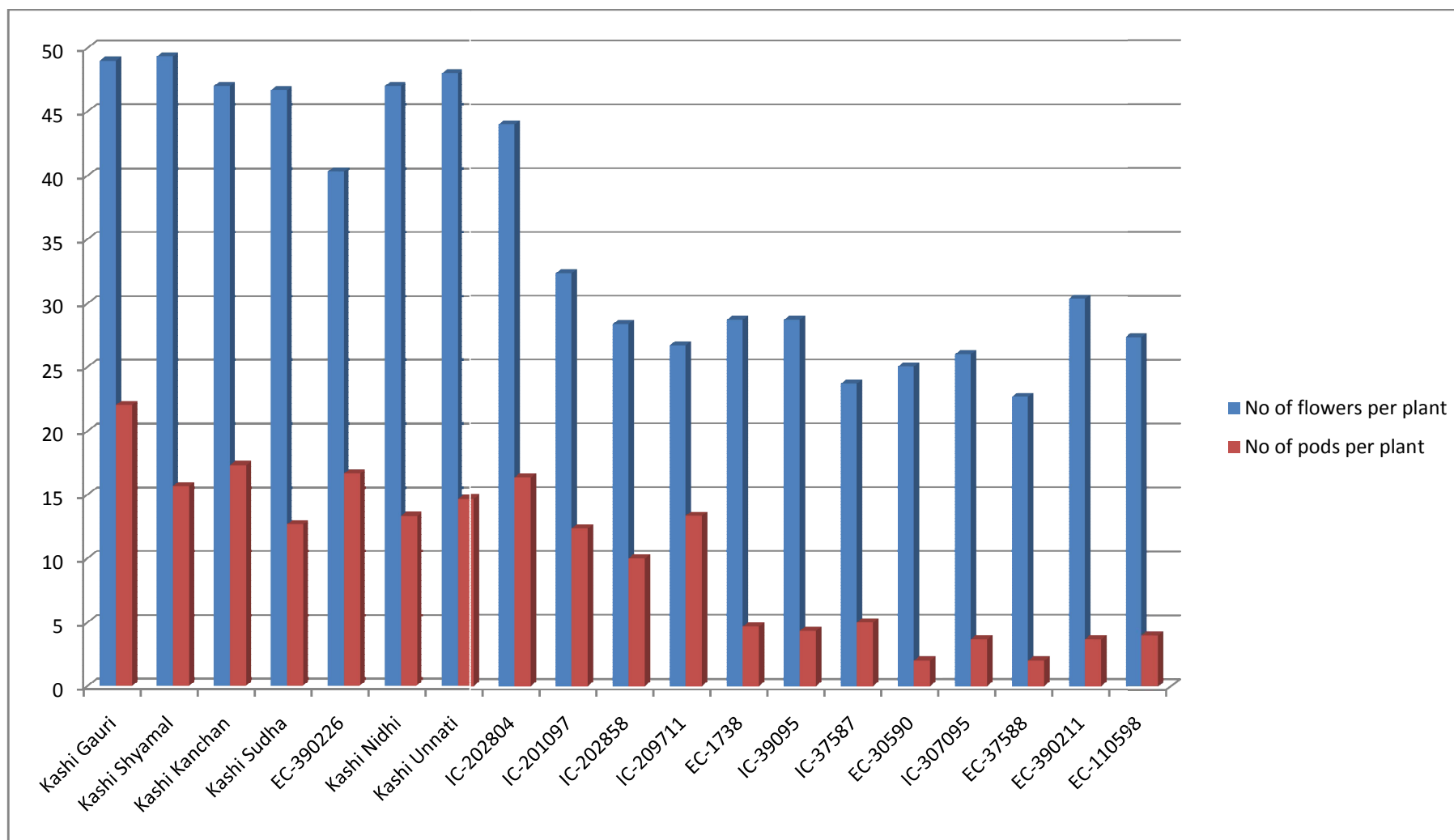


Figure 4.2.4 Performance of genotypes for no. of flowers per plant and no. of pods per plant

recorded in genotype KashiGauri followed by KashiKanchan (17.33) and KashiShyamal (15.67). These were statistically at par with each other and significant to all other genotypes, whereas genotype EC-30590 gave significantly lower number of pods per plant (2.00). The value of number of pods per plant of genotypes ranged between 2.00 to 22.00 pods.

4.2.11 Green pod length (cm)

The length of green pod was varied significantly in different genotypes presented in Table 4.2.5 and graphically represented in Fig. 4.2.5. The maximum length of green pod was recorded in genotype KashiNidhi (40.24 cm) followed by KashiShyamal (32.49 cm) and KashiUnnati (30.47 cm). These were statistically at par with each other and significant to all other genotypes whereas, genotype EC- 37588 was top most significant with a minimum value of 9.63 cm length. The green pod length of different genotypes was recorded in the range of 9.63 to 40.24.

4.2.12 Dry pod length (cm)

The length of dry pod was varied significantly in different genotype presented in Table 4.2.5 and graphically represented in Fig. 4.2.5. The maximum length of dry pod was recorded in genotype KashiNidhi (38.63 cm) followed by KashiShyamal (29.01 cm) and KashiUnnati (28.67 cm). These were statistically at par with each other and significant to all other genotypes whereas, genotype EC- 37588 was top most significant with a minimum value of 7.97 cm length. The dry pod length of different genotypes was recorded in the range of 7.97 cm to 38.63 cm.

4.2.13 Diameter of green pod (cm)

The diameter of green pod was varied significantly in different genotype presented in Table 4.2.6 and graphically represented in Fig. 4.2.6. The maximum diameter was recorded in genotype KashiGauri (0.77 cm) followed by KashiShyamal (0.73 cm), KashiNidhi (0.63 cm) and EC-30590 (0.63 cm). These were statistically at par with each other and significant to all other genotypes whereas, genotype EC- 37588 was top most significant with a minimum value of (0.40 cm). The value of other genotypes ranged between 0.40 cm to 0.77 cm diameter.

Table 4.2.5 Performance of genotypes for green pod length (cm) and dry pod length (cm)

S. No.	Variety	Green pod length (cm)	Dry pod length (cm)
1	KashiGauri	26.10	24.17
2	KashiShyamal	32.49	29.01
3	KashiKanchan	25.18	23.10
4	KashiSudha	26.29	25.40
5	EC-390226	15.55	13.17
6	KashiNidhi	40.24	38.63
7	KashiUnnati	30.47	28.67
8	IC-202804	16.56	14.37
9	IC-201097	16.72	14.57
10	IC-202858	19.88	16.30
11	IC-209711	14.92	12.53
12	EC-1738	12.58	11.57
13	IC-39095	14.47	12.47
14	IC-37587	15.26	13.80
15	EC-30590	14.62	12.07
16	IC-307095	11.19	9.60
17	EC-37588	9.63	7.97
18	EC-390211	16.33	15.40
19	EC-110598	13.92	12.73
C.D. at 5%		1.752	1.741

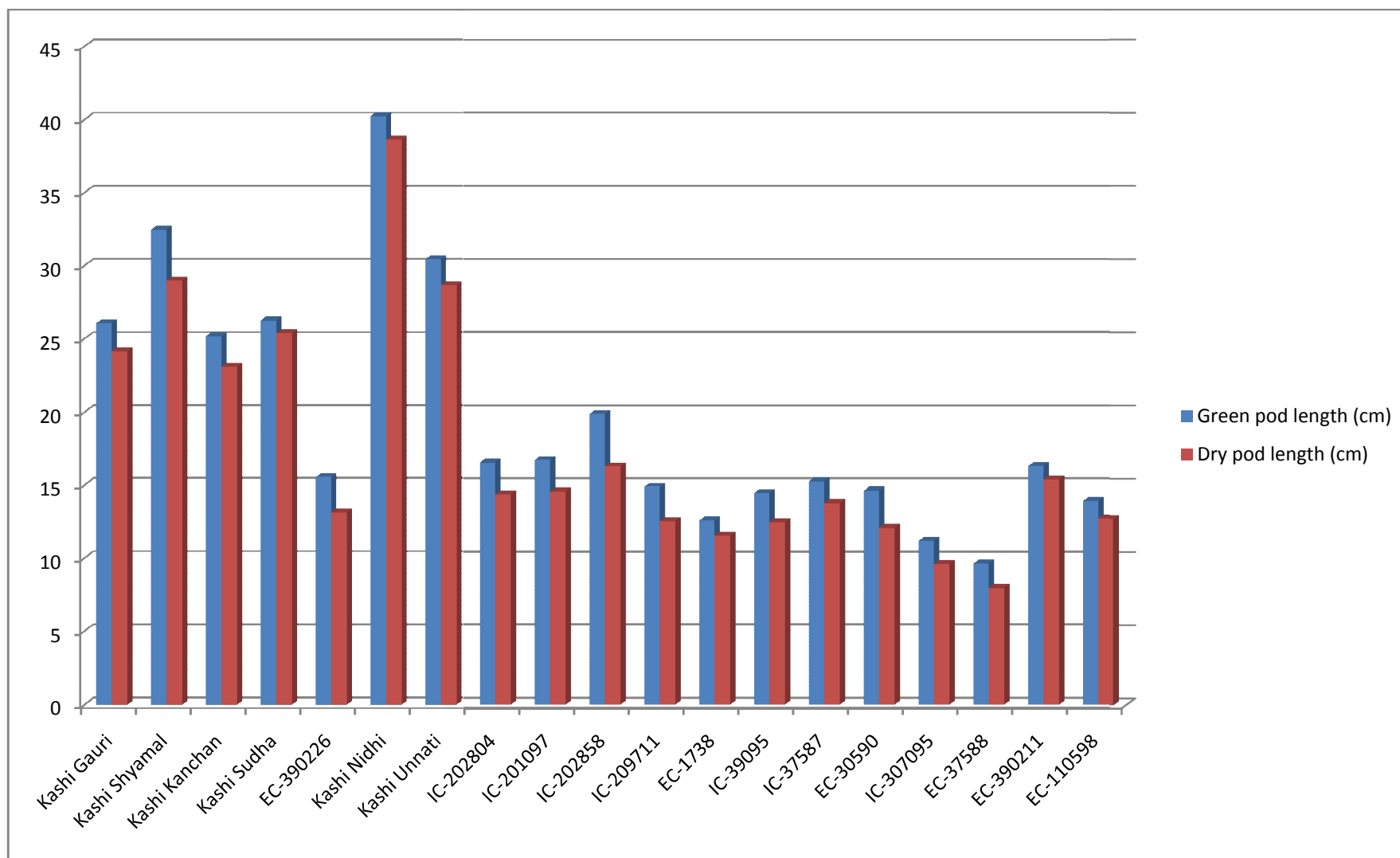


Figure 4.2.5 Performance of genotypes for green pod length (cm) and dry pod length (cm)

4.2.14 Green pod weight (g)

The weight of green pod was varied significantly in different genotype presented in Table 4.2.6 and graphically represented in Fig. 4.2.6. The maximum pod weight was recorded in genotype KashiNidhi (14.32g) followed by KashiShyamal (14.31g) and KashiUnnati (10.95g). These were statistically at par with each other and significant to all other genotypes. The genotype EC- 37588 was most significant with a minimum value of 1.88g. Among the tested genotypes pod weight varied between 1.88g to 14.32g.

4.2.15 Weight of green pod per plant (g)

Data presented in Table 4.2.6 and graphically represented in Fig. 4.2.6 showed significant effect on weight of green pod per plant. The maximum green pod weight was recorded in genotype KashiGauri (220.53g) followed by KashiShyamal (215.40g) and KashiNidhi (208.67g). These were statistically at par with each other and significant to all other genotypes. The genotype EC- 37588 was most significant with a minimum value of 5.70g. Among the tested genotypes green pod weight varied between 5.70g to 220.53g.

4.2.16 Yield of pod per plant (kg)

From observation data, presented in Table 4.2.8 and graphically represented in Fig. 4.2.8 showed significant effect on yield of pod per plant. The maximum yield of pod per plant was recorded in genotype KashiGauri (1.4kg) followed by KashiShyamal (1.20kg) and KashiNidhi (0.80kg). These were statistically at par with each other and significant to all other genotypes. The minimum yield per plant was recorded in genotype EC-37588 (0.40kg). The value of yield of pod per plant of other genotypes ranged between 1.4kg to 0.40kg per plant.

4.2.17 Yield of pod per hectare (q/ha)

It is apparent from the data pertaining to yield of pod per hectare presented in Table 4.2.4 and graphically represented in Fig. 4.2.4. The maximum yield was recorded in genotype KashiGauri (132.67 q/ha) followed by KashiShyamal (126.82 q/ha) and KashiNidhi (126.04 q/ha). These were statistically at par with each other

Table 4.2.6 Performance of genotypes for diameter of pod (cm), average wt. of pod and wt. of green pod per plant

S. No.	Variety	Diameter of pod (cm)	Average wt. of pod (g)	Wt. of green pod per plant (g)
1	KashiGauri	0.77	10.01	220.53
2	KashiShyamal	0.73	14.31	215.40
3	KashiKanchan	0.53	9.42	157.85
4	KashiSudha	0.50	7.90	99.33
5	EC-390226	0.50	4.43	94.77
6	KashiNidhi	0.63	14.32	208.67
7	KashiUnnati	0.43	10.95	167.93
8	IC-202804	0.50	3.88	77.98
9	IC-201097	0.43	4.00	50.77
10	IC-202858	0.53	5.04	60.33
11	IC-209711	0.43	4.23	69.97
12	EC-1738	0.47	3.08	18.55
13	IC-39095	0.47	3.34	20.27
14	IC-37587	0.43	2.81	18.47
15	EC-30590	0.63	3.16	10.30
16	IC-307095	0.50	3.12	14.55
17	EC-37588	0.40	1.80	5.70
18	EC-390211	0.57	3.50	15.63
19	EC-110598	0.53	2.58	10.76
	C.D. at 5%	0.126	0.864	8.533

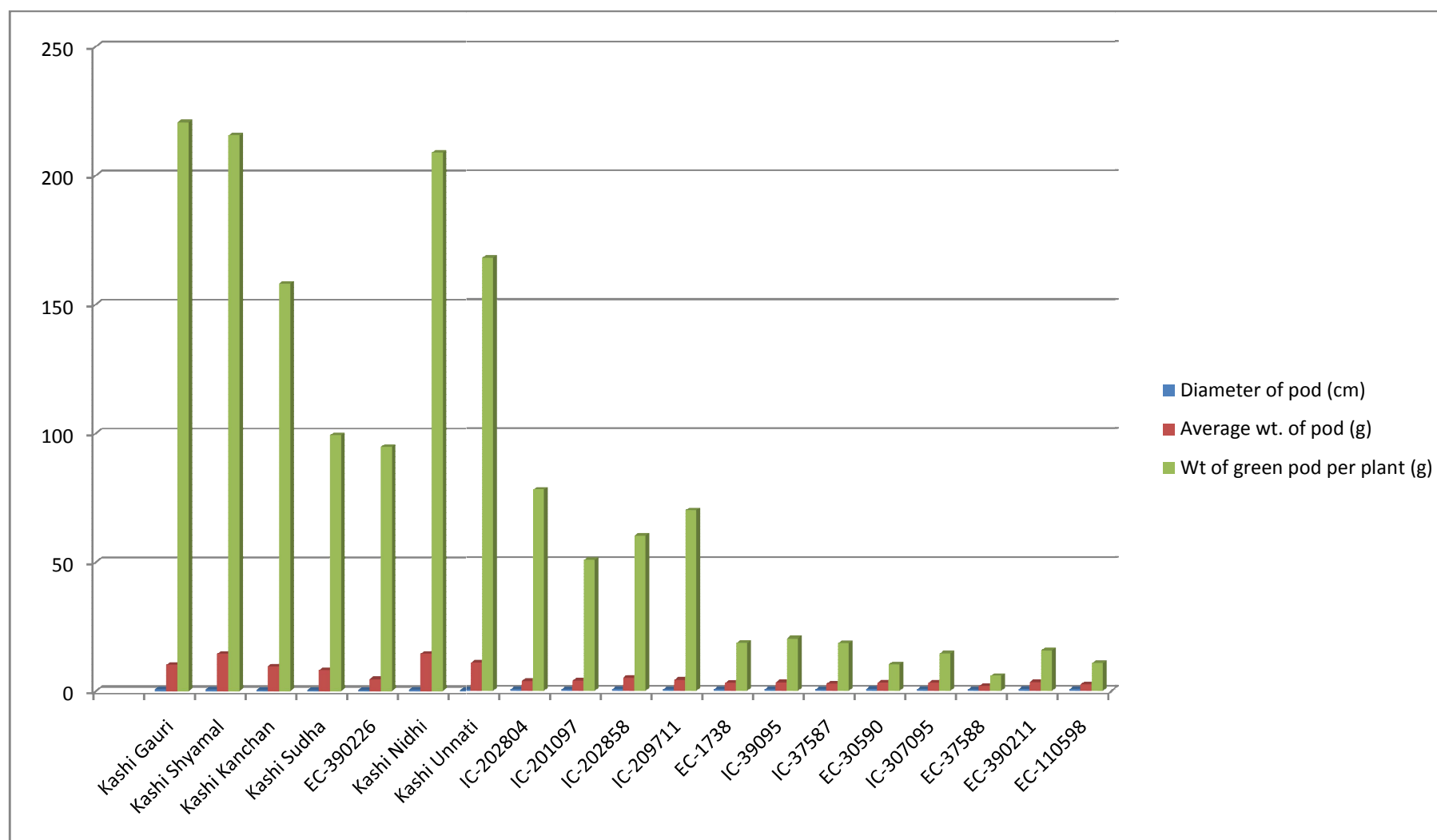


Figure 4.2.6 Performance of genotypes for diameter of pod (cm), average wt. of pod and wt. of green pod per plant

and significant to all other genotypes. The genotype EC-37588 was top most significantly minimum yield 3.65 q/ha. Value of yield of pod per hectare of the other genotypes ranged between 3.65 to 132.67 (q/ha) yield.

4.2.18 Number of seeds per pod

The data pertaining to the number of seeds per pod depicted in Table 4.2.7 and graphically represented in Fig. 4.2.7. The maximum number of seeds per pod was recorded in genotype IC-202804 with the value 18.00 seeds per pod followed by KashiNidhi (17.33) and KashiUnnati (17.00). These were statistically at par with each other and significant to all other genotypes. The minimum number of seeds per pod was recorded in genotype KashiGauri (12.33). The value of number of seeds per pod of other genotypes ranged between 12.33 to 18.00 seeds per pod.

4.2.19 100 Seed weight (g)

The data pertaining to the 100 Seed weight depicted in Table 4.2.7 and graphically represented in Fig. 4.2.7. The maximum seeds per pod were recorded in genotype KashiNidhi (14.47g) followed by KashiUnnati (14.33g) and KashiKanchan (14.08g). These were statistically at par with each other and significant to all other genotypes. The genotype IC-209711 was top most significant with a minimum value of 6.62g seed per pod. The 100 seed weight of different genotypes is ranged between 6.62 g to 14.47 g per pod.

4.2.20 Yield of seed (q/ha)

It is apparent from the data pertaining to yield of seed per hectare represented in Table 4.2.8 and graphically represented in Fig. 4.2.8. The maximum yield was recorded in genotype KashiGauri (9.76 q/ha) followed by KashiShyamal (8.83 q/ha) and KashiUnnati (7.04 q/ha). These were statistically at par with each other and significant to all other genotypes. The genotype EC-30590 was top most significant with a minimum yield of 1.37 (q/ha) yield. Value of yield of seed per hectare of the other genotypes ranged between 1.37 to 9.76 q/ha.

Table 4.2.7 Performance of genotypes for no. of seed per pod and seed index

S. No.	Variety	No. of seed per pod	Seed index (wt. of 100 seed)
1	KashiGauri	12.33	13.06
2	KashiShyamal	16.33	13.83
3	KashiKanchan	12.33	14.08
4	KashiSudha	14.33	12.29
5	EC-390226	16.00	8.55
6	KashiNidhi	17.33	14.47
7	KashiUnnati	17.00	14.23
8	IC-202804	18.00	9.05
9	IC-201097	16.00	7.66
10	IC-202858	13.67	11.60
11	IC-209711	13.67	6.62
12	EC-1738	14.67	6.80
13	IC-39095	15.67	10.81
14	IC-37587	14.67	6.06
15	EC-30590	12.67	11.24
16	IC-307095	15.33	8.62
17	EC-37588	14.33	8.44
18	EC-390211	15.00	8.67
19	EC-110598	15.33	12.90
	C.D. at 5%	2.745	1.190

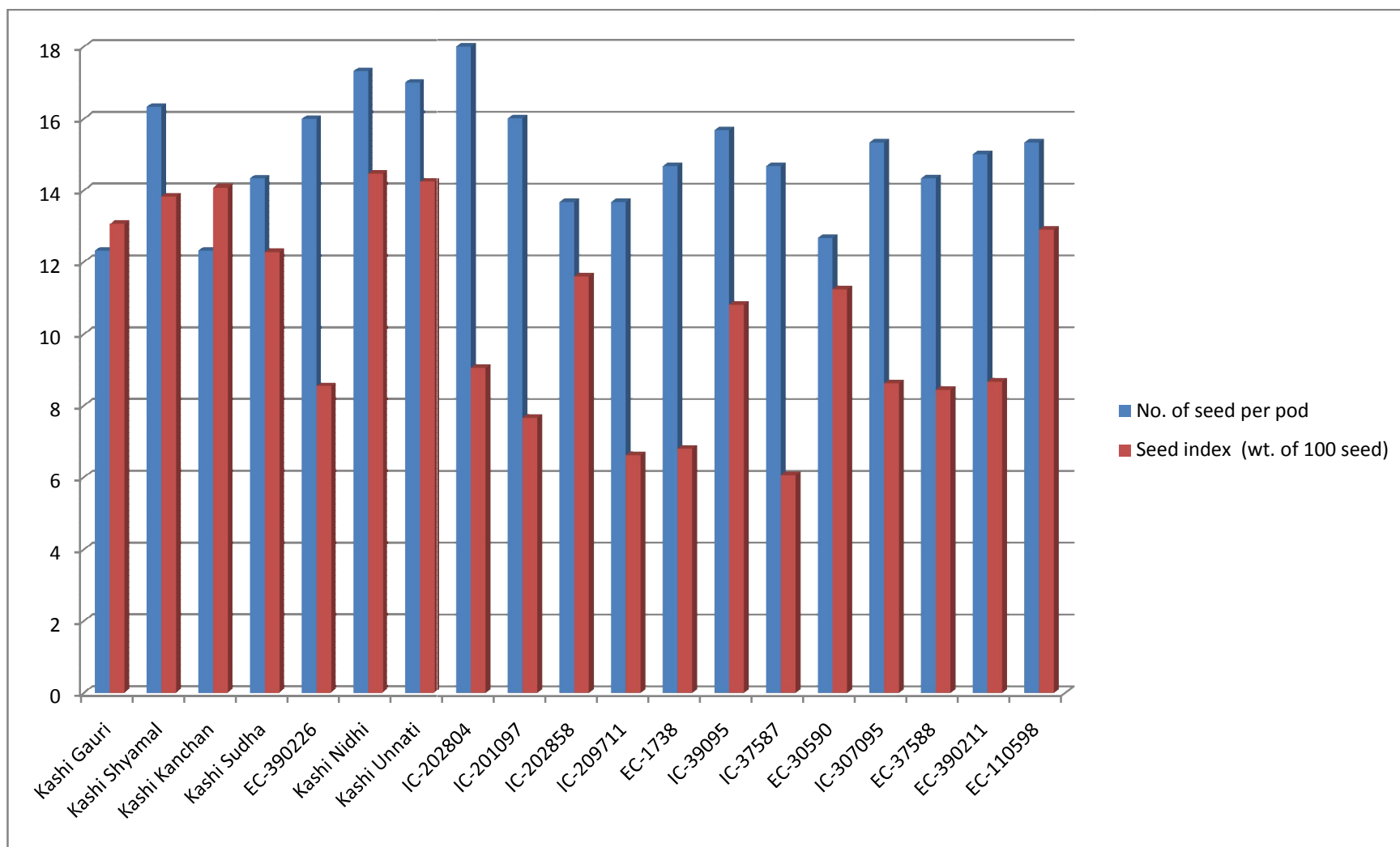


Figure 4.2.7 Performance of genotypes for no. of seed per pod and seed index

Table 4.2.8 Performance of genotypes for yield of green pod per plant, yield of green pod q/ha and yield of seed q/ha

S. No.	Variety	Yield of green pod per plant(kg)	Yield of green pod q/ha	Yield of seed q/ha
1	KashiGauri	2.43	132.67	9.76
2	KashiShyamal	1.57	126.82	8.83
3	KashiKanchan	1.83	96.39	6.48
4	KashiSudha	2.17	61.72	5.28
5	EC-390226	1.46	58.53	5.61
6	KashiNidhi	1.70	126.04	9.62
7	KashiUnnati	1.40	102.31	7.04
8	IC-202804	1.31	48.81	4.89
9	IC-201097	0.99	32.71	4.35
10	IC-202858	0.39	36.88	3.90
11	IC-209711	1.52	42.72	4.65
12	EC-1738	0.05	13.92	2.11
13	IC-39095	0.99	13.12	2.11
14	IC-37587	0.77	11.92	1.91
15	EC-30590	0.96	6.57	1.37
16	IC-307095	0.47	9.37	2.10
17	EC-37588	0.77	3.65	1.59
18	EC-390211	0.32	9.24	2.72
19	EC-110598	0.92	51.86	1.91
	C.D. at 5%	0.39	6.585	1.182

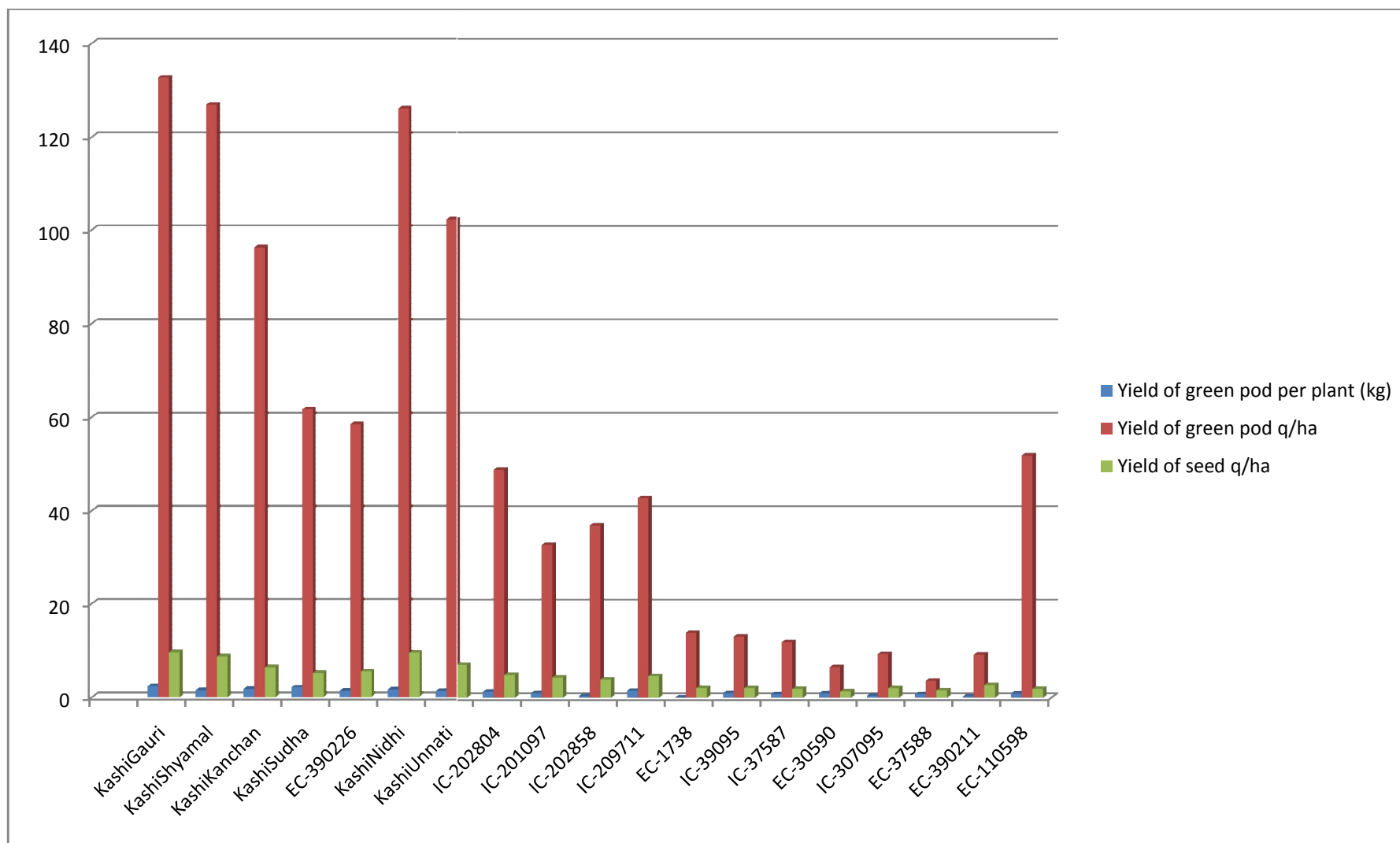


Figure 4.2.8 Performance of genotypes for yield of green pod per plant, yield of green pod q/ha and yield of seed q/ha

4.2.21 Protein content (%)

Data presented in Table 4.2.9 and graphically represented in Fig. 4.2.9 data pertaining to the protein content. The maximum protein content was recorded in genotype KashiUnnati (25.57%) followed by KashiKanchan (23.66%) and KashiShyamal (21.51%). These were statistically at par with each other and significant to all other genotypes. The genotype EC-390211 was top most significant with a minimum value of 15.68%. The protein content of different genotypes is ranged between 15.68% to 25.57%.

4.2.22 Chlorophyll content (SPAD reading)

Data presented in Table 4.2.9 and graphically represented in Fig. 4.2.9 showed significant effect on chlorophyll content (SPAD reading). The maximum SPAD reading chlorophyll content was recorded in genotype KashiGauri (50.53 SPAD reading) followed by EC-1738 (47.77 SPAD reading) and KashiUnnati (46.90 SPAD reading). These were statistically at par with each other and significant to all other genotypes. The genotype EC-390211 was top most significant with a minimum value of 27.15 SPAD reading. The chlorophyll content (SPAD reading) of different genotypes is observed between 27.15 to 50.53 SPAD readings.

4.2.23 TSS (°Brix)

Various genotypes showed significant effect on TSS (°Brix) presented in Table 4.2.9 and graphically represented in Fig. 4.2.9. The maximum TSS was recorded in genotype IC-39095 (11.33 °Brix) followed by IC-37588 (11.03 °Brix) and KashiGauri (10.73 °Brix). These were statistically at par with each other and significant to all other genotypes. The genotype KashiNidhi was top most significant with a minimum value of 7.23 °Brix. The TSS (°Brix) of different genotypes is observed between 7.23 to 11.33 °Brix.

Table 4.2.9 Performance of genotypes for protein content (%), chlorophyll content (mg) and TSS (°Brix)

S. No.	Variety	Protein content (%)	Chlorophyll content (µg)	TSS (°Brix)
1	KashiGauri	20.97	50.53	10.73
2	KashiShyamal	21.51	43.17	10.27
3	KashiKanchan	23.66	45.83	9.97
4	KashiSudha	19.91	42.47	8.03
5	EC-390226	11.35	45.17	7.23
6	KashiNidhi	24.70	43.73	7.23
7	KashiUnnati	25.57	46.90	6.87
8	IC-202804	12.96	41.28	9.20
9	IC-201097	9.86	43.07	10.57
10	IC-202858	11.36	45.33	9.77
11	IC-209711	19.57	42.83	7.53
12	EC-1738	21.79	47.77	10.13
13	IC-39095	16.04	41.87	11.33
14	IC-37587	16.29	39.87	8.03
15	EC-30590	13.56	41.57	8.53
16	IC-307095	17.52	42.07	8.77
17	EC-37588	8.83	44.29	11.03
18	EC-390211	9.20	27.15	8.10
19	EC-110598	15.01	38.25	9.23
	C.D. at 5%	2.762	5.939	2.170

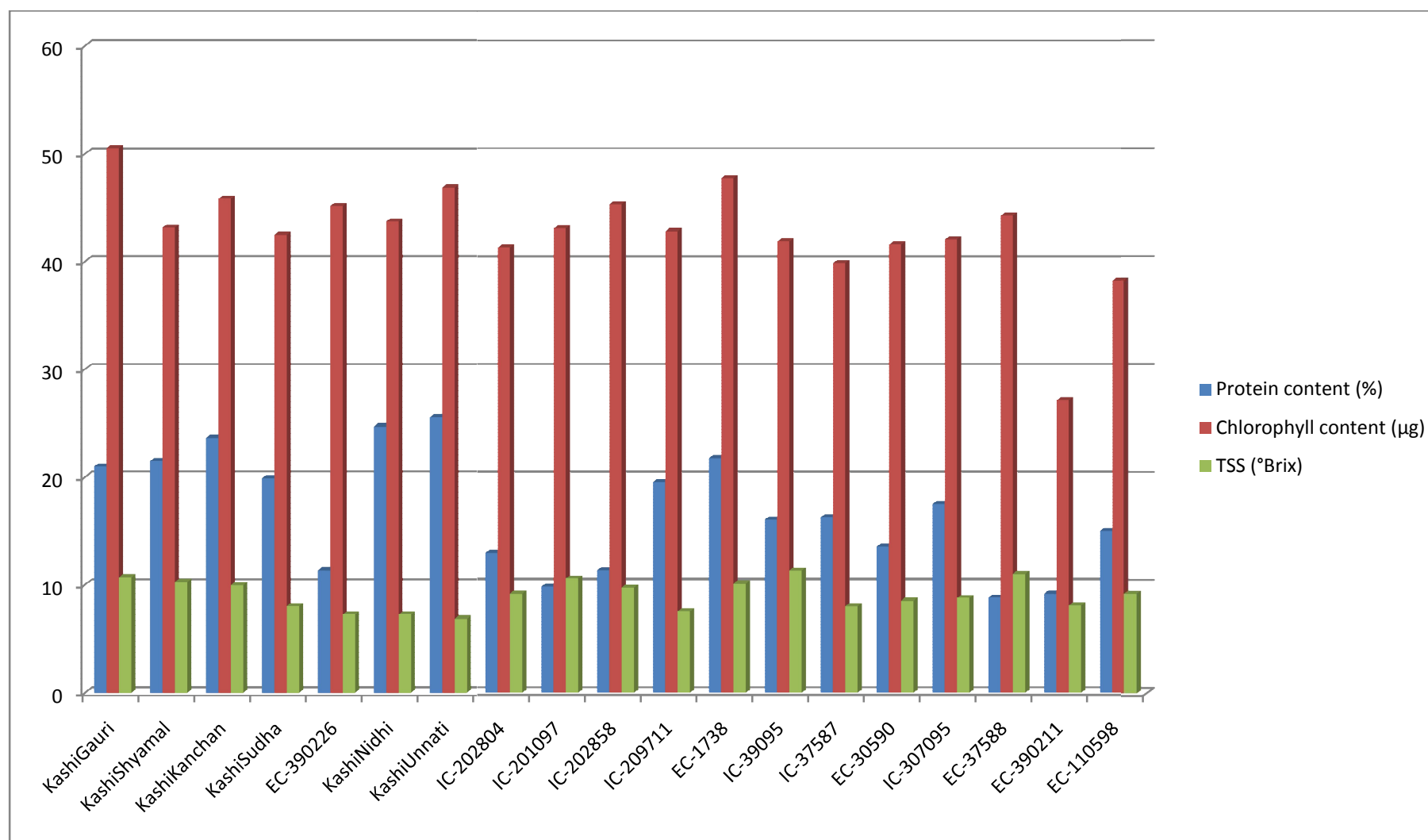


Figure 4.2.9 Performance of genotypes for protein content (%), chlorophyll content (mg) and TSS (°Brix)

4.3 Variability

The range, grand mean, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance and genetic gain are given in Table 4.3 and results are presented under the following heads.

Table 4.3 Mean range and genotypic variability parameters for eighteen characters in cowpea genotypes

S.No	Characters	Range	GCV (%)	PCV (%)	h ² (%)	GAM (%)
1	Days to germination of 1 st seedling	3.0-6.7	15.25	13.89	64.87	17.76
2	Days to 50% germination	3.3-7.0	17.03	6.78	93.88	13.80
3	Days to four leaf emergence	7.0-10.0	18.20	15.20	94.00	36.72
4	No. of primary branches/ plant	2.6-4.0	10.87	16.98	60.87	17.40
5	Days to first flowering	30-58	6.71	22.15	83.09	5.71
6	Length of plant at flowering	73-48	19.87	20.25	98.05	40.45
7	Days to 50% flowering	35-66	6.05	5.68	79.03	5.05
8	No. of flowers per plant	22-50	7.38	17.63	94.49	8.35
9	Days to first pod emergence	36-62	10.87	20.7	15.37	18.87
10	No of pods per plant	16-22	18.31	19.24	92.16	38.31
11	Green pod length	28-128	9.43	8.51	66.32	15.43
12	Dry pod length	27-38	7.45	6.89	59.99	14.98
13	Diameter of pod	0.4-0.7	6.00	5.97	32.43	4.00
14	Average wt. of pod	1.8-14	12.94	17.02	70.69	15.43
15	No. of seeds per pod	12-18	11.89	16.54	71.19	20.89
16	Seed index (Wt. of 100 seed)	1.5-9.7	7.96	8.51	65.66	12.96
17	Yield of green pod/ha	3-132	7.46	9.05	81.54	10.46
18	Yield of seed/ha	0.5-2	16.72	19.00	67.33	39.87

4.3.1 Range

A wide range of variation was recorded for all the characters. Range for days to 1st seedling germination varied from 3.00 days in genotype (KashiKanchan) to 6.67 days (EC-390211). In case of days to 50% germination it varied from 3.33 days (KashiKanchan) to 7.00 days (EC-390211). In case days to four leaf emergence it varied from 7.00 days (KashiKanchan) to 10.67 days (EC-390211). Number of primary branches varied from 2.67 (EC-110598) to 4 (KashiSudha). In case days to 1st flowering 30.33 days (EC-390226) to 58.65 days (EC-110598). Days to 50% flower appear varied from 35.33 days (KashiUnnati) to 66.67 days (EC-110598). The length of plant showed a markedly higher range of variation from 73.00cm (KashiUnnati) to 48.67cm (KashiGauri). In case days to 1st pod emergence appears to varied from 36.67 days (KashiUnnati) to 62.00 days (EC-110598). Number of flowers per plant appears to be varies from 22.67 (EC-37588) to 49.33 (KashiShyamal). The number of pod per plant varied from 22.00 (KashiGauri) to 16.00 (EC-30590). The length of green pod varied from 28.88cm (EC-37588) to 120.72cm (KashiNidhi). The length of dry pod varied from 27.97cm (EC-37588) to 38.63cm (KashiNidhi). The diameter of pod varied from 0.43cm (EC-37587) to 0.77cm (KashiGauri). The number of seeds per pod varied from 12.33 (KashiKanchan) to 18 (IC-202804). Average weight of pod varied from 1.88g (EC-37588) to 14.32g (KashiNidhi). The maximum pod yield per plant varied from 0.05kg/plant to 2.43kg/plant (KashiGauri) (EC-1738). The yield of green pod per hectare ranged between 132.67q/ha (KashiGauri) to 3.65q/ha (EC-37588). The yield of seed per hectare range between 9.76q/ha (KashiGauri) to 1.5q/ha. (EC-37588). The protein content in percentage varied from 25.57% in genotype (KashiUnnati) to 8.83% (EC-37588). The chlorophyll content in leaf range between 27.15 SPAD reading (EC-390211) to 50.53 SPAD reading (KashiGauri). The TSS of green pod varied from 7.23(°Brix) (KashiNidhi) to 11.33 °Brix (IC-39095).

4.3.2 Coefficient of variation

The result of maximum genotypic coefficient of variation revealed that length of plant exhibited moderate genotypic coefficient of variation value (19.87) followed by number of pods per plant (18.31), four leaf emergence (18.20), yield per hectare

(17.15), 50% germination (17.03), seed yield/hectare (16.72), protein content (16.89), 1st seedling germination (15.25) and pod weight (13.94), whereas number of seeds per pod (11.89), days to 1st pod emergence (10.87), number of primary branches per plant (10.40), length of green pod (9.43), weight of pod (8.42), chlorophyll content (8.34), 100 seed weight (7.96), yield of green pod per plant (7.46), number of flowers per plant (7.35), dry pod length (7.33), days to 1st flowering (6.71), days to 50% flowering (6.05), TSS (°Brix) 6.03 and pod diameter (6.00) recorded low genotypic coefficient of variation.

In general, the values of phenotypic coefficient of variation (PCV) were higher than the respective value of genotypic coefficient of variation (GCV).

The maximum value of phenotypic coefficient of variation revealed that the days to 1st flower appearance showed high phenotypic coefficient of variation value (22.15 days) whereas length of plant (20.25 cm), number of pods per plant (19.24), pod yield per hectare (18.88 q/h), number of flowers per plant (17.63), average pod weight (17.02 g) and number of seeds per pod (16.54), chlorophyll content (15.34 µg) four leaf emergence (15.20 days) show moderate phenotypic coefficient of variation value. The value of phenotypic coefficient of variation for yield of green pod per plant (9.05 kg), average 100 seed weight (8.98 g), pod length (8.51 cm), days to 1st flowering (6.26 days), pod diameter (0.97 cm), dry pod length (5.32 cm), TSS (6.33°Brix) and days to 50% flowering (5.68 days) showed low phenotypic coefficient of variation value.

4.4 Correlation Studies

Phenotypic and genotypic correlation coefficients were worked out among all 17 characters of 19 genotypes under study in all possible combination and results have been planted in Table 4.5.1 and Table 4.5.2, respectively. In general, the magnitude of genotypic correlation coefficient was higher than the respective phenotypic correlation coefficient.

Table 4.4.1 Genotypic correlation of yield and yield attributing characters of cowpea genotypes

	Days to germina tion of 1 st seedling	Days to 50% germinat ion	Pod yield per plant	No. of primary branches / plant	Days to first flowering	Days to 50 % flowering	No. of flower per plant	Days to first pod emerge nce	Length of plant at flowerin g time	No. of pod per plant	Green pod length	Pod yield per ha	Diameter of pod Seed	Average wt. of pod	No. of seed per pod	Seed Index (Wt.of 100 seed)
C1	1.00	0.14	0.03	0.101	0.032	0.043	0.011	0.06	0.022	0.111	0.41	0.051	0.01	0.06	0.51	0.12
C2		1.00	0.11	-0.2*	-0.04	-0.54	-0.05	-0.0	0.004	-0.03	0.80	0.033	0.04	0.50	0.60	0.30
C3			1.00	0.045	0.2**	0.043	0.03*	0.00	0.030	0.034	-0.04	-0.03	0.54	0.60	0.2**	0.01
C4				1.000	0.065	-0.01	-0.43	-0.3	-0.90	-0.04	0.50	0.2**	0.08	0.03	0.54	0.02
C5					1.000	0.5**	0.3**	0.34	0.003	0.7**	0.60	0.880	0.34	0.2*	0.32	0.30
C6						1.000	0.520	0.02	-0.06	-0.04	0.02	0.459	0.43	0.30	0.60	0.01
C7							1.000	0.04	0.04*	0.654	0.03	0.008	0.80	0.01	0.41	0.02
C8								1.00	0.033	0.640	-0.0	0.4**	0.39	0.02	0.85	0.03
C9									1.000	0.770	0.02*	0.065	0.42	-0.2	0.32	0.54
C10										1.000	0.040	-0.09	0.21	0.03	0.2**	0.32
C11											1.000	0.650	0.45	0.03	0.53	0.39
C12												1.000	0.32	0.43	0.02	0.42
C13													1.00	0.33	0.03	0.21
C14														1.00	0.01	0.53
C15															1.00	0.02
C16																1.00

*** Significance at 5% probability level**

**** Significance at 1 % probability level**

C1= Days to germination of 1st seedling

C2=Days to 50% germination

C3= Pod yield per plant

C4= No. of primary branches / plant

C5= Days to first flowering

C6= Days to 50 % flowering

C7= No. of flower per plant

C8= Days to first pod emergence

C9=Length of plant at flowering time

C10= No. of pod per plant

C11= Green pod length

C12= Pod yield per ha

C13= Diameter of pod

C14= Average wt. of pod

C15= No. of seed per pod

C16= Seed Index (Wt.of 100 seed)

Table 4.4.2 Phenotypic correlation of yield and yield attributing characters of cowpea genotypes

	Days to germination of 1 st seedling	Days to 50% germination	Pod yield per plant	No. of primary branches / plant	Days to first flowering	Days to 50 % flowering	No. of flower per plant	Days to first pod emergence	Length of plant at flowering time	No. of pod per plant	Green pod length	Pod yield per ha	Diameter of pod Seed	Average wt. of pod	No. of seed per pod	Seed Index (Wt.of 100 seed)
C1	1.00	0.14	0.03	0.101	0.032	0.043	0.011	0.060	0.022	0.111	0.411	0.051	0.01	0.06	0.12	0.90
C2		1.00	0.11	-0.2*	-0.04	-0.54	-0.05	-0.03	0.004	-0.03	0.801	0.033	0.04	0.50	0.30	0.02
C3			1.00	0.045	0.2**	0.043	0.03*	0.002	0.030	0.034	-0.04	-0.03	0.54	0.60	0.01	-0.1
C4				1.000	0.065	-0.01	-0.43	-0.30	-0.90	-0.04	0.570	0.2**	0.08	0.03	0.02	0.03
C5					1.000	0.5**	0.3**	0.340	0.003	0.7**	0.690	0.880	0.34	0.2*	0.30	0.32
C6						1.000	0.520	0.002	-0.06	-0.04	0.023	0.459	0.43	0.30	0.01	0.21
C7							1.000	0.004	0.04*	0.654	0.037	0.008	0.80	0.01	0.02	0.32
C8								1.000	0.033	0.640	-0.01	0.4**	0.39	0.02	0.03	0.30
C9									1.000	0.770	0.02*	0.065	0.42	-0.2	0.54	0.01
C10										1.000	0.040	-0.09	0.21	0.03	0.32	0.02
C11											1.000	0.650	0.45	0.03	0.39	-0.2
C12												1.000	0.32	0.43	0.42	0.03
C13													1.00	0.33	0.21	0.61
C14														1.00	0.53	0.02
C15															0.02	-0.7
C16															1.00	0.60
																1.00

4.5 Path coefficient analysis

Table 4.5. Genotypic path coefficient analysis for morphological and productive characters of cowpea genotypes

	Days to germination of 1 st seedling	Days to 50% germination	Pod yield per plant	No. of primary branches / plant	Days to first flowering	Days to 50 % flowering	No. of flower per plant	Days to first pod emergence	Length of plant at flowering time	No. of pod per plant	Green pod length	Pod yield per ha	Diameter of pod Seed	Average wt. of pod	No. of seed per pod	Seed Index (Wt. of 100 seed)	Yield of green pod/ha	Yield of seed/ha	correlation coefficient
C1	0.005	0.003	-0.000	0.003	0.045	-0.032	0.005	0.003	-0.045	0.033	0.003	0.005	0.033	0.007	0.002	0.086	0.005	-0.001	0.100
C2	0.000	0.023	0.070	0.003	0.063	0.072	0.065	0.013	0.002	-0.003	0.003	0.005	-0.008	0.009	0.004	0.087	0.052	0.006	0.065
C3	0.000	0.008	0.089	0.098	-0.020	0.055	-0.030	-0.018	0.035	0.018	-0.008	0.009	0.023	0.026	-0.065	-0.012	0.098	-0.007	0.129
C4	0.001	0.000	0.030	0.632	0.002	0.056	0.602	-0.072	0.012	0.005	-0.002	0.003	0.009	0.045	0.023	-0.053	0.034	-0.003	0.090
C5	0.000	-0.020	0.002	-0.050	0.566	0.032	-0.066	-0.090	0.009	-0.000	-0.000	0.006	-0.004	0.040	0.054	-0.022	-0.000	-0.009	0.090
C6	0.002	0.004	0.001	0.006	0.064	0.099	0.074	0.036	0.030	0.001	0.006	0.031	0.030	0.072	-0.074	0.003	0.078	0.0046	0.383
C7	0.001	-0.012	0.034	0.002	-0.016	0.032	-0.816	0.112	0.015	-0.052	0.002	0.005	-0.048	0.018	-0.002	0.004	0.062	0.062	0.414
C8	0.000	0.005	-0.050	0.005	0.095	-0.060	0.005	0.670	-0.087	0.065	0.004	-0.007	0.023	0.006	-0.004	0.009	0.034	0.024	0.110
C9	-0.000	0.005	0.023	-0.007	-0.005	-0.022	0.056	-0.107	0.902	0.055	-0.047	-0.003	0.090	0.085	-0.047	-0.007	0.037	-0.043	0.073
C10	-0.000	0.004	0.024	0.024	0.044	-0.029	0.434	-0.224	-0.059	0.0874	-0.004	-0.007	0.0004	0.070	-0.054	-0.012	0.034	-0.094	0.314
C11	0.000	0.021	0.051	0.001	-0.025	0.041	-0.125	0.051	0.098	-0.041	0.054	0.004	-0.081	0.045	0.076	0.067	-0.005	0.091	0.902
C12	0.001	0.009	-0.000	0.039	-0.049	0.000	-0.043	0.030	0.005	0.049	0.031	0.090	0.040	-0.042	0.032	0.034	0.062	0.012	0.432
C13	0.000	0.004	0.023	-0.061	0.074	0.029	-0.044	-0.005	0.035	0.009	-0.015	0.030	0.208	0.001	-0.005	-0.065	0.054	-0.044	0.453
C14	0.000	-0.021	-0.012	0.034	-0.091	-0.016	0.056	0.086	-0.007	-0.051	0.006	-0.070	-0.054	0.098	0.024	0.006	-0.075	0.023	0.213
C15	-0.010	0.000	-0.002	0.000	0.090	-0.082	0.038	0.034	-0.093	0.078	0.004	-0.003	0.058	0.000	-0.086	-0.000	0.004	-0.053	0.251
C16	-0.002	0.000	-0.062	-0.029	0.002	0.034	0.007	-0.087	0.012	0.032	-0.007	0.010	0.098	0.006	-0.027	0.704	0.094	0.057	0.521
C17	0.002	0.001	0.000	-0.001	0.071	0.000	0.021	-0.057	-0.005	0.051	-0.007	-0.085	0.046	0.081	-0.057	-0.003	0.985	-0.065	0.321
C18	0.000	0.000	0.034	0.000	-0.077	0.034	-0.047	0.002	0.084	0.009	0.007	0.080	0.008	-0.057	0.026	0.004	0.002	-0.204	0.543
C19	0.001	-0.000	0.004	-0.040	0.009	0.034	0.679	-0.045	0.034	-0.040	-0.041	0.008	-0.020	0.007	-0.002	0.041	-0.041	-0.041	0.231

C1= Days to germination of 1st seedling

C2= Days to 50% germination

C3= Days to four leaf emergence

C4= No. of primary branches / plant

C5= Days to first flowering

C6= Days to 50 % flowering

C7= No. of flowers per plant

C8= Days to first pod emergence

C9= Length of plant at flowering time

C10= No. of pods per plant

C11= Green pod length

C12= Dry pod length

C13= Diameter of pod

C14= Average wt. of pod

C15= No. of seeds per pod

C16= Seed Index (Wt.of 100 seed)

C17= Yield of green pod/ha

C18= Yield of seed/ha

r= Correlation coefficient



Plate-1. 1st seedling germination



Plate-2. 50% germination of seedlings



Plate-3. Four leaf emergence Plate-4. 1st flower emergence



Plate-5. Field view of plots



Plate-6. Green pods harvesting stage



Plate-7. Dry pods harvesting stage



Plate-8.1. Variation in pods length and colour



Plate-8.2. Variation in pods length and colour



Plate-8.3. Variation in pods length and colour

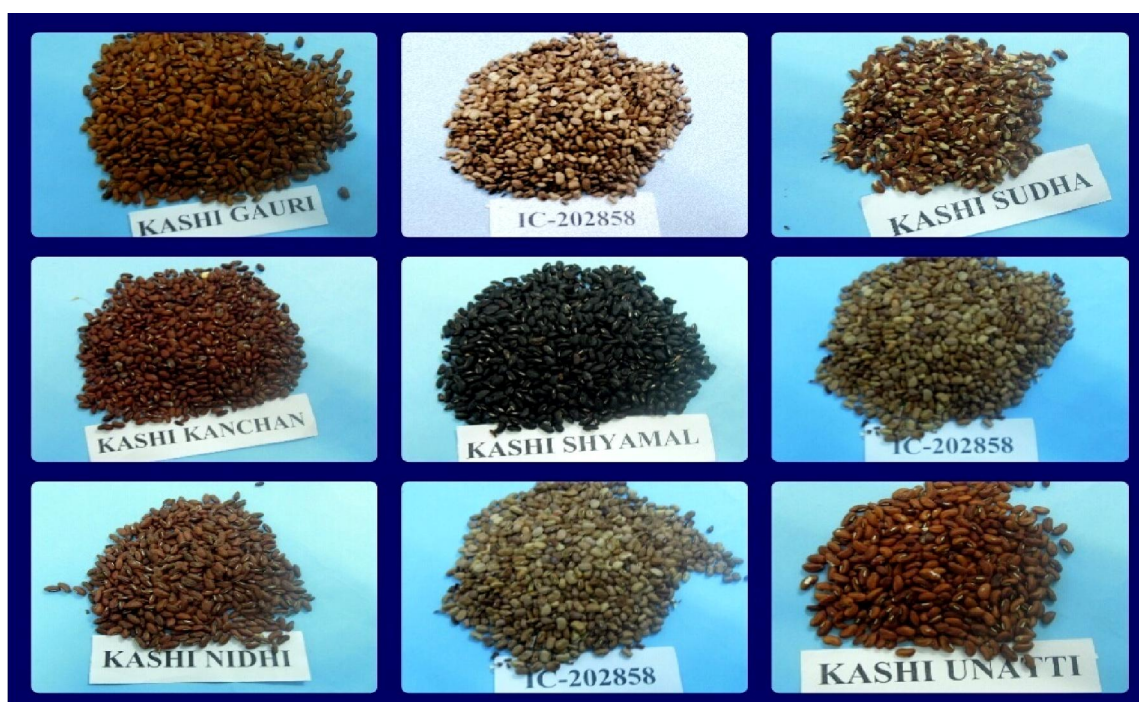


Plate-9. Variation in seed colour



CHAPTER V

DISCUSSION

The present investigation entitled “**Genetic variability, correlation and path coefficient analysis in diverse genotypes of cowpea [*Vigna unguiculata*(L.) Walp.]**” was carried out during June 2015. The experiment was conducted at the Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) India.

Cowpea [*Vigna unguiculata*(L.) Walp.] is an autogamous crop having low out crossing ranging from zero to four percent. The study of variance and other genetic parameters greatly help in formulating a suitable breeding programme for improvement of the crop. The variability of the genetic material is a prerequisite for cowpea improvement. The extent of variation in presently cultivated varieties is relatively low. The purpose of studying variability is to partition the total variation present in the collections into different components such as genotype and phenotype. Variability is the key factor for any selection programme, which can be generated through various ways. To create the variability, addition of some more diverse genotypes with the present collection is necessary or creation of new variability by other means is very much needed. Since the productivity of cowpea is very low due to lack of high yielding varieties with resistance to biotic stresses such as diseases, which is the major hindrance of the crop getting unique production. It is necessary to identify high yielding varieties which are suitable to available environment with resistant to major diseases which causes low productivity. Aiming of these aspects, nineteen genotypes comprising exotic and indigenous collections of cowpea collected from IIVR (Indian Institute of Vegetable Research) Varanasi were evaluated. Planting of genotypes was done during 15th June 2015 for studying the yield and yield attributing components.

Discussion is made on the results obtained from the present study under the following sub headings.

- 5.1 Analysis of variance
- 5.2 Mean performance of genotypes
- 5.3 Parameters of variability
- 5.4 Correlation coefficient
- 5.5 Path coefficient analysis

In summer, 15th June 2015 genotypes recorded highly significant variation for all the characters such as germination percentage, plant length, days to flower initiation, number of primary branches per plant, number of pods per plant, pod length, seeds per pod, hundred seed weight, and seed yield per plant. In experiment significant variation was observed among the same parameters. It indicates presence of sufficient variability for these characters, thus there is a lot of scope for selection. From the present study it can be concluded that presence of sufficient variability among genotypes for the characters, which can be utilized during selection process of suitable basic material for breeding for further improvement. This can be further confirmed by studying genetic variability components such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV).

5.1 Analysis of Variance

The genotypes showed highly significant difference for twenty three characters among nineteen genotypes. These characters were days to 1st seedling germination, days to 50% germination, days to four leaf stage, number of primary branches per plant, days to first flowering, plant length at flowering, days to 50% flowering, number of flowers per plant, days to first pod emergence, number of pods per plant, green pod length, dry pod length, diameter of pod, weight of pods, number of seeds per pod, seed Index (Wt.of100 seed), yield of greenpod per plant, yield of green pod per ha, yield of seed per ha, protein content (%), TSS(°Brix), chlorophyll content (SPAD reading). It indicates presence of sufficient variability for these characters, thus there is a lot of scope for selection. Preetiet *al.* (2003) and Sarvamangala (2004) reported the similar results in studying 32 mungbean genotypes and fifty cowpea genotypes, respectively.

5.2 Mean performance of genotype

The mean performance of genotypes for all observed characters was comparatively show significant variation for all genotype. This may be due to variation in responses of genotypes towards climatic conditions like frequent showers, high relative humidity and temperature during growth, flowering and pod setting stages.

The genotype KashiUnnati(3.00 days, 3.33 days) and KhasiSudha(3.00 days, 3.33 days) was the earliest in producing germination of 1st seedling and 50% germination respectively. Whereas, the genotype EC-390211 (6.67 days, 7.00 days) took longest time of days for germination of 1st seedling and 50% germination. This may be due to variation in germination percentage of seeds of genotypes. These findings are confirm with Aswathi *et al.* (2015).

The genotype KashiKanchan(7.00 days) was the earliest in producing four leaf stages with days whereas, the genotype EC-37588(11.67 days) took longest time of days for four leaf emergence. This is due to variation in growth hormones of different genotypes. The results of four leaf emergence of different genotypes confirm with the findings kumar *et al.* (2002) and Meena *et al.* (2015).

The genotype KashiSudha(4.00) was the producing maximum number of primary branches whereas, the genotype EC-110598 (2.67) took minimum number of primary branches. The results of number of primary branches of different genotypes agree with the findings of Tamilselvan and Das (1994) suggested that number of primary branches per plant, number of pods per plant and test weight should be used as a selection criterion in the development of high yielding genotypes of cowpea.

The genotype KashiUnnati was the earliest in producing flower with 30.33 days, 35.33 days respectively whereas, the genotype Ec-110598 took longest time of days for 1st flowering(58.67 days, 66.00 days) respectively. The genotype KashiUnnati was the earliest in producing 50% flowering whereas, the genotype EC-110598 show late flowering(58.67 days, 66.00 days) respectively. This show more variation in genotypes. The results of genotypes agree with the findings of Thiyagarajan (1989) and Sarvamangala (2004).

The minimum mean value for plant length was recorded in genotype KashiGauri(48.67 cm). The maximum mean value of plantlength was recorded in genotype KashiUnnati(73.00 cm).Average plant lengthwas more favoured in Kashiunnati . The range of mean values was wide, indicating more influence of the environment on the character. (Sarvamangala, 2004).

Days to 1st pod emergence the genotype KashiUnnati (36.67 days) was the earliest,whereas the genotype EC-110598 took longest duration for 1st pod emergence (62.00 days).This show more variation in pod emergence of different genotypes. The results of 1st pod emergence of different genotypes are close conformitywith the findings of Kalaiyarasi and Palanisamy (2002).

The maximum numbers of flowers were recorded in genotype KashiShyamal (49.67), whereasgenotype EC-37588 (22.33) were less number of flowers. The results of number of flowersper plant of different genotypes are in agreement with the findings ofGirishet *al.* (2006).

The maximum number of pods were recorded in genotype KashiGauri whereas(22.00)whereas, genotype EC-30590 (2.00) was most significant with minimum number of pods. This is due to genotypic variation towards the climatic conditionof the area like temperature, humidity and soil condition. The similar results onnumber of pods per plant of different genotypes have been observed by Dhanwaniet *al.* (2014), Meenaet *al.* (2015) andJagadishmurthy (1986).

The maximum green pod length (cm) and dry pod length (cm)was recorded in genotype KashiNidhi(40.24 cm and 38.63 cm) respectively whereas, genotype EC-37588 was top most significant with minimum green pod length (9.63 cm and 7.97 cm). The maximum Green pod diameter was recorded in genotype KashiGauri(0.77 cm) whereas, the minimum diameter of pod was recorded in EC-37587 (0.43 cm).The results of green pod length, dry pod length and diameter of different genotypes are in agreement with the findings of earlier workers(Vardhan and Savithramma 2010, Lopes *et al.* 2000 and Biraderet *al.* 1996).

The minimum number of seeds per pod was recorded in genotype KashiGauri (12.33). The maximum number of seeds per pod was recorded in genotype IC- 202804 (18.00). The results of number of seed per pod of different genotypes are in line with the findings of Kumari *et al.* (2003)

The maximum green pod weight was recorded in genotype KashiNidhi (14.32 g). The genotype EC- 375888 (1.80 g) was recorded minimum value. This is due to higher variation in genotype. The results of weight of green pod of different genotypes close conformity with the findings of Venkatesan *et al.* (2003) and Chattopadhyay *et al.* (2001).

The maximum yield of green pod per plant and yield of green pod was recorded in genotype KashiGauri (2.43q/ha and 132.6q/ha⁷). The minimum yield of green pod per plant was recorded in genotype EC-390211 (0.32q/ha) and EC-37588 (3.65q/ha). This shows high variation in genotype. Earlier workers were also found variation yield of green pod per plant and yield of green pod (q/ha) due to genotypes (Yousaf and Sarwar 2008, Dumet *et al.* 2008 and Musvosvi 2009).

The maximum seed yield per hectare (q/ha) was recorded in genotype KashiGauri (9.76q/ha). The genotype EC-37588 (1.37q/ha) was top most significant with a minimum yield. The maximum seed weight recorded in genotype KashiNidhi. The genotype IC-209711 was top most significant with a minimum value of seed weight. The results of yield of seed per (q/ha) of different genotypes agree with the findings Dhanwani *et al.* (2014), Bhardwaj *et al.* (2014) and Amanakapoore *et al.* (2000).

The maximum protein content (%) was recorded in genotype KashiUnnati (25.00). The genotype EC- 390588 (8.83) was recorded minimum protein content. This shows high variation due to variation in presence of nitrogen content in seeds. The results of protein content of different genotypes correlated with the findings Gupta (1988), Rangel *et al.*, 2004).

The maximum SPAD reading of chlorophyll content was recorded in genotype KashiGauri (58.19). The genotype EC- 390211 (27.13) was recorded minimum SPAD reading of chlorophyll content. The results of chlorophyll content of different

genotypes confined with the of findings of(N.kouannessiMagloire. 2005Ghalmi N *et al*2010)

The maximum TSS(°Brix) was recorded in genotype IC-39095 i.e.11.95°brix.The genotype KashiNidhi was recorded minimum value of 7.23 °Brix.The results ofTSS(°Brix)contentof different genotypes are similar with the findingsCarnideet *al.*, 2007.

5.3 Variability

The range, grand mean, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance and genetic gain are given in Table 4.3 and results are presented under the following heads.

5.3.1 Range

A wide range of variation was recorded for all the characters. Range of days to 1st seedling germinationvariesfrom 3.00 days in genotype (KashiKanchan) to 6.67 days (EC-390211).In case of days to 50% germination itvariesfrom 3.33 days (KashiKanchan) to 7.00 days (EC-390211). In case days to four leaf emergence it varies from 7.00days (KashiKanchan) to 10.67 days (EC-390211).Number of primary branchesvariesfrom 2.67 (EC-110598) to 4 (KashiSudha).In case days to 1st flowering 30.00 days (EC-390226) to 58.65 days (EC-110598). Days to 50 % flower appearvariesfrom 35.33 days (KashiUnnati) to 66.00 days (EC-110598). The length of plant showed a markedly higher range of variation from 73.00cm (KashiUnnati) to 48.67cm (KashiGauri).In case days to 1st pod emergence appears tovariesfrom 36.67days (KashiUnnati) to 62.00 days (EC-110598).Number of flowers per plant appears to be varies from 22.67 (EC-37588) to 49.33 (KashiShyamal).The number of pod per plant varies from 22.00 (KashiGauri) to16.00 (EC-30590).The length of green pod varies from 28.88cm (EC-37588) to 120.72cm (KashiNidhi).The length of dry pod varies from 27.97cm (EC-37588) to 38.63cm (KashiNidhi).The diameter of pod varies from 0.43cm (EC-37587) to 0.77cm (KashiGauri).The number of seeds per pod varies from 12.33 (KashiKanchan) to 18 (IC-202804).Average weight of pod varies from 1.88g (EC-37588)to 14.32g (KashiNidhi). The maximum pod yield per plant varies from 2.43kg/plant (KashiGauri) to 0.05kg/plant (EC-1738).The yield of green pod per hectare ranged between 132.67q/ha (KashiGauri)to 3.65q/ha (EC-37588).The

yield of seed per hectare range between 9.76q/ha (KashiGauri) to 1.5q/ha. (EC-37588).The protein content in percentage varies from 25.57% in genotype (KashiUnnati) to 8.83% (EC-37588).The chlorophyll content in leaf range between 27.15ug (EC-390211) to 50.53ug (KashiGauri). The TSS of green pod varies from 7.23(°Brix) (KashiNidhi) to 11.33°Brix (IC-39095). The results were confined with the findings of Sawant (1994), Kulkarni and Birari (1999).

5.3.2 Coefficient of variation

Genotypic coefficient of variation together with heritability estimates would give the best information on extent of the advance to be expected from selection. The estimates of heritability in determining the effectiveness of selection of character provided they are considered in conjunction with the predicted genetic advances. In the present set of material, where diverse germplasm collections were involved, high heritability and high genetic advance over the mean were exhibited by most of the characters, which indicates the genotypes have high variability and the selection can be more effective for the traits. Proving this, the results were similar with the findings of Ghalmi. N *et al* 2007.

The result of maximum genotypic coefficient of variation revealed that length of plant exhibited moderate genotypic coefficient of variation value (19.87 cm) followed by number of pods per plant (18.31), four leaf emergence (18.20 days), yield per hectare (17.15 q/ha), 50% germination (17.03 days), seed yield per hectare (16.72 q/ha), protein content (16.89), 1st seedling germination (15.25) and pod weight (13.94), similar results were observed by Viswanatha *et al.* (2015) and Santoshkumar *et al.* (2002) whereas number of seeds per pod (11.89), days to 1st pod emergence (10.87), number of primary branches (10.40), length of green pod (9.43), weight of pod (8.42), chlorophyll content (8.34), 100 seed weight (7.96 g), yield of green pod per plant (7.46), number of flower per plant (7.35), dry pod length (7.33 cm), days to 1st flowering (6.71 days), days to 50% flowering (6.05 days, TSS(°Brix) 6.03 and pod diameter (6.00 cm) recorded low genotypic coefficient of variation. The results were similar with the findings of Dhanwani *et al.* (2014) and Bhardwaj *et al.* (2014).

In general, the values of phenotypic coefficient of variation (PCV) were higher than the respective value of genotypic coefficient of variation (GCV). The maximum

value of phenotypic coefficient of variation revealed that the days to 1st flower appearance showed high phenotypic coefficient of variation value (22.15 days) whereas length of plant (20.25 cm), number of pods per plant (19.24), pod yield per hectare (18.88 q/ha), number of flowers per plant (17.63), average pod weight (17.02 g) and number of seeds per pod (16.54), chlorophyll content (15.34) four leaf emergence (15.20) show moderate phenotypic coefficient of variation value (Girish *et al.* 2006). The value of phenotypic coefficient of variation for yield of green pod per plant (9.05 kg), average 100 seed weight (8.98 g), pod length (8.51 cm), days to 1st flowering (6.26 days), pod diameter (5.97 cm), dry pod length (5.32 cm), TSS (°Brix) 6.33 and days to 50% flowering (5.68) showed low phenotypic coefficient of variation value. The results were confined with the findings of Nkouannessi Magloire. (2005).

5.4 Correlation Studies

Phenotypic and genotypic correlation coefficients were worked out among all 17 characters of 19 genotypes under study in all possible combination and results have been shown in Table 4.5.1 and Table 4.5.2, respectively. In general, the magnitude of genotypic correlation coefficient was higher than the respective phenotypic correlation coefficient. The magnitude of Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), Heritability (h^2) and Genetic Advance (GA) was high for seed yield per plant, number of pods per plant and length of plant. Days to first flower opening, days to 50% flowering and days to maturity had a low genetic advance. The results were confined with the findings of Fang, *et al.* (2007). In general, the genotypic correlation coefficients were higher in magnitude than the phenotypic correlation coefficients. Seed yield per plant was highly significantly and positively correlated with number of pods per plant. The results were agree with the findings of Oseni, *et al.* 1992.

5.4.1 Genotypic correlation coefficient

The genotypic correlation coefficient was highly significant and positive for days to 1st flowering and days to 50% flowering. While, it was negatively significant with pod yield per plant and pod yield per hectare. Days to 50% flowering showed negative significant genotypic correlation with number of primary branches, pod yield per plant and pod yield per hectare. The results were similar with the findings

of Rangaiah and Nehru (1998), Selvam *et al.* (2000) and Kumari *et al.* (2003) reported that high GCV and PCV values for pods per plant, hundred seed weight and seed yield per plant. Number of flowers per plant exhibited highly positive significant correlation with number of primary branches per plant, number of pods per plant, pod yield per plant and pod yield per hectare whereas, it showed highly negative significant genotypic correlation with pod diameter days to 1st pod emergence exhibited genotypic highly positive significant correlation with length of plant, pod yield per plant and pod yield per hectare. Number of primary branches per plant exhibited highly positive significant genotypic correlation with length of plant, number of pods per plant, pod yield per plant and pod yield per hectare whereas, it showed negative genotypic correlation with average pod weight. The results were similar with the findings of Rana *et al.* (2014). Length of plant showed significant and highly positive genotypic correlation for number of pods per plant, pod yield per plant and pod yield per hectare. Number of pods per plant recorded highly positive significant genotypic correlation with pod yield per plant and pod yield per hectare whereas, it showed negative genotypic correlation with pod weight. Pod length exhibited positive genotypic correlation with average 100 seed weight. Pod diameter showed negative correlation with number of seeds per pod. Average pod weight exhibited negative genotypic correlation with Number of seeds per pod. Pod Yield per plant showed positive correlation with pod yield per hectare. Number of seeds per pod exhibited negative significant correlation with average 100 seed weight. The results were confirmed with the findings of Mehta *et al.* (2014).

The genotypic correlation coefficient was highly significant and positive for days to 1st flowering and days to 50% flowering. While, it was negatively significant with pod yield per plant and pod yield per hectare. Days to 50% flowering showed negative significant genotypic correlation with number of primary branches, pod yield per plant and pod yield per hectare. Number of flowers per plant exhibited highly positive significant correlation with number of primary branches per plant, number of pods per plant, pod yield per plant and pod yield per hectare whereas, it showed highly negative significant genotypic correlation with pod diameter days to 1st pod emergence exhibited genotypic highly positive significant correlation with length of plant, pod yield per plant and pod yield per hectare. The results were agree with the

findings of Selviet *et al.* (1994), Tyagiet *et al.* (1999) and Selvamet *et al.* (2000) showed higher GCV and PCV values for the character. Number of primary branches per plant exhibited highly positive significant genotypic correlation with length of plant, number of pods per plant, pod yield per plant and pod yield per hectare whereas, it showed negative genotypic correlation with average pod weight. Length of plant showed significant and highly positive genotypic correlation for number of pods per plant, pod yield per plant and pod yield per hectare. Number of pods per plant recorded highly positive significant genotypic correlation with pod yield per plant and pod yield per hectare whereas, it showed negative genotypic correlation with pod weight. Pod length exhibited positive genotypic correlation with average 100 seed weight. Pod diameter showed negative correlation with number of seeds per pod. Average pod weight exhibited negative genotypic correlation with number of seeds per pod. Pod yield per plant showed positive correlation with pod yield per hectare. Number of seeds per pod exhibited negative significant correlation with average 100 seed weight. The results were confined with the findings of Mehta and Zaveriet *et al.*, (1999)

5.4.2 Phenotypic correlation Coefficient

Days to 1st flowering exhibited highly positive significant correlation with days to 50% flowering. Days to 50% flowering showed negative significant phenotypic correlation with pod yield per plant. Days to 1st flowering showed positive phenotypic correlation with number of primary branches per plant. Number of primary branches per plant exhibited highly positive phenotypic significant correlation with length of plant, and positive phenotypic correlation with pod yield per plant and pod yield per hectare. Number of flowers per plant showed highly positive significant phenotypic correlation with length of plant, number of pods per plant, pod yield per plant and pod yield per hectare whereas, it showed negative phenotypic correlation with average pod weight. Length of plant showed highly positive significant correlation with number of pods per plant, pod yield per plant and yield per hectare. The results were similar with the findings of Nigude *et al.* (2004) Number of pods per plant also exhibited highly significant positive correlation with yield per plant and yield per hectare. Pod length exhibited positive correlation with number of seeds per pod. Pod diameter showed positive correlation with average pod weight. Average pod

weight showed positive significant correlation with yield per hectare. Yield per plant showed highly positive significant correlation with yield per hectare. Average 100 seed weight showed positive significant correlation with yield per hectare. The results were confirmed with the findings of Tyagi *et al.* (2000).

5.5 Path coefficient analysis

5.5.1 Days to 1st seedling germination

The genotypic path coefficient studies depicted that day to 1st seedling germination had direct negative effect towards pod yield per hectare. Regarding to indirect effect, this trait exhibited positive indirect effect towards yield *via*, days to 50% flowering, days to 1st flower appear, pod length and length of plant however, it was negative *via*, number of flower per plant, seed index, average pod weight and number of pods per plant. The results were similar with the findings of Venkatesan *et al.* (2003)

5.5.2 Days to 50% germination

The days to 50% germination had direct positive effect towards seed yield. Regarding indirect effect this trait exhibited positive indirect effect, towards yield *via*, node at which 1st flower appear, length of plant however, it was negative *via*, days to 1st flowering, number of flower plant per plant, number of pod per plant, average pod weight. The results were confirmed with the findings of Zargar *et al.* (2005).

5.5.3. Days to four leaf emergence

Days to four leaf emergence which produces number of primary branches had direct negative effect towards yield. Regarding to indirect effect of this trait, exhibited positive indirect effect, towards yield *via*, days to 1st flowering, pod length, number of pods per plant, number of flower per plant, pod weight and however, it was negative *via*, days to 50% flowering, length of plant and dry pod length. The results were similar with the findings of Renganayaki and Rangasamy (1991), Santos *et al.* (1997).

5.5.4 No. of primary branches/plant

Number of primary branches per plant had direct positive effect towards yield. Regarding to indirect effect, this trait exhibited positive indirect effect, towards yield via, days to 1st flowering, number of pods per plant, number of flowers per plant and average pod weight however, it was negative for characters viz. days to 50% flowering, 1st flower appearance, length of plant and pod length. The results were similar with the findings of Sharma and Misra (1997).

5.5.5 Days to first flowering

Days to first flowering had direct positive effect towards yield. Regarding to indirect effect, this trait exhibited positive indirect effect, towards yield via, internodal length, and number of pods per plant however, it was negative via, length of plant, days to 50% flowering, length of plant and pod weight. The results were confirmed with the findings of Bakiyarani *et al.* (2000).

5.5.6 Days to 50 % flowering

Days to 50% flowering had direct negative effect towards yield. Regarding to indirect effect, this trait exhibited positive indirect effect, towards yield via, length of plant, number of flowers per plant and number of pods per plant however, it was negative via, days to 1st pod emergence, number of pod per plant and average pod weight. Similar results have also been observed by Usha Kumari *et al.* (2002).

5.5.7 No. of flowers per plant

Number of flower per plant had direct positive effect towards yield. Regarding to indirect effect, this trait exhibited positive indirect effect, towards yield via, days to 1st flowering, pod length and number of pods per plant however, it was negative via, days to 50% flowering, length of plant and pod weight. The results were in agreement with the findings of Gowda *et al.* (1991).

5.5.8 Days to first pod emergence

Days to 1st pod emergence had direct negative effect towards yield. Regarding to indirect effect, this trait exhibited positive indirect effect, towards yield via, days

to 1st flowering, pod length and number of pods per plant however, it was negative *via*, days to 50% flowering, primary branches and number of flowers per plant. The results were in agreement with the findings of Kumari *et al.* (2003).

5.5.9 Length of plant

Length of plant had direct negative effect towards yield. Regarding to indirect effect, this trait exhibited positive indirect effect, towards yield *via*, days to 50% flowering, 1st flower appearance number of primary branches per plant and pod length however, it was negative *via*, days to 1st flowering, pod length and pod weight. The results are in line with the findings of Tajaneet *et al.* (2014).

5.5.10 Number of pods per plant

Number of pods per plant had direct positive effect towards yield. Regarding to indirect effect, this trait, exhibited positive indirect effect, towards yield *via*, days to 1st flowering, pod length and length of plant however, it was negative *via*, days to 50% of flowering, 1st flower appearance, number of pods per plant and number of flowers per plant. The results are in link with the findings of Neema and Palanisamy (2001).

5.5.11 Green pod length

Green pod length had direct negative effect towards yield. Regarding to indirect effect of this trait, exhibited positive indirect effect, towards yield *via*, days to 1st flowering, pod length, number of pods per plant, number of flower per plant, pod weight and however, it was negative *via*, days to 50% flowering, length of plant and dry pod length. Selviet *et al.* (1994) reported similar findings.

5.5.12 Dry pod length

Dry pod length had direct negative effect towards seed yield. Regarding to indirect effect of this trait, exhibited positive indirect effect, towards yield *via*, days to 1st flowering, pod length, number of pods per plant, number of flower per plant, pod weight and however, it was negative *via*, days to 50% flowering, length of plant and green pod length. The results were in agreement with the findings of Rangaiah and Nehru (1998).

5.5.13 Diameter of pod

Diameter of pods per plant had direct positive effect towards yield. Regarding to indirect effect, this trait, exhibited positive indirect effect, towards yield *via*, days to 1st flowering, pod length and length of plant however, it was negative *via*, days to 50% of flowering, 1st flower appearance, number of pods per plant and number of flowers per plant. Similar result have also been observed by Selviet *al.* (1994).

5.5.14 Average weight of pod

Average weight of pods per plant had direct positive effect towards yield. Regarding to indirect effect, this trait, exhibited positive indirect effect, towards yield *via*, days to 1st flowering, pod length and length of plant however, it was negative *via*, days to 50% of flowering, 1st flower appearance, number of pods per plant and number of flowers per plant. Similar observation made by Thiagarajan (1989).

5.5.15 No. of seeds per pod

Number of seed per pod had direct negative effect towards yield. Regarding to indirect effect, this trait exhibited positive indirect effect, towards yield *via*, days to 1st flowering, pod length and number of pods per plant however, it was negative *via*, days to 50% flowering, primary branches and number of flowers per plant. Amanakapoore *et al.* (2000) revealed that the number of seeds per pod and 100 seed weight were the main contributing characters towards the seed yield. The results were in agreement with the findings Jagadishmurthy *et al.*, (2007).

5.5.16 Seed Index (Wt. of 100 seed)

Seed index had direct negative effect towards yield. Regarding to indirect effect, this trait exhibited positive indirect effect, towards yield *via*, length of plant, number of flowers per plant and number of pods per plant however, it was negative *via*, days to 1st pod emergence, no of pod per plant and average pod weight. Vardhan and Savithramma (2010). Studied path coefficient analysis for

green pod yield per plant in 29 accessions of cowpea and concluded that green pods per plant, pod length, pods per plant, pod length, pod diameter and number of primary branches were major traits contributing to yield. The Present result are in close conformity with the findings of Patil and Baviskar (1987) and Backiyarani and Nadarajan (1996).

Genotypic correlation into direct and indirect effects revealed the interesting picture regarding character association. Further, it provides an insight into the interrelationship of various characters with seed yield. In the present study, all the 19 characters viz., germination percentage, length of plant, days to flower initiation, days to flower termination, days to physiological maturity, number of clusters per plant, number of pods per plant, pod length, seeds per pod, hundred seed weight and harvest index were considered for the path analysis. Among the nineteen characters, fifteen characters showed positive association with seed yield. Hence, the perusal of correlation and path analysis studies of the present investigation revealed that pods per plant, clusters per plant, hundred seed weight and harvest index as highly important yield components in the order of having direct bearing on the improvement of seed yield per plant. The results are in line with the findings Mehta *et al.* (1999).



CHAPTER VI

SUMMARY AND CONCLUSION

The present experiment entitled “**Genetic Variability, correlation and path coefficient analysis in diverse genotypes of cowpea [*Vigna unguiculata*(L.) Walp.]**” was carried out during June 2015. The experiment was conducted at the Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) India.

Profound knowledge on variability of the genetic material would be gained in any of the breeding programmes. Continuous breeding will be ceiling the further improvement of yield in any crop through narrow down the variability among genotypes. One of the ways to increase the variability is introduction of genetically diverse new genotypes. An experiment was conducted at Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi in summer seasons with the objectives to assess the genetic variability, genetic divergence of genotypes and to study the magnitude of association consisting of genetic material collected from Indian Institute of Vegetable Research, Varanasi.

The most salient results of the study are summarized in this chapter.

1. The genotype Kashi Unnati (3.00 days) was the earliest in producing germination of 1st seedling whereas, the genotype EC-390211 (6.7 days) took longest time of days for germination of 1st seedling.
2. The genotype Kashi Unnati (3.33 days) was the earliest in producing 50% germination with days whereas, the genotype EC-390211 (7.00 days) took longest time of days for 50% germination.
3. The genotype Kashi Kanchan (7.00) was the earliest in producing four leaf whereas, the genotype EC-37588 (11.67 days) took maximum days for four leaf emergence.

4. The genotype Kashi Sudha (4.00) was the producing maximum number of primary branches per plant whereas, the genotype EC-110598 (2.67) took minimum number of primary branches per plant.
5. The genotype Kashi Unnati was the earliest in producing 1st flower with 30.33 days whereas, the genotype EC-110598 (58.67 days) took longest time of days for 1st flowering.
6. The genotype Kashi Unnati (35.33 days) was the earliest in producing 50% flowering followed whereas, the genotype EC-110598 (66.00 days) flowered too late.
7. The minimum mean value of plant length at flowering was recorded in genotype Kashi Gauri (48.67 cm) whereas, the maximum mean value of length of plant was recorded in genotype Kashi Unnati (77.67 cm).
8. The genotype Kashi Unnati (36.67) was the earliest in producing 1st pod emergence with days, whereas the genotype EC-110598 (62.00) took longest time for 1st pod emergence.
9. The maximum numbers of flowers per plant was recorded in genotype Kashi Shyamal (49.67). The genotype EC-37588 (22.33) were with less number of flowers.
10. The maximum numbers of pods were recorded in genotype Kashi Gauri (22.00) whereas, genotype EC-30590 (2.00) having minimum number of pods.
11. The maximum green pod length was recorded in genotype Kashi Nidhi (40.24 cm) whereas, genotype EC-37588 (9.63 cm) show minimum length of green pod.
12. The maximum dry pod length was recorded in genotype Kashi Nidhi (38.63 cm) whereas, minimum length was observed in genotype EC-37588 (7.97 cm).
13. The maximum green pod diameter was recorded in genotype Kashi Gauri (0.77 cm) whereas, the minimum diameter of pod was recorded in EC-37587 (0.43 cm).
14. The maximum pod weight was recorded in genotype Kashi Nidhi (14.3 g) whereas, the genotype EC-37588 (1.80 g) recorded minimum pod weight.
15. The minimum number of seeds per pod was recorded in genotype Kashi Gauri (12.33) and the maximum number of seeds per pod was recorded in genotype IC-202804 (18.00).
16. The maximum green pod weight per plant was recorded in genotype Kashi Gauri (220.53 g) whereas, the genotype EC-37588 (5.70 g) with minimum value.

17. The maximum pod per plant was recorded in genotype Kashi Gauri(22.00) and minimum pod per plant was recorded in genotype EC-390211 (2.00).
18. The maximum pod yield per hectare (q/ha) was recorded in genotype Kashi Gauri(132.67) whereas, the genotype EC-37588 (3.65) had minimum yield.
19. The maximum seed yield per hectare (q/ha) was recorded in genotype Kashi Gauri(9.76q/ha) whereas, the genotype EC-37588(1.37q/ha) show a minimum yield.
20. The maximum seed weight was recorded in genotype Kashi Nidhi(14.63 g) whereas, the genotype IC-209711(6.06 g) had a minimum value of seed weight.
21. The maximum protein content (%) was found in genotype Kashi Unnati (25.00) whereas, the genotype EC- 390211 (8.83) having minimum protein content.
22. The maximum chlorophyll content was recorded in genotype Kashi Gauri(58.19) whereas, the genotype EC- 390211(27.13) had minimum chlorophyll content.
23. The maximum TSS (°Brix) was recorded in genotype IC-39095 whereas, the genotype Kashi Nidhi was having a minimum value of 7.23 °Brix.

All the PCV values were higher than the GCV values for each and every character. The high PCV and GCV values were recorded by seed yield per plant, hundred seed weight, number of pods per plant, and germination percentage. However low GCV and PCV values were recorded in days to flower initiation, days to flower termination and days to physiological maturity. Both GCV and PCV values showed similar pattern of changes over the characters.

The highly significant positive genotypic association was recorded between seed yield and seed index. Hundred seed weight, seeds per pod, pod length, number of pods per plant, branches per plant and days to flower initiation recorded positive genotypic association with seed yield. High positive association was observed between days to flower initiation and days to physiological maturity and number of pods per plant and pod length and seeds per pod. Highly significant variation was present among the genotypes and significant variation was present between environments except for germination percentage. The genotype and season interaction exhibited high significance for all the characters except for number of branches per plant. Positive direct effects were recorded by days to flower initiation, pods per plant and hundred

seed weight. Among them, the highest direct effect on seed yield was recorded by seed index at both phenotypic and genotypic level. Seed index had positive indirect effects of pod length and seeds per pod at phenotypic level. The highest positive indirect effects of pods per plant were observed through seed index, both at phenotypic and genotypic level.

All studied characters contributed to diversity, in which the highest contribution was recorded by the number of pods per plant followed by yield per hectare whereas the least contribution to diversity was by hundred seed weight. Based on the overall performance of the studied genotypes, very high variation was observed among genotypes for the studied traits with high GCV and PCV for the characters of germination percentage, number of pods per plant, hundred seed weight and seed yield per plant. High variability was observed for the disease resistance and qualitative characters. Highest genotypic and phenotypic association was recorded between seed yield per plant and seed index followed by pods per plant while highest direct effect recorded by number of flowers per plant. The highest contribution for the diversity was observed through number of pods per plant followed by seed index.

Conclusion

Based on the overall performance of the studied genotypes, very high variation was observed among genotypes for the studied traits with high GCV, PCV, heritability and GAM for the characters of germination percentage, number of pods per plant, hundred seed weight and seed yield per plant. High variability was observed for the qualitative characters. Highest genotypic and phenotypic association was recorded between seed yield per plant and seed index followed by pods per plant.

On the basis of findings it can be concluded that the “Kashi Unnati” is short duration and high yielding genotype. Kashi Unnati, other genotypes like Kashi Kanchan, Kashi Gauri, Kashi Sudha and Kashi Nidhi also perform better than other genotypes. The qualitative and quantitative performances of these genotypes are better as compared to other genotypes belongs to EC and IC groups of genotype of cowpea. There is a possibility to undertake more of such trials to evaluate various genotype for their performance and for various traits.



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