Study on Genetic Variability, Correlation and Path Analysis with yield Attributing traits of Green Gram [*Vigna radiata* (L.) Wilzeck]

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By

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Certificate - I

This is to certify that the thesis "**Study on Genetic variability, correlation, Path analysis with yield attributing traits in green gram (*Vigna radiata* L.)**" submitted in partial fulfilment of the requirement for the award of degree of Masters of Science in the discipline of **agriculture (Genetics and Plant breeding)** is a bonafide research work carried out by **Mr. Pavan Kumar Reddy (reg.no: 11511578)** under my supervision and that no part of this thesis has been submitted for any other degree program or diploma.

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Certificate

This is to certify that the thesis "**Study on Genetic variability, Correlation, Path analysis with yield attributing traits in green gram (*Vigna radiata* L.)**" submitted by **Mr. Pavan Kumar Reddy (reg.no: 11511578)** to the Lovely Professional University, Phagwara in partial fulfilment of the requirements for the degree of **Masters of Science** in the discipline of **Agriculture (Genetics and Plant breeding)** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External examiner.

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ABSTRACT

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ABSTRACT

The present investigation entitled "Study on Genetic Variability, Correlation and Path Analysis on yield attributing traits of Green Gram [*Vigna radiata* (L.) Wilzeck]" was carried out on recombinant inbred lines at Farm of Lovely Professional University, Phagwara with these genotypes in Randomized Complete Block Design with three replications during *Summer* 2016-17.

Observations were recorded based on the data collected from five random plants selected from each recombinant inbreed lines in each and every replication for morphological traits like, days to 50 % flowering, days to maturity, primary branches per plant, secondary branches per plant, plant height, number of clusters per plant, number of pods per cluster, number of pods per plant, pod length, seeds per pod, seed yield per plant, 100 seed weight and harvest index were as per the standards.

The mean of the data was subjected to Analysis of Variance as per RBD. This analysis of data reveled that, existence of highly significant difference among the inbreed lines for all the traits. The PCV and GCV were comparatively high for the characters, seed yield per plant, harvest index, pods per plant, cluster per plant, pods per cluster, seeds per pod, pod length and secondary branches per plant. Whereas, low genetic variability was observed in the characters like days to maturity, days to 50 % flowering, primary branches per plant, 100 seed weight and plant height in cm.

Heritability estimates based on broad sense were highest in the characters pods per plant, seed yield per plant, harvest index, 100 seed weight, pods per cluster and clusters per plant. Whereas, low in the case of characters like, days to maturity, primary branches per plant, secondary branches per plant, plant height in cm, pod length in cm and seeds per pod.

Genetic advance as percentage mean at Five per cent selection intensity estimates were high with the characters, seed yield per plant, harvest index and pods per plant as well as moderate with the characters like pods per cluster, clusters per plant, seeds per pod, secondary branches per plant, pod length in cm and 100 seed weight. Whereas low with days to maturity, primary branches per plant, days to 50 % flowering and plant height in cm. The heritability

estimates accompanied with genetic advance indicated the predominance of additive gene action in the characters like, harvest index and pods per plant.

With respect to findings of the present experimental work, inbred lines *viz.,* HUM-16, Kopergan, Pusa Vishal and LM-05 were identified as superior inbreed lines with respect to yield attributing traits.

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Introduction

Green gram (*Vigna radiata.* L) is an important pulse crop which comes up well under humid tropics, semi-arid and arid regions. It is cultivated worldwide mainly in Asian countries viz, Bangladesh, China, India, Indonesia and Myanmar. At global scenario, India is contributing about 25 to 28 percent of total production in pulses. India is the primary producer of green gram contributes about 75 percent of the world production. In India, mung bean is cultivated as the third major pulse crop after chick pea and red gram. The states, viz, Andhra Pradesh, Maharashtra, Gujarat, Orissa and Tamil Nadu are major producers of green gram. In *kharif* season green gram is cultivated about 70 percent and remaining 30 percent in summer or *Rabi* season. The major pulse crops grown in the country under varied range of agro-climatic conditions are chick pea, green gram, black gram, pigeon pea and lentils. As per reports of FAO 2016 total production of pulses was 17.5 MT cultivated under 24.8 million ha area, which was estimated highest of all till now. Even after this much production, as per FAO 2016 India is still importing 3.6 MT of pulses per year sharing 32 percent of global imports. As of this, there is necessary to increase the productivity by varietal improvement in the pulse crops to meet hunger and demand of public in India. The debris of this crop will be taken as organic supplements to succeeding crop as they contain large of amount of nitrogen and also the succeeding crop after green gram will yield more than regular as soil is enriched nitrogen which is fixed by the root nodules of green gram.

Biological classification:

Kingdom	: Plantae
Division	: Phanerogams
Class	: Dicotyledonae
Sub class	: Polypetale
Series	: Calyciflorae
Order	: Rosales
Family	: Fabaccae/ Leguminasae
Genus	: *Vigna*
Species	: *radiata* .L

Table: 1.1 Major cultivars of green gram which are commercialized according to state:-

Different states commercially grow green gram cultivars in India:

† **Andhra Pradesh: -**	**ML-267, LGG-450, LGG-460, LGG-407, WGG-37, Pusa-105**
† **Gujarat:-**	**K-851, GM-4**
† **Jharkhand:-**	**Pant G 114, H-208, Radhe, C-235, BG-256, BR-77**
† **Karnataka:-**	**Pant G 114, H-208, Radhe, C-235, BG-256, BR-77**
† **Maharashtra:-**	**Kopargaon, S-8, T-44, BM-4, Chamki, Mughlai, Fule M-2**
† **Orissa:-**	**Local, Tarm-1, Pusa 9072, LGG-407, Pusa Baisakhi, K-851, ML-5, ML-131, Sujata, Dhauli, PDM-54, PDM-11**
† **Tamil Nadu:-**	**ADT2,ADT3, Vamban, Paiur-1, K-1, URM(GGI), CO5, VBN(GG2), CO6**
† **Uttar Pradesh:-**	**Pant Moong-1, Type-44, Pant Moong-2, Pant Moong-3,** **Narendra Moong-1, PDM-54, Pant Moong-4, PDM11,**
† **West Bengal:-**	**B-77, B-108, T-163, T-4**

Green gram is a short day plant, requires warm climate, and grows mainly in sub humid tropics and sub tropics with average temperature of 22 to 35 º C and rainfall of 60 to 100 cm annually for crop production with mean sea level of not exceeding 1800 to 2000m. Deep well drained or sandy loam soils are well desired. Mung bean is erect or sub erect annual with branches and has a tendency of twinning in upper branches slightly, usually it grows to a height of 40 to 120 cm. The leaf arrangement is trifoliate with large, ovate, entirely or rarely lobed membranous leaflets with hairs present on both sides. The pods length is 10 to 15 cm long wide, which are cylindrical, straight or slightly curved and seeds are small globular or oblong often green but may be yellow brown and speckled.

In leguminous crops, pulses are the important ones. After cereals, legumes are the second largest family among cultivated crops of agriculture (Doyle and Luckow, 2003). In developing countries farmers with lack of resources depend upon the legumes to maintain their family health and livestock for their welfare. As the pulses are rich source of protein and amino acid these are the primary part of daily diet among vegetarians. Approximately 25 % protein present in pulses, 3 times to cereals. It is taken as whole gram as well as split pulse. In India, for ill or aged person moong dal kichadi is suggested as complete diet as it is smoothly digestible. The diet value of gram increases when it is mixed along with rice or wheat as of essential amino acids will combine and rich in amino acids particularly lysine, isoleucine, leucine, phenylalanine and valine. But as contrast to the impressive achievement in cereals, pulse production in our country remained almost stagnant with slight increase in productivity. As well as there is a lot decline in availability of per capita from 70 grams per day during 1960-61 to present as low as 35 grams against 80 grams per day as recommended by FAO or WHO-2016 In the country, for future purpose the required amount of pulses is 32 million tons which is 4.2% higher as compared to now, as the population will rise around 1.66 crores by the year 2030.

Pulses (green gram) are essential components in system of cropping in India as they has ability to fix atmospheric nitrogen into soil through rhizobium nodules, can draw water from deeper layers of soil as they got taproot system and through shedding leaves serves as organic matter to soil. They are not grown as major crops but as additional crops i.e., intercropping with other crops by the farmers that too without manuring. In green gram (*Vigna radiata* .L) the low yield is due to many reasons like cultivation in rainfed areas, in unfertile land, low application of fertilizers and lack of superior varieties or hybrids. Yield component characters play important role in the genetic variability, correlation and path analysis.

The inclusive range of variability in a crop will lead to the success of plant breeding programme in India. When it is on the basis of effectiveness of selection genetic variability range is related with the economic characters present in the population. The characters which are important economically and quantitatively inherited has great influence of environment. So that, it is very hard to decide that the observed character is inheritable or occurred due to impact of environment and thus it is, essential to separate this characters into the heritable and non-heritable components.

Studies of correlation considers mostly related association among two traits and which doesn't affect the relationship effect and cause between that two traits. According to Wright, 1921 path analysis is a partial regression analysis, which permits to separate coefficient of correlation to direct and indirect components effects of dependent and independent variables, which further permits the partitioning of correlation coefficient in to components of direct and indirect effects of independent variable on the dependent variable. Also Path analysis is an effective technique in statistics which is made to quantify relationship of different components and their direct and indirect effect on crop yield. From this technique ranks can be given for yield attributing characters (Rao et al., 2006).

Mash (*Vigna mungo)* laid emphasis on number of pods per plant and plant height by Veeraswamy et al. (1973). In green gram, about yield and yield components based on the genetic variability and correlation among different genotypes by Islam et al. (1999) as well as about genetic variability in inbred lines of green gram which are cultivated for high yield and breeding purpose was by Yimram et al. (2009).

Even though India is a leading producer in green gram globally but its productivity is very low. So that, there is a great scope for to increase its productivity by developing disease and pest resistance, high yielding varieties with good nutritional value. Amount of variability is high in green gram for different characters like flowering, number of days to maturity, plant height, harvest index, number of pods per plant, number of clusters per plant, etc. all this characters were utilized in breeding programs to release good number varieties in green gram. On the other hand these varieties cannot be used for many years due to genetic erosion and susceptibility to pest and diseases. This makes to put forth replacement of old varieties with new developed ones

So, in this study, all the component characters are included with reference to assess the genotypes for high genetic variability, correlation and path analysis potential. Main aim of this research is to check genetic variability, correlation and path analysis between the genotypes.

Considering the above mentioned information, the present study has been initiated to obtain the precise information on the extent of natural variability in respect of various Attributing Traits in Inbred Lines of Green gram. To accomplish such goals the investigation will be conducted with the following objectives:

- To identity superior Inbred Lines based on Yield Attributing traits.
- To estimate Genetic Parameters of Variability for Yield Attributing traits in Inbred Lines.
- To study Correlation, Genotypic and Phenotypic association among traits.
- To estimate Path Coefficient Analysis of traits under study on seed yield.

Review of Literature

The present investigation is aimed at finding out statistical parameters *viz,* genetic variability, correlation, path analysis and genetic diversity in 13 cultivars of green gram *(Vigna radiata* (L.) Wilczek). The literature relating to genetic variability, correlation and path analysis in mung bean is studied and presented in this review under the following:

1 .Genetic variability

2. Heritability and Genetic advance

3. Correlation and path analysis

1. Genetic Variability

The tendency of individual genetic characteristics in a population to vary from one another. This is useful in detection of variation between the genotypes of working population. There are so many studies been conducted to evaluate the genetic variability among different genotypes of green gram. More than fifty genotypes of green gram for genetic variability was analyzed by Loganathan *et al.* (2001b). High phenotypic coefficient of variability indicated the favorable effect of environment for number of clusters per plant and seed yield per plant and high genotypic coefficient of variability suggested substantial amount of genetic variability for number of pods per plant and seed yield per plant. Similarly another study of Venkateswarlu, (2001) reports that seed yield expressed high genotypic coefficient of variation coupled with high heritability and genetic advance. While comparing variability parameters of green gram, a large differences between phenotypic and genotypic coefficients of variability were observed for root length, number of secondary roots per plant and root shoot ratio, indicating that these characters are influenced by environment Chakraborty *et al.* (2001).

The major constraints for achieving higher yields are inherently low yielding potential of the varieties that lack genetic variability, inefficient plant type and low yielding potential, absence of suitable ideotypes for different cropping systems, poor harvest index, low level of crop management, more competition with weeds and susceptibility to biotic and abiotic stresses Sarobol, (1997); Souframanien and Gopalakrishna, (2004); Srinivas, (2006). This is probably due to the utilization of only a few selected genotypes of mungbean in cultivar development programme and underutilization of the gene pool of the Indian subcontinent Gupta *et al,* (2004) and Chattopadhyay *et al.* (2010). Ten diverse genotypes of green gram are evaluated for yield and nine other economic traits during *kharif* season. The study revealed considerable genetic variability was found among 10 genotypes days to 50% flowering, days to maturity, plant height (cm), number of productive branches per plant, number of productive pods per plant, number of seeds per pod, harvest index and seeds per plant (g) Atar *et al.* (2009).

Sufficient genetic variability was observed for plant height, pods per plant, total plant weight and seed yield Aqsa Tabasum, (2010). Moderate to high heritability estimates were found for all traits like primary and secondary branches per plant, pod length and 100-seed weight exhibited negative and non-significant genotypic and phenotypic correlations with seed yield Irum Aziz (2010). While different morphological and economic traits like plant height, clusters per plant, pods per plant, hundred seed weight, biological yield, seed yield and harvest index exhibited considerable genetic variability Ghulam Abbas *et al.* (2010). Even though the genotypes differed significantly for all characters studied. Higher genotypic coefficient of variation and phenotypic coefficient of variation was observed for harvest index followed by biological yield per plant Gadakh.S. S *et al.* (2013) and also variability studies revealed that the traits plant height, number of primary branches per plant, number of clusters per plant, number of pods per plant, test weight and seed yield per plant possessing high heritability and genetic advance as percent of mean offer much scope for further improvement through simple selection technique. All other traits may be improved upon through selection as the estimates of genetic advance were low or moderate Prasanna. B. L, (2013).

The genotypic coefficients of variation for all the characters studied were lesser than the phenotypic coefficients of variation indicating the modifying effects of the environment in association with the characters at genotypic level. High PCV and GCV estimates were observed for number of pods per plant, seed yield per plant Nand *et al.* (2013). Phenotypic coefficient of variation was slightly higher in magnitude than the genotypic coefficient of variation Kumar *et al.* (2013). But dominant variance were more pronounced except for the traits like plant height, pod cluster per plants, pods per plant, 100 seed weight and yield per plant indicating the importance of dominant gene effects for those traits. Partial dominance was observed for plant height, number of pods per plant and yield per plant P. S. Bainade *et al.* (2014).

2. **Heritability and Genetic advance**:

Heritability is the ratio of the genotypic variance to the phenotypic variance. It denote the proportion of phenotypic variation that is due to genotype. Generally expressed in terms of percentage (%). It is a good index of transmission of characters from parents to offsprings. Apart from this there are several studies which relates with heritability and genetic advance among those some are reviewed below, genetic advance is the improvement in the mean genotypic value of selected population over the parental population. It measure the genetic gain under selection. The success of GA depends on three factors Allard (1960), genetic variability, and heritability and selection intensity.

There is high heritability associated with high genetic advance over mean was observed for plant height, branches per plant, pods per plant and pod length which was reported by Das *et al,* (1998). It indicates that these traits were mostly controlled by additive gene action. Seeds per pod and yield per plant recorded low heritability coupled with low and high genetic advance, respectively. Low heritability, low genetic advance and non-additive gene action for days to first flowering, plant height, number of branches per plant, pod length and 100 seed weight reported by Loganathan *et al.* (2001b). As well as moderately high heritability with genetic advance for seed yield per plant suggesting the partial role of additive gene effects in their inheritance reported by Chakraborty *et al.* (2001). However, low heritability coupled with low genetic advance for root length, number of secondary roots per plant and root shoot ratio indicated that these traits were predominantly governed by non-additive gene effects.

High heritability estimates coupled with high genetic advance were observed for 100 seed weight, pod length, plant height and number of seeds per pod in *kharif*, while in summer for plant height, seed yield, number of pods per plant and 100 seed weight Peerajade *et al.* (2001). High heritability coupled with high genetic advance was observed in pods per plant, plant height and test weight indicating the importance of additive gene effect for expression of these characters Makeen *et al.,* (2007). The magnitude of phenotypic coefficients of variation was higher than genotypic coefficients of variation for all the traits showing greater influence of environment on these traits with the finding of by Siddique *et al*. (2006) and Makeen *et al.* (2007) who also reported similar effects of environment. Jagadeesan *et al.* (2008) and Tah, (2009) who reported high heritability and partial agree with Neha *et al*. (2005) and Veeramani *et al*. (2005) and also the heritability estimates for different characters in green gram were in broad agreement with reports of Momin and Misra, (2004); Idress *et al.* (2006); Babu *et al*. (2007); Tabasum *et al,* (2010); Rahim *et al*. (2010); Reddy *et al.* (2011); Makeen *et al*. (2007); Roychowdhury *et al.* (2012). High heritability, associated with high expected genetic advance, observed for harvest index, pods per plant, seed yield per plant, plant height, and number of productive branches per plant revealed preponderance of these traits.

For any yield improvement programme selection of superior parents possessing better heritability and genetic advance for any quantitative trait is an essential prerequisite Khan *et al.* (2005). Heritability indicates the relative success of selection Ortiz and Nq, (2000). Heritability in conjunction with genetic advance is more useful than heritability alone in the prediction of resultant effect of selecting the best individual Johnson et al. (1955) and Singh *et al*. (2010). On the basis of genetic variability study only 100 seed weight exhibited high heritability estimates (narrow sense) coupled with high genetic advance, indicating the preponderance of additive gene action Kumar *et al.* (2013).High heritability and genetic advance was observed in biological yield per plant, harvest index and number of pods per plant indicating the impact of additive gene affecting expression of three characters Gadakh. S. S *et al.* (2013). High heritability coupled with high expected genetic advance was observed in seed yield per plant indicating the impact of additive gene expression Sheetal Patel, (2014).

3. Correlation and path analysis:

Correlation is the process to establish connection between two or more variables. It is of two type's phenotypic and genotypic correlation. Phenotypic correlation is the correlation of line means for different traits, or for the same trait in different environments. Genotypic correlation is the correlation of genotypic effects free from difficulties with the effect of plots. Depend on the moment of variables correlation again divided into two types, they are positive and negative correlation. Positive correlation is the relation between two variables where if one variable increases the other variables also increases. Negative correlation is the relation between two variables where one variable increases the values of the other variable will decrease simultaneously. Correlation and path analysis are important biometrical tools for getting information regarding inter relationship among various traits for use in selection programme Prasanna *et al.* (2013).

Path analysis is a straightforward extension of multiple regression. Its aim is to provide estimates of the magnitude and significance of hypothesized causal connections between sets of variables. This can be well explained by considering a *path* diagram. It is also distinguished into three types of effects, direct effects, indirect effects and total effects. The association of one variable with another net of the indirect paths specified in a model is called direct effect. The association one variable with another variable mediated through another variables in the model is called as indirect effect. The sum of direct and indirect effects is called as total effect Qian-Li Xue, (2002).

While the result of Khan, (1991) concluded that number of pods per plant and number of clusters per plant should be considered as selection criteria for improvement of yield as these traits had significant positive correlation with yield studied by Warn *et al.,* (1992). The correlation and path coefficients were studied in 7 parents and F2 population of their 21 crosses in green gram by Ebenezer Babu Rajan *et al.,* (2000), found that seed yield had significant positive genotypic correlation with number of secondary roots at maturity, dry weight of plants at maturity, plant height, clusters per plant, pods per plant, seeds per pod and hundred grain weight and harvest index. Number of pods, clusters per plant and harvest index showed high positive correlation with gram yield and also with each other. Path analysis revealed that pods per plant had the highest positive direct effect on seed yield, followed by hundred grain weight.

In *kharif* yield per plant was positively and significantly correlated with number of pods per plant, seeds per pod, pod length and number of pods per cluster, while in summer with plant height, number of primary branches, number of pods per plant and number of pods per cluster Peerajade *et al.* (2002). A negative direct effect of number of primary branches on seed yield has also been reported by Arshad *et al.* (2004) and Idress *et al.* (2006): Hakim, (2008). A negative indirect effect via secondary branches, plant height, cluster per plant, and pod length and was also reported by Ajmal & Hassan, (2002); Celal (2004) and Rao *et al.* (2006). In correlation studies on root characters of 24 green gram genotypes revealed that seed yield was positively correlated with root length, nodules per plant and root dry weight Chakraborty *et al.* (2001).

Pods per plant, days to maturity plant height, 100 seed weight, seeds per pod and pod length showed significant and positive association with seed yield found by Venkateswarlu, (2001b).

Pods per plant and seeds per pod had maximum positive direct effect on seed yield. Days to maturity, clusters per plant, plant, height, 100 seed weight and seeds per pod exhibited high indirect effect on seed yield *via* pods per plant. Positive association of clusters per plant with pods per plant was reported earlier by Gopi Krishnan *et al*. (2002) while with harvest index was reported by Veeranjaneyulu *et al.* (2007). Significant positive association of clusters per plant and pods per plant with seed yield was reported earlier in urdbean by Natarajan and Rathinaswamy, (1999); Umadevi and Meenakshi Ganesan (2005); Chauhan *et al.* (2007). Similarly, Soundarapandian *et al*. (1976) and Veeranjaneyulu *et al.* (2007)

The correlation values decide only the nature and degree of association existing between pairs of characters. A character like seed yield is dependent in several mutually associated component characters and change in any one of the component is likely to affect the whole network of cause and effect of relationship. This in turn might affect the true association of component characters, both in magnitude and direction and tend to vitiate association of yield and yield components. Hence it is necessary to partition the phenotypic correlation of component characters into direct and indirect effects Biradar *et al.* (2007). Negative direct effects were recorded by days to 50% flowering, number of primary branches per plant, number of pods per cluster, number of clusters per plant and pod length with the reports of Pooran Chand and Rabhunandha Rao, (2002); Sunil Kumar *et al.* (2003) for days to 50% flowering, Nagarjunasagar and Reddi Sekhar, (2001); Chauhan *et al.* (2007) for number of primary branches and number of pods per cluster and Govindaraj and Subramanian, (2001) for number of clusters per plant and pod length.

Plant height, clusters per plant, pod length and 100 seed weight revealed negative indirect effects Rahman & Hussain, (2003); Celal, (2004); Makeen *et al*. (2007); Rao *et al.* (2006); Hakim, (2008) proving the effectiveness of direct selection through pods per plant for yield improvement. Association between seed yield and pods per plant, clusters per pod and seeds per pod was positive and highly significant Dhananjay *et al.* (2009). Traits like pods per plant and seeds per pod exhibited high order direct effects on seed yield Ramakanth *et al.* (2009). Significant positive association of pods per cluster with seed yield Ramesh Babu (1998) and Chauhan *et al.* (2007). While, Pooran Chand and Rabhunanda Rao, (2002); Rameshwari Netam *et al*. (2010) found significant positive association of 100-seed weight with seed yield. Character association indicated that pods per plant and plant height have significant positive correlation with seed yield.

Maximum direct effect on seed yield was observed through pods per plant, test weight and plant height Makeen *et al.* (2007). For number of primary branches and number of pods per cluster and Santha and Paramasivam, (1999b) and Govindaraj and Subramanian, (2001) for number of clusters per plant and pod length. Negative direct effects were recorded by days to 50% flowering, number of primary branches per plant, number of pods per cluster, number of clusters per plant and pod length Pooran Chand and Rabhunandha Rao, (2002) and Sunil Kumar *et al*. (2003). For days to 50% flowering, Nagarjunasagar and Reddi Sekhar, (2001) and Chauhan *et al.* (2007).

Of the association of character components plant height, number of cluster per plant, and number of pods per plant, pod length and number of seeds per pod showed highly significant positive correlation with yield per plant both at phenotypic and genotypic level. Similar high positive correlation was reported by many workers. For number of pods per plant, number of seeds per pod Rahim *et al.* (2010). For plant height, number of pods per plant, number of seeds per pod, 100 seed weight Reddy *et al*. (2011). For number of pods per plant, number of clusters per plant, number of seeds per pod Khajudparn and Tantasawat, (2011). Correlation analysis indicated that seed yield per plant was positive and significantly associated with days to maturity, plant height, number of pods per plant, number of seeds/pod and 100-seed weight Reddy. D *et al.* (2011). Path co-efficient analysis revealed that days to flowering, days to maturity, number of pods/plant, seed protein, shoot dry matter/plant and 100-seed weight had positive direct effects on seed yield/plant. Hence, selection on these traits could be improving seed yield in green gram Reddy. D *et al.* (2011).

Days to 50% flowering showed negative effect on seed yield via number of pods per plant. Significant negative correlation was shown pods per plant and days to 50% flowering with seed yield in eight genotypes of mungbean Aparna Raturi and S.K Singh, (2014) and whereas number of pods per plant, pod yield per plant and threshing percentage had shown positive and significant correlation along with their high positive direct effect with seed yield, suggesting that these parameters may be considered as prime traits during the course of selection to have the higher potential of yield in green gram Reddy. P *et al.*, (2014).

Most of the yield attributing quantitative traits measured under present study have also been reported to have highly significant variations with regard to different sets of mungbean genotypes

(Siddique et al., 2006; Abbas et al., 2008; Abbas et al., 2010; Rahim et al., 2010; Tantasawat et al., 2010; Mondal et al., 2011). Correlation study in green gram for different biometrical traits have been reported by earlier scientist Reddy D. et al. (2011), Makeen et al., (2007), Begum et al. (2012) Thippani et al. (2013) and Lalinial et al. (2014). Thus the significant, association of plant height in centimeters, pod length in centimeters, number of pods per plant and number of seeds per pod with yield and among them indicated that selection of genotype based on these characters will be effective for yield improvement.

While Rahim et al., (2010) reported highly significant positive correlation and positive correlation of pod length and number of seeds per pod with seed yield in 26 mungbean genotypes. High positive correlation of pods per plant with seed yield is attributed to the sink strength Tyagi and Khan, (2011). Number of secondary branches per plant, number of bunches per plant, number of pods per plant, number of grains per pod, pod length and 100 seed weight had shown positive and significant correlation along with their high positive direct effect with grain yield, suggesting that these parameters may be considered as prime traits during the course of selection to have the higher potential of yield in case of green gram (Kumar *et al.,* 2013). Number of primary branches per plant, number of clusters per plant, numbers of pods per plant, number of seeds, per pod and harvest index had significant and positive correlation with seed yield per plant. Number of pods per plant, harvest index, number of seeds per pod and days to maturity recorded to have maximum positive direct effect towards seed yield per plant (Prasanna *et al*., 2013).

Path coefficient measured of seed yield revealed, that the number of pods per plant had the maximum direct effect followed by plant, height and 1000-seed weight (Aparna Raturi and S.K Singh, 2014). Positive direct effect of pods per plant on seed yield via indirect positive effect through 1000-seed weight, number of seeds per pod, pod length, number of clusters per plant, number of primary branches, number of secondary branches and plant height (Aparna Raturi and S.K Singh, 2014). The plant height, number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of seeds per pod and 100-seed weight had highly significant and positive correlations with seed yield, at both genotypic and phenotypic levels (Sheetal Patel, 2014). Number of pods per plant, pod yield per plant and threshing percentage had shown positive and significant correlation along with their high positive direct effect with seed yield, (Muralidhar. Y. S *et al.,* 2015).

Materials and Methods

The present experimental research on green gram named as **'Study on genetic variability, correlation and path analysis with yield attributing traits in green gram (*Vigna radiata* L.)'** was conducted during the *Summer* season of 2016-2017, in main experimental form of Lovely Professional University, Phagwara, Kapurthala (district), Punjab at the latitude and longitude range of 31.2554° N and 75.7058° E respectively, following detailed plan of work. Each genotype was space planted in row plot of 5m length, having spacing of 40 cm × 10 cm, following row method in replication, to keep the plant population at optimum level. The experimental area occupied was quite uniform in respect of topography and fertility with sandy loam soil. Recommended agronomic practices were followed to have a good crop. The particulars of materials and methods used during these experimental trail and the statistical procedures followed were listed below.

3.1 Experimental Materials:

The material used for the experiment consists of 13 genetically diverse genotypes which are obtained from the source Banaras Hindu University, Varanasi and from Punjab Agricultural University, Ludhiana. The list of genotypes and their source is listed below.

Table. No: 3.1 genotypes and their source:

Serial.no	Genotypes	Source
1	**Pusa Vishal**	**Banaras Hindu University, Varanasi**
2	**HUM 12**	**Banaras Hindu University, Varanasi**
3	**HUM 8**	**Banaras Hindu University, Varanasi**
4	**Kopergan**	**Banaras Hindu University, Varanasi**
5	**HUM 16**	**Banaras Hindu University, Varanasi**
6	**ML 720**	**Banaras Hindu University, Varanasi**
7	**LM 5**	**Banaras Hindu University, Varanasi**

8	**LG 420**	**Banaras Hindu University, Varanasi**
9	**IPM 2**	**Banaras Hindu University, Varanasi**
10	**PUSA 4061**	**Banaras Hindu University, Varanasi**
11	**HUM 1**	**Banaras Hindu University, Varanasi**
12	**Moongi**	**Punjab Agricultural University, Ludhiana**
13	**Gold**	**Punjab Agricultural University, Ludhiana**

3.2 Climate and Weather:

Punjab is classified under humid subtropical climate with variations between summer and winter temperatures. The dry summer starts in April and lasts until June followed by the monsoon season from the last week of July to September. The temperature ranges between 22 and 46 °C in the summers. Winters in Punjab experience very large diurnal variations with warm days and downright cold nights. The average annual rainfall is 554.5 mm. The meteorological data during mung bean crop growth period from February to May 2016-17 have been given in appendix.

3.3 Experimental methods:

3.3.1 *Summer* season, 2016-17

Totally, 13 genotypes are considered for the experiment. These genotypes were sown in a single day in all three replications. Standard agronomic practices were followed to raise the crop. The seeds of each genotype were harvested separately from each replication to analyze the genetic variability, correlation and path analysis.

3.3.2 Observations recorded:

The following observations were recorded from the 13 genotypes during the experimental year randomly from 5 selected plants for each genotype in each replication and averages are worked out.

3.3.3 Days to 50% percent flowering:

Number of days required from date of sowing to the date on which 50 percent of the plants flowered was recorded.

3.3.4 Days to maturity:

Number days required for the physiological maturity from the date of sowing were required.

3.3.5 Plant height (cm):

At the physiological maturity the height of individual sampled plant were measured in centimeters from the ground level to the flower of the main shoot.

3.3.6 Number of pods per plant:

Number of pods per plant were to be counted at the time of harvesting.

3.3.7 Length of the pod (cm):

The length of the pod was calculated after harvesting all pods from the randomly selected plants.

3.3.8 Number of seeds per pod:

The seeds of different randomly selected plants were counted and average was taken out considering number of seeds per pod.

3.3.9Number of primary branches per plant:

The branches of the observational plant like primary branches were counted and recorded at the time of harvest.

3.3.10 Number of secondary branches per plant:

The branches of the observational plant like secondary branches were counted and recorded at the time of harvest.

3.3.11Number of clusters per plant:

The number of clusters per plant were counted and recorded after maturity.

3.3.12 Number of pods per cluster:

The number of pods per cluster were counted and recorded after maturity.

3.3.13 Number of seeds per plant:

The seeds from different randomly selected pods of the chosen plants were taken out and counted and worked out average for number of seeds per pod.

3.3.14 Harvest Index:

Harvest index was calculated by,

$$\text{Economic yield} = \frac{\text{Harvest index}}{\text{Biological yield}} \times 100$$

3.3.15 1000 grain weight(g):

One thousand threshed grains will be take randomly after sun drying at 12% moisture level and weighted in gram with the help of electric balance.

3.4 Statistical Analysis:

The mean values of five randomly selected observational plants for ten different characters were used for statistical analysis. The following statistical parameters were calculated for presentation of data on different quantitative attributes.

3.4.1 Analysis of variance (ANOVA):

The analysis of variance (ANOVA) was calculated as proposed by Sukhatme and Panse (1985) in the following format:

Table 3.2: ANOVA

Sr. No.	Source of variation	Degrees of freedom	Expected mean sum of squares
1	Replication	r-1	$\sigma^2 e + t\sigma^2 r$

2	Treatment	t-1	$\sigma^2 e + r\sigma^2\, t$
3	Error	(r-1) (t-1)	$\sigma^2 e$
4	Total	(rt-1)	

Whereas, r = number of replications t = number of treatments

3.4.2 Genotypic coefficient of variation (GCV):

The gcv was estimated by the formula proposed by Burton (1952).

$$GCV = \sqrt{\sigma^2 g}\ /\ 8\ X\ 100$$

Where, $\sigma^2 g$ = Vg = genotypic variance

8 = general mean of the character

3.4.3 Phenotypic Coefficient of Variation (PCV):

The pcv was estimated by the formula proposed by Burton (1952).

$$PCV = \sqrt{\sigma^2 p}\ /\ 8\ X\ 100$$

Where, $\sigma^2 p$ = Vp = phenotypic variance

8 = general mean of the character.

3.4.4 Heritability percentage:

Heritability percentage in broad sense calculated as suggested by Burton (1952).

h^2 (bs) = heritability percentage in broad sense

$$h^2 \text{(bs)}\ \% = \frac{\sigma^2 g}{\sigma^2 p} x\ 100$$

Whereas, $\sigma^2 p$ = phenotypic variance; $\sigma^2 g$ = genotypic variance

3.4.5 Genetic advance:

Genetic advance was calculated by the formula proposed by Johnson *et al* (1955).

$$G\,A = k \times (\sigma^2 g / \sigma^2 p) \times \sigma p \quad \text{Or } G\,A = k \times h^2 \times \sigma p$$

Where, K = selection differential which is 2.06 at 5 percent selection intensity

$\sigma^2 g$ = Vg = Genotypic variance;

$\sigma^2 p$ = Vp = Phenotypic variance

3.4.6 Correlation:

To understand the association among the characters, genotypic and phenotypic correlation coefficients were worked out by adopting the method described by Singh and Chaudhary (1977).

3.4.7 Phenotypic correlation coefficient:

$$rp = \text{covariance } X, Y\,(P) / \sqrt{variance X\,(P).\,variance\ Y\,(P)}$$

Where, rp = phenotypic correlation coefficient between character X and Y;

P = Phenotypic

3.4.8 Genotypic correlation coefficient:

$$rp = \text{covariance } X, Y\,(g) / \sqrt{variance X\,(g).\,variance\ Y\,(g)}$$

Where, rg = Genotypic correlation coefficient between character X and Y;

g = Genotypic

Significance of correlation coefficients were tested by using "t – test" (Panse and Sukhatme, 1985).

3.4.9 Path coefficient analysis:

The cause and effect relationship is well defined in path coefficient analysis. It is possible to represent the whole system of variables in the form of a diagram known as path diagram. Path coefficient analysis can be defined as the ratio of the standard deviation of the effect due to a given cause to the total standard deviation of the effect, in other words it is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects, i.e. it measures the direct and indirect contribution of various independent characters on a dependent character.

Designing new plant type, the knowledge of direct and indirect influence of yield contributing characters, path coefficient analysis will be under taken in parents and crosses. Wright (1921) proposed the original technique; analysis was carried out by modified method devised by Dewey and Lu. (1959). Following set of simultaneously equations were formed and solved for estimating direct and indirect effects.

If "Y" is the effect and X_1 is the cause, the path coefficient for the path from cause X_1 to the effect Y is $\sigma X_1 / \sigma Y$.

Direct and indirect methods were worked out on basis of genotypic correlations as:

Direct effect of X_1 on y = $PX_1 Y$

Where,

PX = path coefficient of X_1 on Y

Similarly, direct effects of other attributes on yield were worked out.

Indirect effect of X_1 via X_2 on y = $PX_1\ Y\ r\ X_1\ X_2$

Where,

PX_2Y = Path coefficient of the component character X_2 on Y

$r\ X_1\ X_2$ = genotypic correlation between X_1 and X_2

Similarly, indirect effects in all possible combinations were calculated for all component characters.

The residual effect of R is calculated as below.

$$R = (1- (PX_1\ Y.\ r\ X_1\ Y) – (PX_2\ Y.\ r\ X_2\ Y) – (PXn\ Y.\ r\ Xn\ Y))$$

Where,

$PX_1Y, PX_2Y, \ldots PXnY$ = direct effects of respective characters on seed yield.

The above equations will be written in a matrix form as under-

A C

$$\begin{bmatrix} r_1Y \\ r_2Y \\ . \\ . \end{bmatrix} \quad \begin{bmatrix} 1 & r_{12} & r_{13} \ldots\ldots r_{1i} \\ r_{21} & 1 & r_{23} \ldots\ldots r_{2i} \\ . & & \\ . & & \end{bmatrix} \quad \begin{bmatrix} P_1Y \\ P_2Y \\ . \\ . \end{bmatrix}$$

r_kY r_{k1} r_{k2} r_{k3}.....................1 P_kY

Then,

$B = [C]^{-1} A$

Where,

$$[C]^{-1} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \ldots\ldots\ldots\ldots & C_{1i} \\ C_{21} & C_{22} & C_{23} & C_{2i} \\ \cdot & & & \\ \cdot & & & \\ C_{i1} & C_{i2} & C_{i3} & C_{ii} \end{bmatrix}$$

Then the direct effects will calculated as follows -

$$P_1Y = \sum_{i=1}^{k} C_{1i}\, r_iy$$

$$P_2Y = \sum_{i=1}^{k} C_{2i}\, r_{iy}$$

$$P_kY = \sum_{i=1}^{k} C_{ki} r_k y$$

Residual effect will be obtained as per for formula given below –

$$R = \sqrt{1 - \sum d_i r_{ij}}$$

Where,

d_i = Direct effect of the i^{th} character

r_{ij} = Correlation coefficient of the i^{th} character with j^{th} character.

Path coefficient were to be rated based on the scales given below. (Lenka and Mishra 1973).

> 1.0	Very high
0.30 – 0.99	High
0.2 – 0.29	Moderate
0.1 – 0.19	Low
0.00 – 0.09	Negligible

Experimental Results

The contemporary experiments on green gram **[***Vigna radiata* (L.) Wilzeck**]** with 13 genotypes were done to understand the genetic variability, correlation and path analysis in *Summer* season 2017. Several parameters were considered and the results obtained from observations were represented in this section.

4.1 Analysis of Variance:

The 13 characters which were included in this experimental work showed highly significant differences through analysis of variance were shown in the table 4.1.1.

4.1.1 Days to 50% flowering:

This character had a population mean of **67.17** and Kopergan (62.33), LM-5 (62.33) were the genotypes in which flowering was early, followed by HUM-16 (65.33), Pusa Vishal (65.66), HUM-12, IPM-2 and HUM-08. Some required very less time to 50 % flowering compared to mean of population they are Kopergan (62.33), LM-05(62.33), HUM-16 (65.33), Pusa Vishal (65.66) and HUM-12 (66.66). The genotypes LG-420 (70.33), HUM-01 (70.33) followed by Pusa-460 (69.66), ML-720 (69.66), IPM-02 (67.33) and HUM-08 (67.66) were the one to flower late when compared with mean.

4.1.2 Days to maturity:

The character had a population mean of **99.25**. The first matured genotype was LM-05 (95.00) followed by Kopergan (96.33), HUM-16 (97.00), Gold (97.33), IPM-02 (97.66) and Moongi (98.33). There are some genotypes which had early maturity than population mean LM-05 (95.00), Kopergan (96.33), HUM-16 (97.00), Gold (97.33), IPM-02 (97.66) and Moongi (98.33). The genotypes which were lately matured were listed as LG-420 (102.66), Pusa-460 (102.33), ML-720 (102.00) followed by HUM-08 (101.66), HUM-01 (101.33), HUM-12 (99.33) and Pusa Vishal (99.33).

4.1.3 Plant height (cm):

In this character out of 13 genotypes, the mean population was evaluated as **30.83** .The maximum plat height was recorded by a genotype Pusa-460 (34.33), followed

4.1.1 Analysis of variance in green gram for 13 different characters.

sl.no	characters	Mean sum of squares		
		Replications (R)	Treatment (T)	Error (E)
1	**Days to 50% flowering**	11.0833	21.7564**	4.4583
2	**Days to maturity**	15.6987	19.3974	7.5320
3	**Pri, branches per plant**	0.1116	0.1965	0.0754
4	**Sec. branches per plant**	0.7033	2.1485	0.7627
5	**Clusters per plant**	0.2471	3.8502**	0.6271
6	**Pods per cluster**	0.1323	1.0085**	0.1567
7	**Plant height (cm)**	0.9155	12.4818	4.2030
8	**Pod length (cm)**	0.4430	1.9564	0.6569
9	**Pods per plant**	19.9017	174.700**	10.5501
10	**Seeds per pod**	2.0392	3.9778*	0.9903
11	**Test weight**	0.1187	0.3797**	0.0534
12	**Seed yield per plant**	3.2215	41.5776**	2.7790
13	**Harvest index**	227.821*	882.954**	60.7774

'*' and '**' denotes significance at 5 % and 1 % level of probability respectively by LM-05 (33.97), HUM-08 and Pusa Vishal. The dwarf genotype was HUM-12 (27.53). Along with this some plants had recorded less than the population mean, they are HUM-01 (28.70), Moongi (29.33), LG-420 (29.73), HUM-16 (29.83), Kopergan (30.00), Gold (30.66) and ML-720 (30.68).

4.1.4 Number of primary branches:

The character got the mean population as **4.97**. The variation of primary branches ranged as 4.33 to 5.40.Pusa Vishal (5.40), ML-720 (5.23), LG-420 (5.13), Pusa-460 (5.00), LM-05 (5.00), HUM-16 (5.00) and HUM-08 (5.00) were genotypes given rise to more number of primary branches than the mean. Out of 13 genotypes, 4 were shown profuse branching than the population mean. The genotype type with less primary branches was Moongi (4.33).

4.1.5 Number of secondary branches:

The population mean of this character was **6.51**. The variation of secondary branches range as 4.53 to 7.80. The genotype Moongi (7.80) recorded highest number of secondary branches which was followed by HUM-16 (7.46), ML-720 (7.40), Pusa-460 (6.86), LG-420 (6.80), Gold (6.66) and HUM-01 (6.60). Out of 13 genotypes, 4genotypes given rise to more secondary branches compared to mean.

4.1.6 Length of Pod:

This character recorded population mean as **7.21**. The range of variation among the genotypes was 5.32 to 8.62. The genotypes HUM-16 (8.62) showed the highest pod length which was followed by genotypes HUM-01 (8.20), LM-05 (7.97), Pusa Vishal (7.46), LG-420 (7.33) and Moongi (7.24). The genotype HUM-12 (5.32) recorded smallest pod length, which were also followed by HUM-08 (6.73), Gold (6.74), Pusa-460 (6.91), IPM-02 (6.95) recorded less pod length then mean.

4.1.7 Number of pods per plant:

More number of pods were harvested from the genotype Kopergan (44.20), followed by LM-05(37.60), Pusa Vishal (36.06), HUM-16 (32.66). The population mean

4.1.2 Mean performance of green gram genotypes for 13 different characters:

Sl.no	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
Kopergan	62.33	96.33	4.86	6.43	9.00	4.46	7.50	30.06	7.06	44.20	17.31	5.20	73.26
PusaVishal	65.66	99.33	5.40	6.26	7.80	4.46	7.70	32.08	7.46	36.06	15.36	5.41	74.00
LM-05	62.33	95.00	5.00	5.93	8.06	4.73	7.97	33.97	7.7	37.60	12.88	4.37	60.96
HUM-16	65.33	97.00	5.00	7.46	7.26	4.53	10.18	29.83	8.62	32.66	18.03	5.39	88.70
HUM-12	66.66	99.33	4.80	4.53	5.00	3.60	5.33	27.53	5.32	16.66	3.95	4.60	33.43
HUM-08	67.66	101.66	5.00	5.86	5.33	4.53	7.70	33.20	6.73	23.80	10.25	4.62	72.80
ML-720	69.66	102.00	5.23	7.40	6.0	3.66	8.60	30.68	7.27	24.53	10.98	5.23	46.36
LG-420	70.33	102.66	5.3	6.80	7.26	3.53	7.46	29.73	7.33	24.66	9.92	5.33	35.96
IPM-02	67.33	97.66	5.13	6.00	6.73	3.46	8.73	30.73	6.95	23.60	10.82	5.11	70.66
Pusa-460	69.66	102.33	5.00	6.86	8.40	3.20	8.43	34.33	6.1	25.13	11.14	5.27	48.36
HUM-01	70.33	101.33	4.93	6.60	7.00	3.00	9.33	28.70	8.20	21.23	10.75	5.16	67.43
Gold	68.33	97.33	4.80	6.66	7.26	3.53	8.56	30.66	6.74	25.20	11.52	5.37	54.33
Moongi	67.66	98.33	4.33	7.80	8.13	3.26	7.53	29.33	7.24	25.20	8.21	4.69	40.53
Mean	67.17	99.25	4.97	6.51	7.23	3.84	8.08	30.83	7.2	27.73	11.62	5.06	58.98
S.E±	1.21	1.58	0.15	0.50	0.45	0.22	0.57	1.18	0.46	1.87	0.96	0.13	4.50
C.D 5 %	3.55	4.62	0.46	1.47	1.33	0.66	1.67	3.45	1.36	5.47	2.80	0.38	13.13
C.D 1 %	4.82	6.26	0.62	1.99	1.80	0.90	2.27	4.68	1.85	7.41	3.95	4.37	33.43

Whereas, P1 =days to 50 % flowering**, P2 =**days to maturity**, P3 =**primary branches per plant**, P4 =**secondary branches per plant**, P5** =clusters per plant**, P6 =**pods per cluster**, P7 =**seeds per pod**, P8 =**plant height (cm)**, P9 =**pod length (cm), **P10 =**pods per plant**, P11** =seed yield per plant**, P12 =**test weight and **P13 =**harvest index (%)

S.E= standard error;

C.D 5% and 1% = critical difference

of this character was **27.73**. Some genotypes had recorded lowest number of pods harvested from them compared to population mean they are HUM-12 (16.66), HUM-01 (21.23), IPM-02 (23.60), HUM-08 (23.80), ML-720 (24.53), LG-420 (24.66), Pusa-460 (25.13), Moongi (25.20), Gold (25.20). Out of 13 genotypes, 5 genotypes were recorded lowest number of pods harvested from them.

4.1.8 Number of seeds per pod:

Out of 13 genotypes, 4 genotypes such as HUM-16 (10.18), HUM-01 (9.33), IPM-02 (8.73) and ML-720 recorded more number of seeds per pod than population mean. The population mean for this character was **8.08**. The genotype HUM-12 recorded with least number of seeds per pod.

4.1.9 Number of pods per cluster:

The population mean of this character was **3.84**. The inbreed lines like LM-05 (4.73), HUM-16 (4.53), HUM-08 (4.53), Pusa Vishal (4.46) and Kopergan (4.46) recorded more number of pods. Among 13 genotypes only 5 produced more number of pods than the population mean. The inbreed line HUM-01 (3.00) had very least number of pods per cluster.

4.1.10 Number of clusters per plant:

The population mean of this character was **7.23**. The inbreed line Kopergan (9.00) showed maximum number of clusters per plant, followed by Pusa-460 (8.40), Moongi (8.13), LM-05 (8.06), Pusa Vishal (7.80), Gold (7.26), LG-420 (7.26) and HUM-16 (7.26) . Among 13 inbreed lines only 4 had more number of clusters per plant compared to population mean. The genotype HUM-12 (5.33) had very least number of clusters per plant.

4.1.11 Yield per plant:

Out of 13 genotypes only 4 had recorded high yield per plant than the population mean. The population mean of this character was **11.62**. The inbreed line HUM-16 (18.03) showed highest yield per plant, followed by Kopergan (17.31), Pusa Vishal (15.36), LM-05 (12.88). The range of variation among the inbreed lines was 3.95 to 18.03. The genotype HUM-12 (3.95) showed very low yield per plant.

4.1.12 100 Seed Test weight (gm):

The mean of population was **5.06**. Out of 13 genotypes, 10 genotypes were shown highest test weight than the population mean. The genotype Pusa Vishal (5.41) shown test weight higher, followed by HUM-16 (5.39), Gold (5.37), LG-420 (5.33), Pusa-460 (5.27), ML-720 (5.23), Kopergan (5.20), IPM-02 (5.11) and HUM-01 (5.16). Minimum test weight was recorded by the genotype LM-05 (4.37).

4.1.13 Harvest Index:

The population mean of this character was **58.98**. The range of variation among this genotypes was 33.43 to 88.70. Compared to mean, out of 13 genotypes only 4 genotypes were recorded highest harvest index. The genotypes such as HUM-16 (88.70), Pusa Vishal (74.00), Kopergan (73.26), HUM-08 (72.80), IPM-02 (70.66), HUM-01 (67.43) and LM-05 (60.96) showed highest harvest index.

4.2 Parameters of genetic variability:

The parameters of genetic variability were viz., variability, range, GCV, PCV, heritability (BS), genetic advance, genetic advance as per percent mean were discussed in the table. 4.2. Some major findings were descripted below.

4.2.1 Variation coefficient:

The estimates of GCV (genotypic coefficient of variation) were lower than the PCV (phenotypic coefficient of variation) in the experiment for all the characters for all characters. The highest GCV was recorded for yield per plant (30.92), followed by harvest index (28.06) , pods per plant (26.66)., pods per cluster (14.58), cluster per plant (14.32), seeds per pod (12.34), sec. branches per plant (10.43), pod length in cm (9.11), 100 seed weight (6.51), plant height in cm (5.38), primary branches per plant (4.04), days to 50 percent flowering (3.57) and days to maturity (2.00). Days to maturity (2.00) was the one character which had recorded magnitudinally lowest GCV and the character

Table no: 4.2.1; Traits showing Genetic Parameters of Variability 2017:

Sl.no	*Characters*	*Range*	*G.M*	*GCV*	*PCV*	*Heritability (bs) (%)*	*G.A*
1.	**D T F 50%**	62.33–70.33	67.17	3.57	4.76	56.4	3.71
2.	**D T M**	95.00–102.66	99.25	2.00	3.41	34.4	2.40
3.	**Pri. branches/ plant**	4.33-5.40	4.97	4.04	6.84	34.8	0.24
4.	**Sec. branches/ plant**	4.53-7.80	6.51	10.44	16.99	37.7	0.86
5.	**Clusters/ plant**	5.00-9.00	7.23	14.32	18.02	63.1	1.69
6.	**Pods per cluster**	3.00-4.73	3.84	14.58	17.85	66.8	0.94
7.	**Seeds / pod**	5.33-10.18	8.08	12.34	17.43	50.1	1.45
8.	**Plant height (cm)**	27.53-34.33	30.83	5.38	8.55	39.6	2.154
9.	**Pod length (cm)**	5.32-8.62	7.21	9.11	14.46	39.7	0.85
10.	**Pods / plant**	16.66-44.20	27.73	26.67	29.12	83.8	13.95
11.	**Seed yield / plant**	3.95-8.03	11.62	30.92	34.09	82.3	6.72
12.	**100 seed wt (gm)**	4.37-5.41	5.06	6.51	7.95	67.1	0.55
13.	**Harvest index (%)**	33.43-88.70	58.98	28.06	31.02	81.8	30.85

G.M= general mean;

GCV= genotypic coefficient of variation;

PCV= phenotypic coefficient variation;

bs = broad sense**;**

G.A= genetic advance.

shown magnitudinally low PCV was days to maturity (3.415). The maximum PCV was shown by the characters pods per plant (29.12), clusters per plant (18.02), pods per cluster (17.85) seeds per pod (17.43), secondary branches per plant (16.99), pod length in cm (14.46) and plant height in cm (8.55).

The highest magnitudinal differences among the GCV and PCV were shown to the character secondary branches per plant (10.44 and 16.99 respectively) followed by pod length, seeds per pod, clusters per plant, pods per cluster and plant height in cm. The character days to 50% flowering has the minimal differences between the GCV and PCV.

4.3 Heritability Percentage (broad sense):

The estimates of heritability varied as 34.4 (days to maturity) and 83.8 (pods per plant). The character pods per plant (83.8) has the highest heritability which was followed by yield per plant (82.3), harvest index (81.8), test weight (67.1) and pods per cluster (66.8).

The character days to maturity (34.4) had recorded lowest heritability which was followed by primary branches per plant (34.8), secondary branches per plant (37.7), plant height (39.6), pod length (39.7) and seeds per pod (50.1).

4.4 Genetic advance as 5% of mean:

The highest Genetic advance as percent of mean 5% was shown in the character yield per plant (57.80), harvest index (52.30), pods per plant (50.30), pods per cluster (24.54) and clusters per plant (23.44). The character days to maturity (2.42) exhibited lowest genetic advance as mean of 5%. The remaining characters were also shown low genetic advance as mean of 5% such as primary branches per plant (4.91) days to 50% flowering (5.53), plant height (6.98) and test weight (10.99). However yield per plant (57.80) and harvest index (52.30) recorded high genetic advance as mean of 5% accompanied with higher genetic variabilities.

High values of genetic advance were observed in the characters harvest index (30.85), pods per plant (13.95) and yield per plant (6.72). Whereas primary branches per plant (0.24), test weight (0.55), pod length (0.85), secondary branches per plant (0.86) and pods per cluster (0.94) recorded lowest genetic advance.

4.5 Correlation:

The correlations like phenotypic coefficient of correlation and genotypic coefficient of correlation among yield attributing traits were considered in table 4.5.1 and 4.5.2

4.5.1 Association between seed yield per plant and its components

The seed yield per plant shows that it is highly significant and positively correlated with characters like pods per plant (0.77), harvest index (0.74), pod length (0.79), seeds per pod (0.78), clusters per plant (0.67), test weight (0.46) at genotypic level. But the character days to 50 % flowering (-0.67) and days to maturity (-0.66) recorded highly significant negative association at genotypic level with seed yield per plant. The characters pod length and pods per cluster and pods per plant were positive but non-significant to yield per plant. At genotypic level, the character number of primary branches per plant (-0.20) and number of secondary branches per plant (-0.50) were negative but non-significant to seed yield per plant.

The characters like pods per plant (0.78), harvest index (0.71), clusters per plant (0.58), pod length in cm (0.56), seeds per pod (0.48) and pods per cluster (0.48) with phenotypic correlation showed significantly positive correlation with yield per plant. However, some characters like days to maturity (-0.15) and days to 50 % flowering (-0.27) were negative but non-significant association with yield per plant. And also characters like primary branches per plant (0.33) and secondary branches per plant (0.36) were positive but non-significant to yield per plant.

4.5.2 Association between yield components:

At genotypic level and phenotypic level association between yield components was detailed below

4.5.2.1 Days to 50 % flowering:

The character days to 50 percent flowering was significant and positively correlated at genotypic level with characters days to maturity (0.84), secondary branches per plant (0.26), seeds per pod (0.15) and test weight (0.29) showed at phenotypic level significant and positive correlation. While the characters primary branches per plant (-0.20), clusters per plant (-0.45), pods per cluster (-0.90) and harvest index (-0.51) were negative and significantly correlated at genotypic level.

Table.no: 4.5.2.1 Genotypic coefficient correlation among the 13 characters of green gram in summer 2017:

characters	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
P1	**1.0000**	0.8417	-0.2004	0.2694	-0.4590	-0.9045	0.1534	-0.4152	-0.3071	-0.8886	0.2984	-0.5124
P2		**1.0000**	0.0244	0.0182	-0.5763	-0.6263	-0.1752	-0.1941	-0.4348	-0.7682	0.2283	-0.5238
P3			**1.0000**	-0.5067	-0.1901	0.5306	0.1641	0.3695	0.0194	0.3053	0.4610	0.4489
P4				**1.0000**	0.6730	-0.1541	0.7893	-0.2869	0.7997	0.2068	0.4448	0.0709
P5					**1.0000**	0.1883	0.3787	0.2428	0.6176	0.7722	0.3514	0.1490
P6						**1.0000**	0.380	0.6028	0.4131	0.7582	-0.1799	0.6429
P7							**1.0000**	0.1913	1.0419	0.2565	0.5306	0.6944
P8								**1.0000**	0.0943	0.4145	-0.3029	0.2800
P8									**1.0000**	0.6158	0.2132	0.7476
P10										**1.0000**	0.1410	0.5516
P11											**1.0000**	0.2581
P12												**1.0000**

P1 = days to 50% flowering, **P2 =** days to maturity, **P3 =** primary branches per plant, **P4 =** secondary branches per plant, **P5 =** clusters per plant, **P6 =** pods per cluster, **P7 =**seeds per pod, **P8 =** plant height (cm), **P9 =** pod length (cm), **P10 =** pods per plant, **P11 =** 100 seed weight and **P12 =** harvest index.

4.5.2.2 Days to maturity:

The character days to maturity was significantly and positively correlated with the characters days to 50% flowering (0.84), test weight (0.22) and primary branches per plant (0.02), but with the characters clusters per plant (-0.57), pods per cluster (-0.62), pods per plant (-0.76) and harvest index (-0.52) at genotypic level showed negative correlation significantly.

4.5.2.3 Plant height (cm):

The character plant height was significantly and positively correlated with pods per plant (0.41) and harvest index (0.28), but at genotypic level it showed negative correlation with test weight (-0.30). At phenotypic level, plant height was significantly positively correlated with pods per plant (0.26), pod length (0.22) and harvest index (0.19).

4.5.2.4 Number of primary branches per plant:

At genotypic and phenotypic levels number of primary branches per plant was significantly and positively correlated with pods per cluster (0.53), test weight (0.46), harvest index (0.44), plant height (0.36) and test weight (0.41), plant height (0.35) and pod length (0.34) respectively. But at genotypic level it showed negative correlation with secondary per plant (-0.50) and clusters per plant (0.19) pod length and number of seeds per pod.

4.5.2.6 Number of secondary branches per plant:

This character at genotypic level, it showed significant and positive correlation with pod length (0.79), seeds per pod (0.78), clusters per plant (0.67) and test weight (0.44). At phenotypic level, it showed significant and positive correlation with seeds per pod (0.50), test weight (0.48), pod length (0.47) and clusters per plant (0.44). But at genotypic and phenotypic level this character showed significantly negative correlation with plant height (-0.28), pods per cluster (-0.15) and pods per cluster (-0.22) respectively.

4.5.2.7 Clusters per plant:

Clusters per plant was significant and positively correlated with pods per plant (0.77), pod length (0.61) and seeds per pod (0.37) at genotypic level. At phenotypic levels Clusters per plant was significant and positively correlated pods per plant (0.62), pod length (0.34), plant height (0.33) and test weight (0.32). For the character pods per cluster (-0.07) showed significantly negative correlation.

4.5.2.8 Pods per cluster:

Pods per cluster at genotypic level, significant and positively correlated with pods per plant (0.75), harvest index (0.64) and plant height (0.60). At phenotypic level, it was significant and positively correlated with pods per plant (0.67) and harvest index (0.50). But at both genotypic and phenotypic levels, it was non-significant and negatively correlated with test weight.

4.5.2.9 Number of seeds per pod:

For the characters harvest index (0.69) and test weight (0.53) at genotypic level it showed significant and positive correlation. At phenotypic level, harvest index (0.50) and pod length (0.58).

4.5.2.10 Pod length (cm):

The character pod length at phenotypic and genotypic levels significantly and positively correlated with harvest index, test weight and pods per plant. But there was no negatively significant correlation with any character

Table.no:4.5.2.2 Phenotypic coefficient correlation among the 13 characters of green gram in summer 2017:

characters	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
P1	**1.0000**	0.8464**	0.2693	0.2813	-0.1538	-0.6509**	0.1585	0.0599	0.0785	-0.6647**	0.3785	-0.3841
P2		**1.0000**	0.4489**	0.7157	-0.1165	-0.3686	0.0299	0.1682	0.0232	-0.4337**	0.2635	-0.2726
P3			**1.0000**	0.0948	0.0006	0.1149	0.2732	0.3519	0.3419	0.3419	0.0586	0.4178
P4				**1.0000**	0.4438*	-0.2298	0.5075**	0.2803	0.4786*	0.1404	0.4816*	0.0784
P5					**1.0000**	-0.0706	0.2106	0.3390	0.3405	0.6285**	0.3218	0.1516
P6						**1.0000**	-0.0688	0.1632	0.0526	0.6727**	-0.2160	0.5028*
P7							**1.0000**	0.2025	0.5858**	0.0461	0.4739*	0.5002*
P8								**1.0000**	0.2217	0.2652	0.0721	0.1983
P9									**1.0000**	0.2605	0.3637	0.3647
P10										**1.0000**	0.1121	0.5216**
P11											**1.0000**	0.2105
P12												**1.0000**

Whereas, '*' and '**' refers to 5% and 1% level of significance.

P1 = days to 50% flowering, **P2 =** days to maturity, **P3 =** primary branches per plant, **P4 =** secondary branches per plant, **P5 =** clusters per plant, **P6 =** pods per cluster, **P7** =seeds per pod, **P8 =** plant height (cm), **P9 =** pod length (cm), **P10 =** pods per plant, **P11 =** 100 seed weight and **P12 =** harvest index.

Figure 4.5.2 Phenotypical correlations:

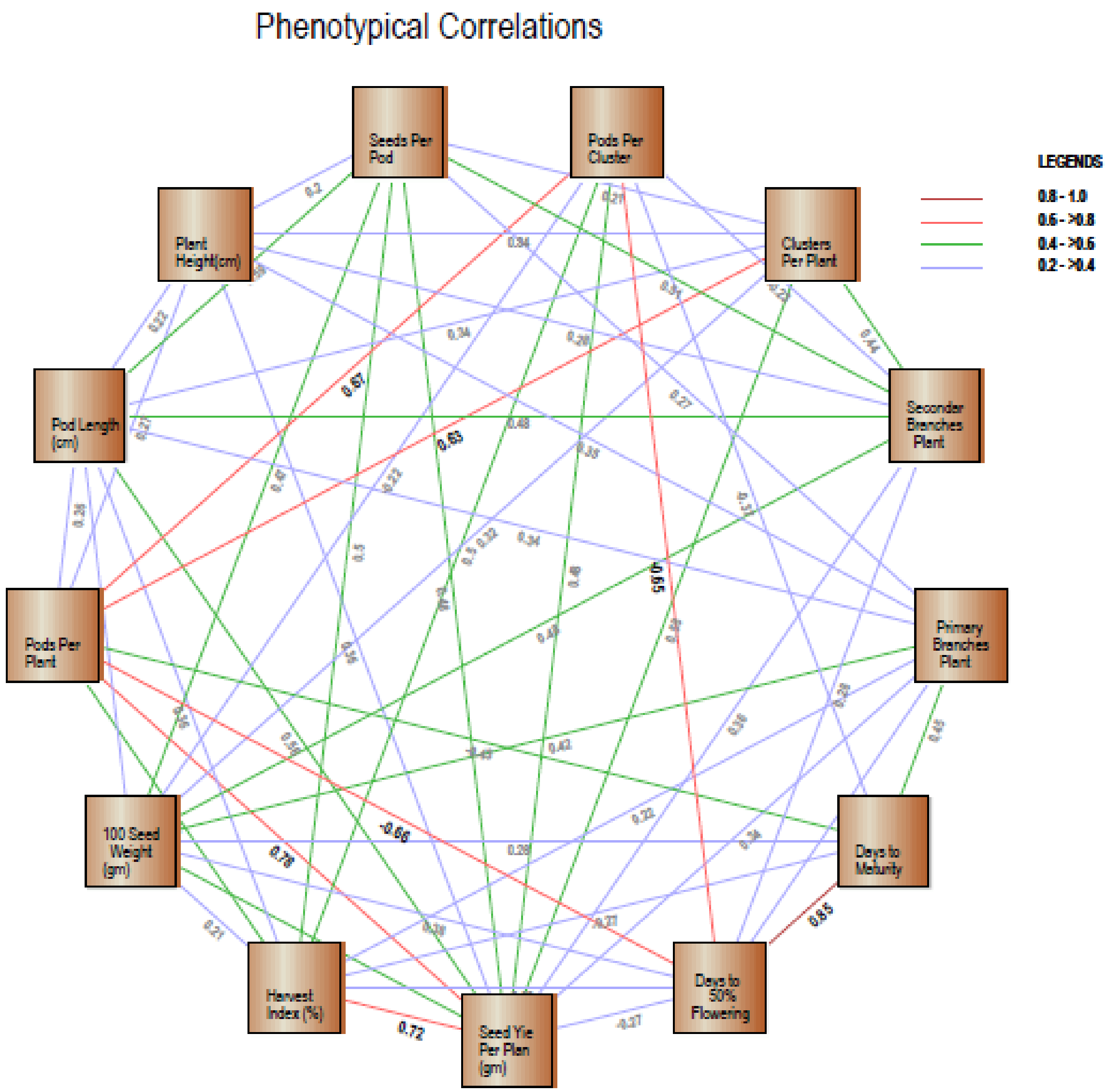


Figure showing positive and negative correlations among the characters of green gram

4.6 Path Analysis:

The contributions of direct and indirect effects of each character towards the yield per plant revealed by the path analysis were represented in the table. In path analysis, the magnitude of phenotypic coefficient of correlation is more important so it was taken into consideration.

4.6.1 Genotypical path analysis:

In all the 13 characters evaluated, harvest index (0.18), recorded high magnitude and positive direct effect towards the yield per plant which was followed by pods per plant (0.13). The other characters such as pods per cluster (-0.12), pod length (-0.013), seeds per pods (-0.014), harvest index (0.074) showed direct effect which is negative with high magnitude. Clusters per plant, pods per plant, secondary branches per plant, pods per cluster showed positive direct effect with low magnitude.
The characters pods per cluster, clusters per plant and harvest index recorded maximum and positive magnitude towards direct effect on seed yield per plant and their association with seed yield was also highly significant. But some characters like pods per plant, seeds per pod and days to maturity recorded magnitudinally negative direct effect on yield per plant. Days to 50 percent flowering, test weight were the characters which recorded maximum and positive magnitude direct effect on yield per plant and their association with seed yield was also highly significant and positive. But, some characters like pod length, plant height, secondary branches showed positive direct effect but non-significant and negative to seed yield per plant. Number of seeds per pod and days to maturity, clusters per plant showed negative direct effect but positive and significant association with seed yield per plant.

4.6.1.1 Days to maturity:

Days to maturity recorded magnitudinally negative direct effect on seed yield per plant and their association was significant. Clusters per plant, pods per plant and harvest index showed indirect positive effect on days to maturity. But some characters like 100 seed weight, secondary branches per plant and primary branches per plant showed indirectly negative effect and non-significant association with days to maturity.

Table.no: 4.6.1

Genotypic path coefficient analysis showing direct and indirect effect of different contributions on yield per plant in green gram 2017:

characters	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
P1	**0.2444**	0.2060	-0.0490	0.0659	-0.1123	-0.2213	0.0375	-0.1016	-0.0751	-0.2175	0.0730	-0.1254
P2	-0.1771	**-0.2104**	-0.0051	-0.0038	0.1213	0.1318	0.0369	0.0409	0.0915	0.1616	-0.0480	0.1102
P3	-0.0069	0.0008	**0.0343**	-0.0174	-0.0065	0.0182	0.0056	0.0127	0.0007	0.0105	0.0158	0.0154
P4	0.0183	0.0012	-0.0345	**0.0680**	0.0458	-0.0105	0.0537	-0.0195	0.0544	0.0141	0.0303	0.0048
P5	-0.2867	-0.3600	-0.1188	0.4204	**0.6247**	0.1176	0.2365	0.1517	0.3858	0.4824	0.1970	0.0931
P6	-0.5970	-0.4133	0.3502	-0.1017	0.1243	**0.6600**	0.0251	0.3978	0.2726	0.5004	-0.1188	0.4243
P7	-0.0459	0.0524	-0.0491	-0.2360	-0.1132	-0.0114	**-0.2990**	-0.0572	-0.3115	-0.0767	-0.1587	-0.0206
P8	-0.0399	-0.0564	0.0026	0.1038	0.0802	0.0536	0.1352	**0.0122**	0.1298	0.0799	0.0277	0.0970
P9	0.3812	0.3295	-0.1310	-0.0887	-0.3312	-0.3252	-0.1100	-0.1778	**-0.2641**	-0.4289	-0.060	-0.2366
P10	0.1047	0.0801	0.1618	0.1561	0.1107	-0.0631	0.1862	-0.1063	0.0748	**0.0495**	0.3509	0.0906
P11	0.1047	0.0801	0.1618	0.1561	0.1107	-0.031	0.1862	-0.1063	0.0748	0.0495	**0.3509**	0.0906
P12	-0.3034	-0.3101	0.2658	0.0420	0.0882	0.380	0.4111	0.1658	0.4426	0.3265	0.1528	**0.5920**

P1 =days to 50% flowering**, P2 =** days to maturity**, P3 =**primary branches per plant**, P4 =** secondary branches per plant**, P5 =**clusters per plant**, P6 =**pods per cluster**, P7 =**seeds per pod**, P8 =**plant height (cm)**, P9 =**pod length (cm)**, P10 =**pods per plant**, P11 =**test weight **and P12 =**harvest index**.**

R SQUARE = 1.0196; RESIDUAL EFFECT = SQRT (1-1.0196)

4.6.1.2 Primary branches per plant:

Primary branches plant recorded magnitudinally positive direct effect but non-significant association with seed yield per plant. Characters like pods per plant, 100 seed weight, harvest index and plant height showed magnitudinally indirect positive effect and significant association with primary branches per plant. Whereas secondary branches per plant and clusters per plant showed magnitudinally indirect negative effect on primary branches per plant.

4.6.1.3 Secondary branches per plant:

Secondary branches plant showed magnitudinally positive direct effect on seed yield per plant. Seeds per pod, pod length, 100 seed weight showed indirect positive effect on secondary branches per plant. But plant height and pods per cluster showed magnitudinally indirect negative effect on secondary branches per plant.

4.6.1.4 Clusters per plant:

Clusters per plant showed magnitudinally positive direct effect on seed yield per plant. Pods per plant, seeds per pod, pod length, 100 seed weight, plant height and pods per cluster showed indirect positive effect on clusters per plant, but harvest index showed indirect positive effect and non-significant association with clusters per plant.

4.6.1.5 Pods per cluster:

Pods per cluster showed magnitudinally positive direct effect with seed yield per plant. Pods per plant, harvest index, plant height and pod length had showed indirect positive effect on pods per cluster with significant association. But the character 100 seed weight showed indirect negative effect on pods per cluster.

4.6.1.6 Seeds per pod:

Seeds per pod magnitudinally negative direct effect with seed yield per plant. Pod length and 100 seed weight had shown negatively indirect effect with seeds per pod. But the characters plant height and pods per plant had shown negatively indirect effect and non-significant association with seeds per pod.

4.6.1.7 Plant height:

Plant height magnitudinally negative direct effect with seed yield per plant. Pods per plant and 100 seed weight showed indirect positive effect on plant height. Harvest index had shown negative indirect effect on plant height whereas pod length had shown negative indirect effect and non-significant association with plant height.

4.6.1.8 Pod length:

Pod length magnitudinally positive direct effect with seed yield per plant. Harvest index, pods per plant and 100 seed weight had shown indirect positive effect and significant association with pod length.

4.6.1.9 Pods per plant:

Pods per plant magnitudinally negative direct effect with seed yield per plant. Harvest index had shown indirect negative effect with pods per plant whereas 100 seed weight showed negative indirect effect with non-significant association with pods per plant.

4.6.1.10 100 seed weight:

100 seed weight magnitudinally positive direct effect with seed yield per plant. For the characters seeds per pod, clusters per plant and primary branches per plant it was positive and showed indirect effect towards 100 seed weight Harvest index showed indirect positive effect and significant association with 100 seed weight. Plant height shown negatively indirect effect towards 100 seed weight.

4.6.1.11 Harvest index (%):

Harvest index magnitudinally positive direct effect and significant association with seed yield per plant. The characters pod length, seeds per plant, pods per cluster and pods per plant were positive and shown indirect effect towards harvest index. Whereas the character days to 50 % flowering shown highly negative and indirect effect towards the harvest index.

Figure 4.6.1 Genotypical path diagram for seed yield per plant.

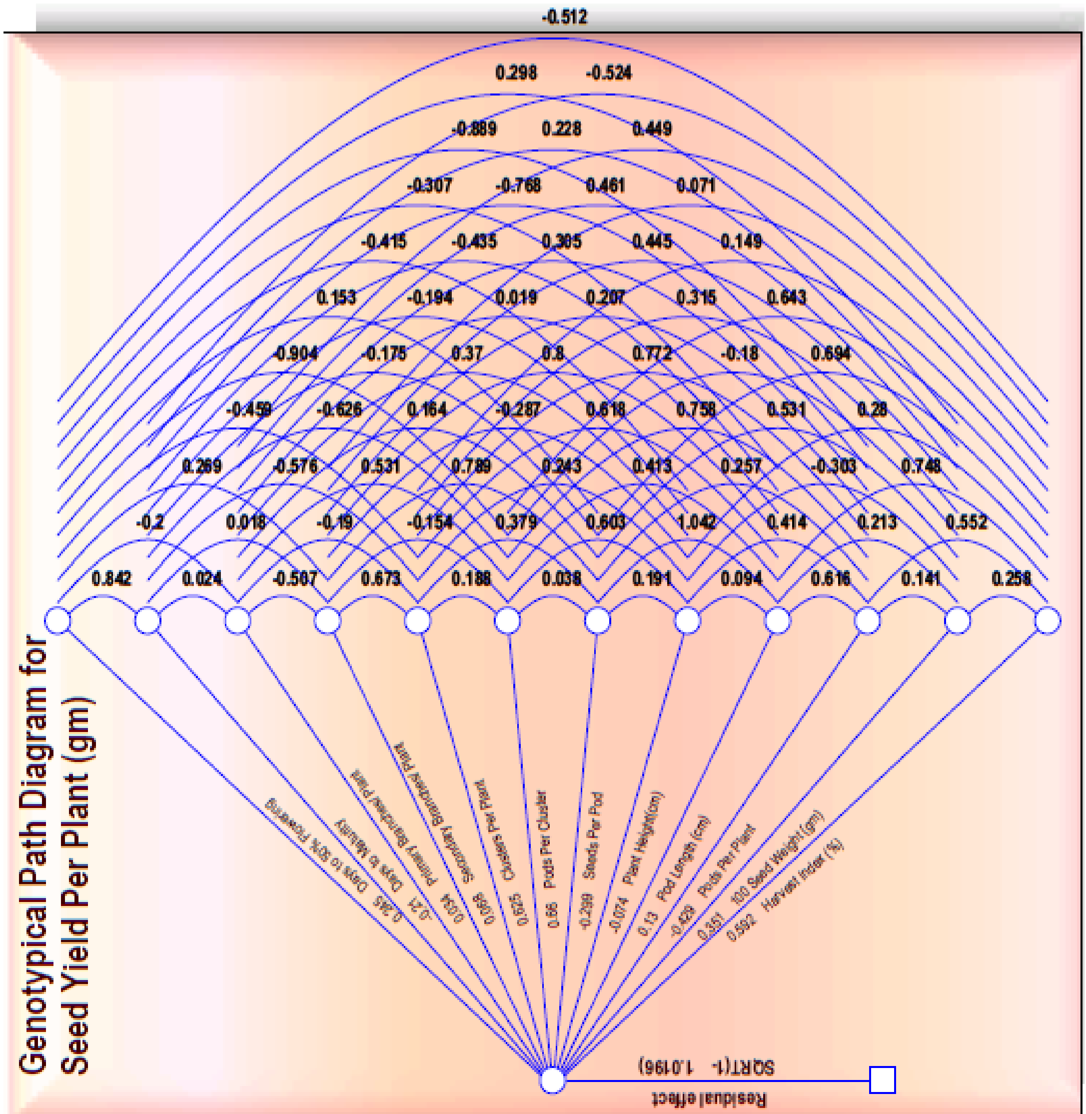


Figure showing positive and negative direct and indirect effects with seed yield per plant genotypically.

4.6.2 Phenotypical path analysis:

4.6.2.1 Days to 50% flowering:

Days to 50% flowering magnitudinally positive direct effect with seed yield per plant. Days to maturity showed indirect positive effect with and significant association with days to 50% flowering. Pods per plant and pods per cluster had shown indirect negative effect and significant association with days to 50% flowering. But harvest index and clusters per plant had shown negatively indirect effect and non-significant association with days to 50% flowering.

4.6.2.2 Days to maturity:

Days to maturity magnitudinally negative direct effect with seed yield per plant. Pods per plant, pods per cluster and harvest index had shown indirect positive effect with days to maturity. Primary branches per plant, 100 seed weight had shown negative indirect effect on days to maturity. Secondary branches per plant, seeds per pod and pod length had shown negative indirect effect and non-significant association with days to maturity.

4.6.2.3 Primary branches per plant:

Primary branches per plant magnitudinally positive direct effect with seed yield per plant. 100 seed weight, pod length and plant height had shown indirect positive effect with primary branches per plant but clusters per plant, pods per plant, secondary branches per plant, pods per cluster had shown indirect positive effect and non-significant association with primary branches per plant.

4.6.2.4 Secondary branches per plant:

Secondary branches per plant magnitudinally negative direct effect with seed yield per plant. Pods per cluster was the only character showed indirect positive effect with secondary branches per plant. 100 seed weight, seeds per pod, pod length and clusters per plant had shown negative indirect effect with secondary branches per plant. But plant height and pods per plant had shown negative indirect effect and non-significant association with secondary branches per plant.

Table.no: 4.6.2

Phenotypic path coefficient showing direct and indirect effect of different contributions on yield per plant in green gram 2017:

characters	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
P1	**0.1951**	0.1651	0.0525	0.0549	-0.0300	-0.1270	0.0309	0.0117	0.0153	-0.1297	0.0738	-0.0749
P2	-0.0346	**-0.0409**	-0.0184	-0.0072	0.0048	0.0151	-0.0012	-0.0069	-0.0009	0.0177	-0.0108	0.0111
P3	0.0007	0.0011	**0.0025**	0.0002	0.0000	0.0003	0.0007	0.0009	0.0009	0.0001	0.0010	0.0006
P4	-0.0082	-0.0051	-0.0028	**-0.0291**	-0.129	0.0067	-.00148	-0.0081	-0.0139	-0.0041	-0.0140	-0.0023
P5	-0.0337	-0.0255	0.0001	0.0972	**0.2190**	-0.0155	0.0461	0.0743	0.0746	0.1377	0.0705	0.0332
P6	-0.1823	-0.1032	0.0322	-0.0644	-0.0198	**0.280**	-0.0193	0.0457	0.0147	0.1884	-0.6065	0.1408
P7	0.0117	0.0022	0.020	0.0374	0.0155	-0.0051	**0.0737**	0.0149	0.0432	0.0034	0.0349	0.0369
P8	0.0021	0.0060	0.0125	0.0100	0.0121	0.0058	0.0072	**0.0355**	0.0079	0.0094	0.0026	0.0070
P9	0.0104	0.0031	0.0453	0.0634	0.0451	0.0070	0.0777	0.0294	**0.1326**	0.0345	0.0482	0.0483
P10	-0.2327	-0.1518	0.0205	0.0491	0.2200	0.2354	0..161	0.0928	0.0912	**0.3500**	0.392	0.1826
P11	0.1026	0.0714	0.1133	0.1306	0.0872	-0.0586	0.1285	0.0195	0.0986	0.0304	**0.2711**	0.0571
P12	-0.1058	-0.0751	0.0606	0.0216	0.0418	0.1386	0.1378	0.0546	0.1005	0.1437	0.0580	**0.2756**

P1 =days to 50% flowering**, P2 =** days to maturity**, P3 =**primary branches per plant**, P4 =** secondary branches per plant**, P5 =**clusters per plant**, P6 =**pods per cluster**, P7 =**seeds per pod**, P8 =**plant height (cm)**, P9 =**pod length (cm)**, P10 =**pods per plant**, P11 =**test weight **and P12 =**harvest index**.**

R SQUARE= 0.9395; RESIDUAL EFFECT= 0.2459

4.6.2.5 Clusters per plant:

Clusters per plant magnitudinally positive direct effect with seed yield per plant. Pods per plant, pod length, plant height, 100 seed weight and seeds per pod had shown significantly indirect positive effect with clusters per plant. Pods per cluster had shown significantly indirect negative effect with clusters per plant.

4.6.2.6 Pods per cluster:

Pods per cluster magnitudinally positive direct effect with seed yield per plant. Pods per plant and harvest index had shown significantly positive indirect effect with pods per cluster. But 100 seed weight and seeds per pod had shown non-significant and indirect negative effect with pods per cluster.

4.6.2.7 Seeds per pod:

Seeds per pod magnitudinally positive direct effect with seed yield per plant. Pod length, harvest index, 100 seed weight and plant height had shown significantly positive indirect effect with seeds per pod. But the character pods per plant had shown positive indirect effect and non-significant association with seeds per pod.

4.6.2.8 Plant height (cm):

Plant height magnitudinally positive direct effect with seed yield per plant. Pods per plant, pod length, harvest index and 100 seed weight had shown significantly positive indirect effect with plant height.

4.6.2.9 Pod length:

Pod length magnitudinally positive direct effect with seed yield per plant. Harvest index, 100 seed weight and pods per plant had shown significantly positive indirect effect with pod length.

4.6.2.10 Pods per plant:

Pods per plant magnitudinally positive direct effect with seed yield per plant. Harvest index and 100 seed weight had shown significantly positive indirect effect with pods per plant, days to maturity and days to 50 % flowering had shown negative indirect effect towards pods per plant.

4.6.2.11 100 seed weight:

100 seed weight magnitudinally positive direct effect with seed yield per plant. Harvest index had shown significantly positive indirect effect with 100 seed weight. Seeds per pod, primary branches per plant, secondary branches per plant and days to 50 % flowering had shown positive indirect effect over 100 seed weight. Whereas, pods per cluster had shown non-significant and negatively indirect effect with 100 seed weight.

4.6.2.12 Harvest index:

Harvest index magnitudinally positive direct effect with seed yield per plant. Pods per plant, pods per cluster, seeds per pod and pod length had shown positively indirect effect over the harvest index. Whereas, the characters days to maturity and days to 50 % flowering had shown negatively indirect effect via harvest index over seed yield per plant.

Picture: 4.6.2 Phenotypical Path diagram for seed yield per plant (gm):

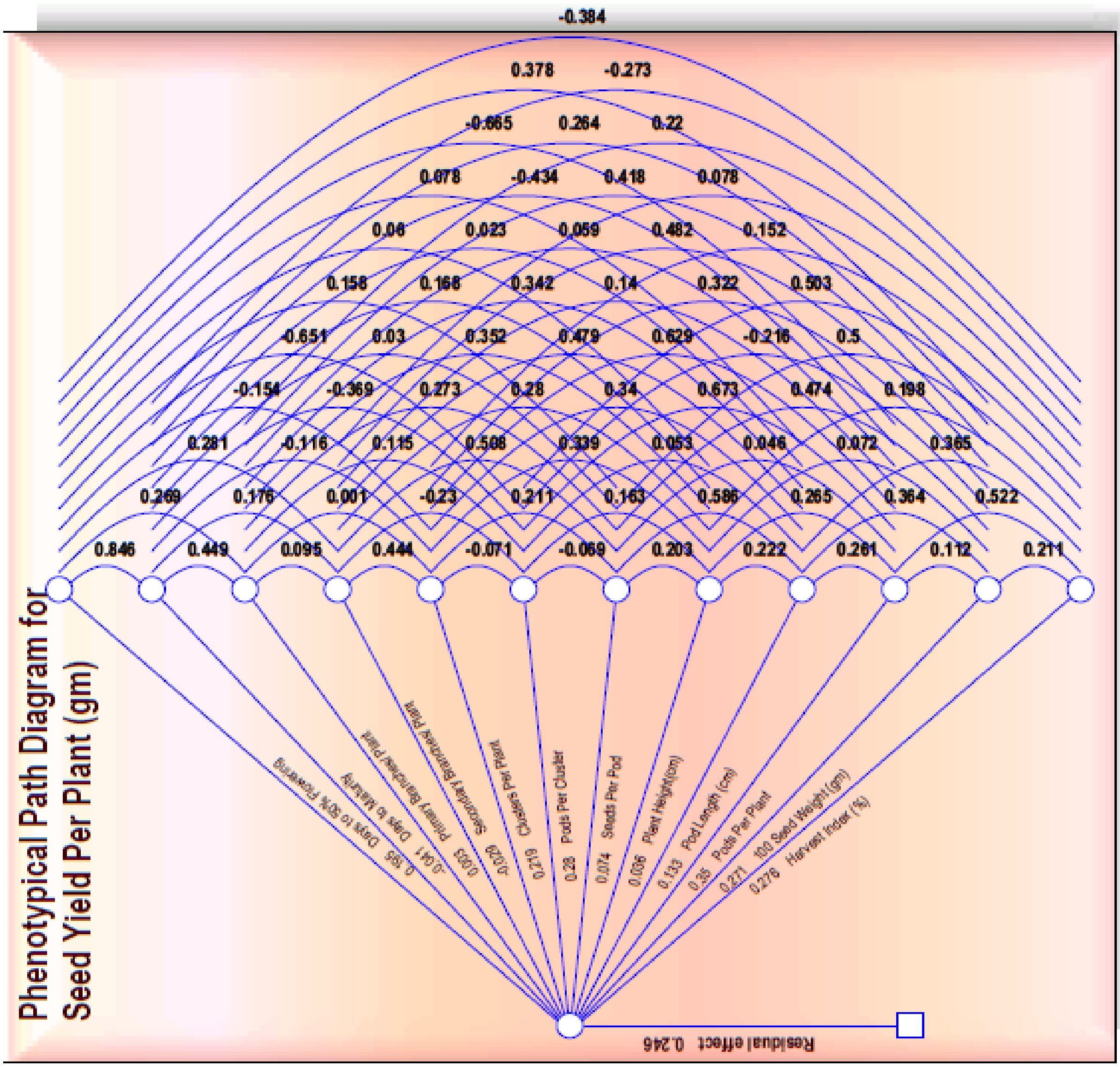


Figure showing positive and negative direct and indirect effects among the traits

Discussion of Results

Any experimental work related with plant breeding success depends on selection of exclusive genotypes and also knowledge of genetic diversity and variability of the germplasm which is selected. For a particular character, GCV and PCV measures the extent of variation present in a population. Transmission of character from parents to their off springs will be indicated by heritability and it is also very important to determine the phenotypic characters in the off springs were transferred from the parents or due to environmental effect. Best selection is possible when heritability combines with genetic advance. For selecting suitable parents and best method of breeding programme for crop improvement correlation helps a lot while direct and indirect effects of the characters towards yield are known by path analysis.

The genetic divergence enables the evaluation of the genotypes without actual crossing and grouping of the germplasm into clusters in a significant pattern. The results obtained from present experimental work on "study of genetic variability, correlation and path analysis on yield attributing traits of green gram" were discussed under the following sub-heads.

5.1 Variability:

During experimental work considerable variation was observed in all the 13 characters evaluated. The variability range of yield per plant ranged between 3.95 g to 18.03 with a mean of 11.62. As well as other yield related characters had also shown considerable variability such as days to 50 percent flowering (62.33 to 70.33), days to maturity (95.00 to 102.66), plant height in cm (27.53 cm to 34.33), number of primary branches (4.33 to 5.40), number of secondary branches (4.53 to 7.80), number of clusters (5.00 to 9.00), number of pods per cluster (3.00 to 4.73), number of pods per plant (16.66 to 44.20), pod length (5.32 to 8.62), seeds per pod (5.33 to 10.18), 100 seed weight (4.37 to 5.41) and harvest index (33.43 to 88.70). This range of variability is similar with the characters days to 50% flowering, days to maturity, plant height (cm), number of productive branches per plant, number of productive pods per plant, number of seeds per pod, harvest index and seeds per plant (g) in the findings of **Atar *et al.* (2009)** and plant height, pods per plant, total plant weight and seed yield, **Aqsa Tabasum, (2010).** Within the 13 genotypes of green gram for the character days to 50 percent flowering- HUM-01, character days to maturity- LG-420, number of primary branches- Pusa Vishal, number of secondary branches- Moongi, number of clusters per plant- Kopergan, number of pods per cluster- LM-05, number of pods per plant- Kopergan, pod length in cm- HUM-16, seeds per pod- HUM-16 , 100 seed weight in gm- HUM-16, harvest index % -HUM-16 recorded highest per se performance for respective characters.

The estimates of PCV were magnitudinally higher than the estimates of GCV for all the characters indicating the environmental influence factor on these traits. The estimates of GCV and PCV were of high magnitude for seed yield per plant, harvest index and number of pods per plant indicating fine scope for improvement through selection. These confirmed on the finding of **Nand *et al* (2013)** for seed yield per plant and pods per plant. The characters like seed yield per plant, harvest index and number of pods per plant had high estimates of PCV, while for the characters like seed yield per plant, harvest index and pods per plant, pods per cluster, clusters per plant and seed per pod had high estimates of GCV. Whereas low magnitude for PCV and GCV was reported in characters like days to maturity, days to 50 % flowering, primary branches, plant height and test weight. Whereas, the estimates of GCV and PCV were, moderate in pod length in cm and number of secondary branches per plant. This was match to the findings of **Irum Aziz (2010)** with pod length in cm. The PCV estimates were high for the characters seed yield per plant, harvest index and number of pods per plant. The GCV estimates were higher in the characters like seed yield per plant, harvest index and pods per plant. This results are opposite to the finding of **Kumar *et al.* (2013).**

In yield per plant character, the magnitude of GCV was lower than that of PCV. The magnitude of phenotypic coefficients of variation was higher than genotypic coefficients of variation for all the traits showing greater influence of environment on these traits with the finding of by **Siddique *et al*. (2006) and Makeen *et al.* (2007)** who also reported similar effects of environment. But on the characters like secondary branches per plant, seeds per pod, pod length, clusters per plant and seed yield per plant had high magnitudinal difference which was shown that environment played major role in the expression of this characters. While, for other characters like days to maturity and days to 50 % flowering, 100 seed weight and harvest index the magnitudinal difference is low for genotypic coefficient of variation and phenotypic coefficient of variation which shows that less influence of environment on genotypes for the expression of phenotype, during selection only phenotype can be taken into consideration.

5.2 Heritability and genetic advance:

The effectiveness of selection based on phenotype performance which will estimate high heritability. But that doesn't mean high genetic gain for that trait. Panse, 1957 reported that the characters with high genetic gain may be attributed to the additive gene effects which can be easily improved by selection. On the other side low genetic advance with high heritability endorsed to non-additive genetic action and such characters may be improved through hybridization. According to **Burton, 1952** through GCV the heritable variation cannot be estimated and for the most reliable information on the genetic advance to be expected for selection is possible through GCV with heritability. In the present investigation the heritability coupled with genetic advance estimates were high, indicating less influence of environment and major role of genotype on the characters pods per plant(83.8), seed yield per plant (82.3), harvest index(81.8) and 100 seed weight (67.1). For the characters like days to maturity (34.4), primary branches per plant (34.8), secondary branches per plant (37.7), plant height (39.6) and pod length (39.0) heritability was comparatively low. This results were similar with the findings **Gadakh *et al.* (2013)** for the characters harvest index and number of pods per plant**, Venkateshwarlu (2001)** for the character seed yield and moderate to high heritability estimates were found for traits like primary and secondary branches per plant, pod length and 100-seed weight in the findings of **Irum Aziz (2010)** and also there is high heritability, associated with high genetic advance over mean was observed for plant height, branches per plant, pods per plant and pod length which was reported by, **Das *et al,* (1998)**. This results are in broad agreement with the high heritability estimates of **Momin and Misra, (2004)**; **Idress *et al.* (2006)**; **Babu *et al*. (2007)**; **Tabasum *et al,* (2010)**; **Rahim *et al*. (2010)**; **Reddy *et al.* (2011)**; **Makeen *et al*. (2007)** and **Roychowdhury *et al.* (2012)**.

According to **Johnson *et al.* (1955)** that the genetic gain will be low when there is no additive gene interaction, whereas genetic advance would be high when there is additive gene interaction. While in the present experimental work high heritability for pods per plant (83.8), seed yield per plant (82.3) and harvest index (81.8) which was accompanied with high genetic advance which shows that high heritability is due to additive gene interaction and for improving such traits simple selection is practiced. This shows that heritability coupled with genetic advance gives best result instead of heterosis alone **Johnson *et al.* (1955)** and **Singh *et al.* (2010).** This are similar with the finding of **Sheetal Patel, (2014),** high heritability coupled with high expected genetic advance was observed in seed yield per plant indicating the impact of additive gene expression and also similar with **Das *et al.* (1998)** for the character pods per plant and also similar with **Chakraborty *et al.* (2001).** But were opposite to the finding of **Loganathan *et al.* (2001b).**

5.3 Correlations:

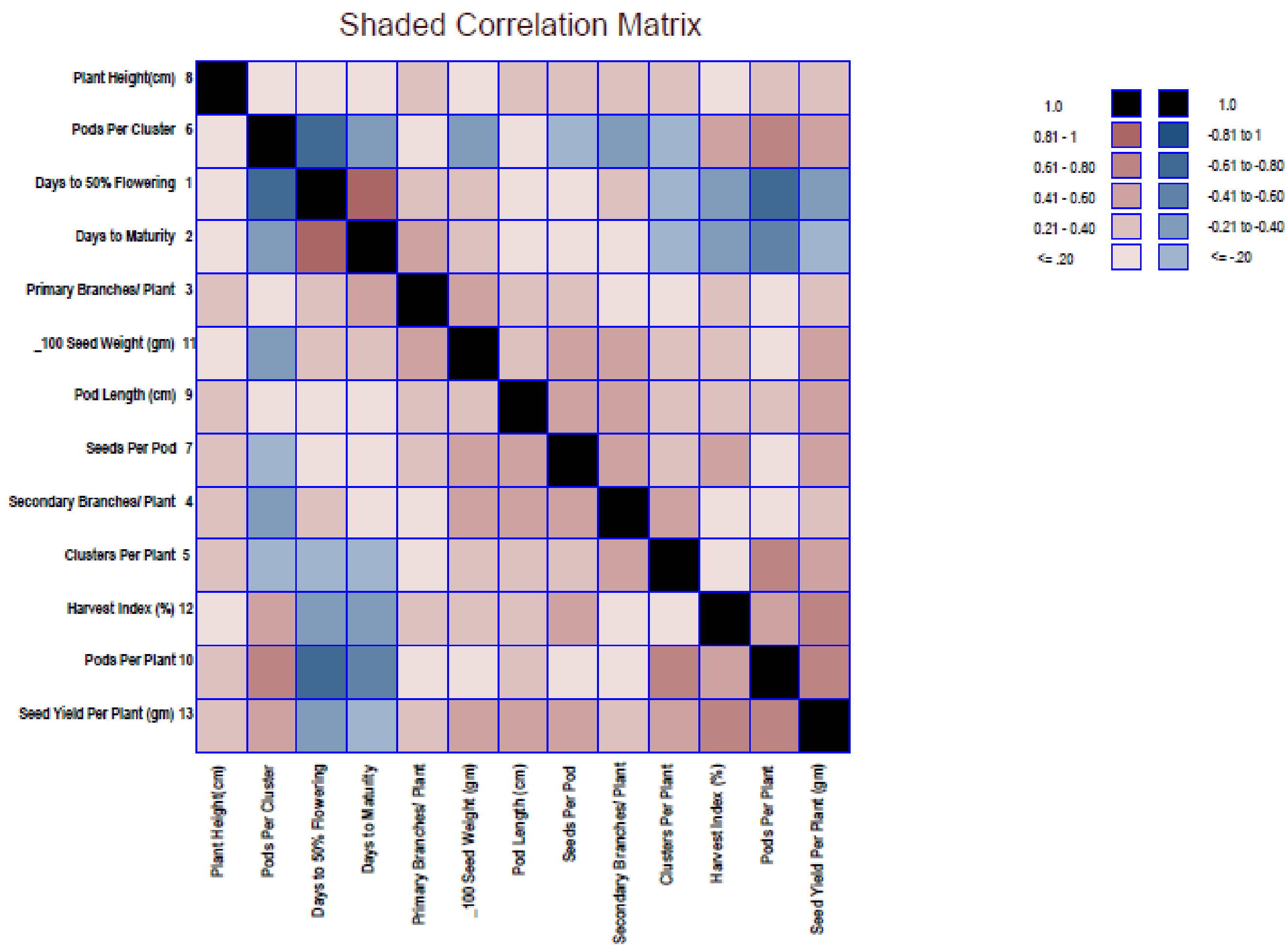
For the method of suitable breeding and selection for the improvement of crop knowledge about association between yield and yield components is necessary. In the breeding programme GCV and PCV has their own key role. Selection index determined with the help of phenotypic correlation coefficients and whereas with the genotypic correlations gives the measure of close association between the characters and indicates the use of all the characters in overall improvement of crop and also helps in identifying little or no importance in improvement of crop. In the present research work, at level of genotype, yield per plant was positively and significantly correlated with pod length, pods per plant, harvest index and seeds per pod. The other character which was significantly and positively correlated with days to maturity, secondary branches per plant, 100 seed weight and seeds per pod was days to 50 percent flowering which are similar to the findings of **Ebenezer Babu Rajan *et al.* (2000)** with the characters pods per plant, 100 seed weight, harvest index and seeds per pod, similar with plant height, number of primary branches, pods per plant and pods per cluster in the findings of **Peerajade *et al.* (2002)** and also similar with pods per plant, 100 seed weight and seeds per pod showed significant and positive association with seed yield found by **Venkateswarlu, (2001b)** but were contrasting to the findings of **Natarajan *et al.* (1988)**. Days to maturity showed significantly positive correlation with 100 seed weight, primary branches per plant and secondary branches per plant and significantly negative association with pods per plant, clusters per plant, pods per cluster and harvest index. This were opposite to the findings of **Gopi Krishnan *et al.* (2002)** with the characters cluster per plant and to the finding of **Veeranjaneyulu *et al.* (2007).**

Plant height was the character which showed significantly positive correlation with the characters pods per plant, harvest index and pod length. The character number of primary branches per plant showed significantly negative correlation with the characters pods per plant, 100 seed weight, harvest index and plant height.. Number of pods per plant showed significantly positive correlation with the characters harvest index and 100 seed weight. Similar results were obtained from the experiments of **Tyagi** and **Khan, (2011)**. Number of clusters per plant significantly and positively correlated with number of pods per plant, pod length, seeds per pod and 100 seed weight. This are similar to significant positive association of clusters per plant and pods per plant with seed yield was reported by **Natarajan and Rathinaswamy, (1999); Umadevi and Meenakshi Ganesan (2005)**; **Chauhan *et al.* (2007)**. Similarly, **Soundarapandian *et al*. (1976)** and **Veeranjaneyulu *et al.* (2007)**. Test weight was significantly correlated with number of seeds per pod, primary branches per plant, secondary branches per plant, clusters per plant and harvest index.

At the phenotypic level, seed yield per plant significantly and positively correlated with pods per plant, harvest index, pod length and 100 seed weight. This were similar to the finding of **Siddique et al. (2006)**; **Abbas et al. (2008)**; **Abbas et al. (2010)**; **Rahim et al. (2010)**; **Tantasawat et al. (2010)**; **Mondal et al. (2011).** The character days to 50% flowering significantly and positively correlated with days to maturity, secondary branches per plant, 100 seed weight and primary branches per plant. The character days to maturity was significantly and positively correlated with primary branches per plant, 100 seed weight and secondary branches per plant and also negatively correlated with pods per plant, pods per cluster and harvest index. This results were contradictory to the finding of **Aparna Raturi and S.K Singh, (2014)**. Primary branches per plant was significantly and positively correlated with 100 seed weight, plant height, pod length and seeds per pod but it was non-significant with clusters per plant and pods per plant. This results were contrasting to the findings of **Rahim *et al.* (2010).** Clusters per plant was significantly and positively correlated with pods per plant, pod length, plant height and 100 seed weight but it was negatively associated with pods per cluster.

With the character plant height, characters significantly and positively correlated were pod per plant, pod length and harvest index. Pod length was significantly and positively correlated with harvest index and 100 seed weight. These was similar to the finding of **Sheetal Patel (2014)** in the characters 100 seed weight. The characters pod length, harvest index, 100 seed weight and plant height were significantly and positively correlated with seeds per pod. The character 100 seed weight was significantly and positively correlated with harvest index. While comparing the present experimental result with the earlier finding, it was witnessed that yield contributing characters showing significant association with the yield in desirable direction like, number of clusters per plant, plant height, test weight, number of seeds per pod, days to maturity and days to

Figure 5.3 phenotypical correlation shaded matrix



Graph showing phenotypically direct effects, positive indirect effects and negative indirect effects with in the characters

50 percent flowering could directly be useful to construct the selection index which will help in identifying high yielding and matured genotypes in green gram.

5.4 Path analysis:

Path coefficient analysis can be defined as the ratio of the standard deviation of the effect due to a given cause to the total standard deviation of the effect, in other words it is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects, i.e. it measures the direct and indirect contribution of various independent characters on a dependent character. In these experimental work path analysis was worked out by the following **Dewey and Lu (1959)**. To estimate the magnitude and direct and indirect effect of various yield attributing traits. Path analysis when combined with correlation coefficients provides exact information, which can be effectively used in crop improvement programme. Direct selection is possible, when correlation between causal factor and direct effect is more or less of equal magnitude it shows true and perfect relationship between the traits and will be satisfying. But if correlation coefficient is positive and the direct effect is negligible or negative.

The direct and indirect effects of yield components studied in 13 genotypes of green gram were presented in table 4.6.1 and 4.6.2 and also in figures 4.6.1 and 4.6.2. For the characters pods per plant, 100 seed weight, harvest index, pods per cluster and clusters per plant had recorded high magnitudinal direct effect with seed yield per plant which indicates true and perfect relationship between these characters and seed yield per plant. This will help in selecting high yielding genotypes. This were similar with results of **Gopi Krishnan *et al.* (2002)** for pods per plant but, were disagreeing with the findings of **Pooran Chand and Rabhunandha Rao, (2002),** for number of pods per cluster **Chauhan *et al.* (2007),** and for cluster per plant **Govindaraj and Subramanian, (2001).** The characters secondary branches per plant and days to maturity had shown highly magnitudinal negative direct effect and non-significant association with seed yield per plant. This are contrasting with the experiments of **Rahman & Hussain, (2003)**; **Celal, (2004)**; **Makeen *et al*. (2007)**; **Rao *et al.* (2006)**; **Hakim, (2008)** as their findings are negative and showing indirect effect towards seed yield per plant. Plant height, seeds per pod, primary branches plant showed magnitudinal direct effect and non-significant association with seed yield per plant. This results were agreed with the results of **Reddy *et al.***

(2011) for the character seed per pod. Pods per plant, harvest index, clusters per plant, pod length, 100 seed weight, pods per cluster, seeds per pod, plant height, secondary branches per plant and primary branches per plant had shown significantly positive direct effect with seed yield per plant.

Summary and Conclusion

The present experimental work **"Genetic Variability, Correlation and Path Analysis with Yield Attributing traits of Green Gram [*Vigna radiata* (L.) Wilzeck]"** was carried out based on following objectives:

1. To identify superior Inbred Lines based on Yield Attributing traits.
2. To estimate Genetic Parameter of Variability for Yield Attributing traits in Inbred Lines.
3. To study Correlation, Genotypic and Phenotypic association among traits.
4. To estimate Path Coefficient Analysis of traits under study on Seed Yield.

Thirteen genotypes were collected from Banaras Hindu University, Varanasi as well as from Punjab Agricultural University, Ludhiana. The experimental plot was laid out in the experimental farm with three replications in *summer* season, 2017. All these genotypes are evaluated under 13 yield attributing characters viz., days to 50 percent flowering, days to maturity, number of primary branches, number of secondary branches, number of clusters per plant, number of pods per cluster, number of pods per plant, number of seeds per pod, plant height (cm), pod length (cm), seed yield per plant (gm), test weight (gm) and harvest index in percent.

Significant treatment squares of mean for all characters revealed that the characters which were studied has considerable amount of variability in the evaluated genotypes. The magnitude of PCV and GCV were high for seed yield per plant, pods per plant, clusters per plant, pods per cluster, seeds per pod, secondary branches per plant and pod length indicating presence of good amount of variability per plant. Whereas, average amount of PCV and GCV was obtained to the characters pod length, plant height and 100 seed weight. But for the characters days to maturity, days to 50% flowering and primary branches per plant had shown very less GCV and PCV. Whereas, for the characters secondary branches per plant, number of seeds per pod, pod length and clusters per plant had recorded high magnitudinal difference between PCV and GCV.

High magnitude of heritability was recorded for the character pods per plant followed by seed yield per plant, pods per cluster and clusters per plant test weight. High heritability coupled with high genetic advance was observed for the character pods per plant and seed yield per plant, suggest the role of additive gene effect and possibility of achieving high genetic progress through selection.

The phenotypic coefficients correlation were greater in magnitude than their corresponding genotypic coefficients of correlation for all the characters. Seed yield per plant was significantly and positively correlated with days to maturity, primary branches per plant, seeds per pod, pod length, pods per plant, 100 seed weight and harvest index at phenotypic level which shows seed yield depend upon this characters. Yield per plant was also significantly and negatively associated with clusters per plant.

In the path coefficient analysis highest direct effect was recorded by the characters pods per plant, 100 seed weight and harvest index and their association with the seed yield was positive and significant indicating that their exits a true and perfect association between those two traits which also suggests that direct selection in this traits will help in isolating early and high yielding genotypes. For the characters secondary branches per plant and days to maturity the direct effect was negative and also their association with seed yield per plant was non-significant which indicates their role was negligible. The characters like pods per plant, plant height and 100 seed weight were good indicators of seed yield per plant.

With respect to findings of the present experimental work, inbred lines *viz.,* HUM-16, Kopergan, Pusa Vishal and LM-05, were identified as superior recombinant inbreed lines with respect to yield attributing traits.

List of Bibliography

Ajmal, S, and Hassan, M. (2003) Correlation and Path Coefficient Analysis in Promising lines of Mash Bean (*Vigna mungo*). *Pakistan General of Biological Sciences.* 6: 370-372.

Aparna Raturi., Singh, S.K., Vinay Sharma, and Rakesh Pathak. (2015) Genetic Variability, Heritability, Genetic Advance and Path Analysis in Mung Bean [*Vigna radiata*. (L.) Wilczek]. Central Arid Zone Research Institute, *Legume Research.* 38 (2): 157-163.

Arshad, M., Aslam, M, and Irshad, M. (2009). Genetic Variability and Character Association among Morphological traits of Mungbean, [*Vigna radiata* (L.) Wilczek] genotypes. *Journal of Agricultural Research.* 47:121-126.

Babu, G.C., Reddy, B.S., and Lavanya, G.R., 2007, Evaluation of quantitative characters in mutant lines of mungbean, *Journal of Food Legumes*, 20(2): 205-206.

Bainade, P.S., Manjare, M.R., Deshmukh, S.G, and Kumbhar, S.D. (2014). Genetic Analysis in Green Gram [*Vigna radiata* (L.) Wilczek] subjected to North Carolina Mating Design-1, Department of Agricultural Botany, M.P.K.V., Rahuri. *The Bioscan.* 9(2): 875-878.

Biradar, K., Salimath, S.P.M. and Ravikumar R.L. (2007.) Genetic studies in green gram and association analysis. *Karnataka Journal Agricultural Sciences* 20: 843-844.

C. Natarajan and R. Rathinaswamy (1999). Genetic variability and path coefficient analysis in black gram. *Madras Agricultural Journal*. 86(4-6): 228-231.

Chakraborty, S., Borah, B., Borah, H., Pathak, D., Kalita ,H, and Barman B. (2011) Genetic Correlation and Coheritability between F1 and F2 Generations for Quantitative Traits in Crosses of Green Gram [*Vigna radiata* (L.) Wilczek]. Assam Agriculture Research Institute. *Acta Agronomica Hungarica.* Volume 59, Issue 1.

Chauhan, M.P., Mishra, A.C, and Ashok Kumar Singh. (2007). Correlation and path analysis in urdbean. *Legume Research*. 30(3): 205-208.

Das, S.Y., Supnyo Chakraborty., and S. Chakraborty. (1998). Genetic variation for seed yield and its components in green gram [*Vigna radiata* (L.) Wilczek]. *Advanced PI Sciences.* 11 (1) 271-273.

Dewey, D.R., and Lu, K.H. (1959). A Correlation and Path Coefficient Analysis of Components of Crested Wheat Grass Seed Production. *Agronomy*. J. 51:515-518. 1959.

Dewey, J.R and K.H Lu. (1954). A Correlation and path coefficient analysis components of crested wheat seed production. *Agronomical Journal*.51: 515-518.

Dhananjay., Ramakant., Singh, B. N. and Singh, G. (2009). Studies on genetic variability, correlations and path coefficients analysis in mung bean [*Vigna radiata* (L.) Wilczek].. *Crop Research*. Hisar. 38(1/3): 176-178.

Ebenezer Babu Rajan, R., Wilson, D., and Vijayaraghava Kumar. (2000). Correlation and path analysis in the F2 generation of green gram *Madras Agricultural Journal*. 87 (10-12) 590-593.

Gadakh, S.S., Dethe, A.M., Kathale, M.N, and Kahate, N.S. (2013). Genetic diversity for yield and its component traits in green gram [*Vigna radiata* L. Wilczek], *Journal of Crop and Weed*, 9(1): 106-109.

Ghulam Abbas., Amjad Hameed., Muhammad Rizwan., Muhammad Ahsan., Muhammad J., Asghar, and Nayyer Iqbal. (2015). Genetic Confirmation of Mungbean (*Vigna radiata*) and Mashbean (*Vigna mungo*) Interspecific Recombinants using Molecular Markers. *Frontiers in Plant Sciences.* Volume 6: 1107.

Govindaraj, P, and Subramanian, M. (2001). Association analysis in black gram (*Vigna mungo* L. Hepper). *Madras Agricultural Journal*. 88(4-6): 240-242, 2001.

Govindaraj, P, and Subramanian, P. (2001). Association analysis in black gram (*Vigna mungo* L. Hepper). *Madras Agricultural Journal*. 88(4-6): 240-242, 2001

Gupta, S.K and Gopalakrishna, T. (2008). Molecular markers and their application in grain legumes breeding. *Journal of Food Legumes*. 21: 1-14.

Hafiz, B., Salsabeel, R., Muhammad, R, Atta, U.M., Umar, S, and Muhammad S. (2014). Genetic Variability for Yield Contributing Traits in Mung Bean [*Vigna radiata* (L.) Wilczek]. Pulses Research Institute, Faisalabad. *Journal of Global Innovation Agricultural Social Sciences.* 2(2): 52-54.

Hakim, L. (2008). Variability and correlation of agronomic character of mung bean [*Vigna radiata* (L.) Wilczek].germplasm and their utilization for variety improvement programme. *Indonesian journal of Agricultural Sciences*. 9: 24-28, 2008.

Idress, A., Sadiq, M.S., Hanif, M., Abbas, G, and Haider, S. (2006). Genetic Analysis and Path Coefficient Analysis in Mutated Generation of Mungbean. [*Vigna radiata* (L.) Wilczek]. *Agricultural Research.* 44: 181-191.

Isha Parveen., Reddi, M. Shekar, Reddy, D. Mohan, and Sudhakar, P (2011). Correlation and Path Coefficient Analysis for Yield and Yield Components in Blackgram [*Vigna mungo* (L.) Hepper] Regional Agricultural Research Station, Tirupati. *International Journal of Applied Biology and Pharmaceuticals Technology* 2 (3).

Jagadeesan., Kandasamy, S.G., Manivannan, N., Muralidharan, V. (2008). Mean and variability studies in M1 and M2 generations of sunflower (*Helianthus annuus* L.). 31(49): 71-78.

Johnson, H,F., Robinson, H.F., and Comstock, R.E. (1995). Estimates of genetic and environmental variability in soybean. *Agronomy Journal.* 47: 314-318.

Kamleshwar Kumar., Yogendra Prasad., Mishra, S. B., Pandey, S. S, and Ravi Kumar. (2013).Study on Genetic Variability, Correlation and Path Analysis with Grain Yield and Yield Attributing Traits in Green Gram [*Vigna radiata* (L.) Wilczek]. Rajendra Agricultural University, Pusa. *The Bioscan.* 8(4): 1551-1555.

Khajudparn, P., and Tantasawat, P. (2011). Relationships and variability of agronomic and physiological characters in mungbean [*Vigna radiata* (L.) Wilczek]. *African Journal of Biotechnology*. 10: 9992-10000, 2011

Khan, I.A. (1991). Multiple correlation and regression analysis in mungbean [*Vigna radiata* (L.) Wilczek]. *Indian Journal of Agronomical Research*. 25 (4) 177-180.

Khan, S., Wani M.R., and Parveen, K. (2004). Induced genetic variability for quantitative traits in [*Vigna radiata* (L.) Wilczek]. *Pakistan Journal of Botany*. 36: 845–50.

Lalinial, A.A, and Khameneh, M.M. (2014). Multivariate statistical method for determining interrelationships among seed yield and related characters in mung bean, *International Journal of Farming and Allied Sciences*. 274-281.

Loganathan, P., Saravanan, P.K,and Ganeasan, J. (2001b). Genetic variability in green gram [*Vigna radiata* (L.) Wilczek] *Research Crops*. 2 (3). 396-397

Makeen, K., Abrahim, G., Jan, A, and Singh, A.K. (2007). Genetic variability and correlations studies on yield and its components in mungbean (Vigna radiata (L.) Wilczek). J. Agron. 6(1): 216-218.

Mallikarjuna Rao, C., Koteswara Rao, Y, and Mohan Reddy. (2006). Genetic variability and path analysis in green gram [*Vigna radiata* (L.) Wilczek]. *Legume Research*. 29: 216-218.

Momin, B.W., and Misra, R.C. (2004). Induced variability, character association and path coefficient analysis in mutant cultures of green gram, *Environment and Ecology*, 22(3): 608-61.

Nagarjuna Sagar, M, and Reddi Sekhar, M. (2001). Character association studies in black gram (*Vigna mungo* L. Hepper). *Madras Agricultural Journal*. 88(4-6): 222-224.

Nand, M.J, and Anuradha, C. (2013). Genetic variability, correlation and path coefficient analysis for yield and yield components in mungbean [Vigna radiata (L.) Wilczek]. *Journal of Research ANGRAU*. 41: 31-39.

Neha, J., Sarvjeet, S., Inderjit, S. (2005). Variability and association studies in lentil. *Indian Journal of Pulses Research.*18: 1444-146.

Ortiz, R., and Nq, N.Q. (2000). Genotype x Environment interaction and its analysis in germplasm characterization and evaluation. In: Genotype x Environment interaction analysis of IITA mandate crops in sub-Sharan Africa. *Ekanavake International Journal*, IITA, Ibadan. pp 32-40.

Parthasarathy, K, and Eswari, K.B. (2005). Genetic Diversity Analysis in Green Gram [*Vigna radiata*. (L.) Wilczek] Acharya N.G. Ranga Agricultural University, Hyderabad, *Kriskosh.* D7973.

Peerajade., Ravi Kumar., R. L. and Salimath, P.M. (2009). Genetic variability and character association in local green gram [*Vigna radiata* (L.) Wilczek] genotypes. *Environment and Ecology*. 27(1): 165-169.

Pooran Chand, and C. Rabhunandha Rao. (2002). Breakage of undesirable correlations in black gram (*Vigna mungo* L. Hepper). *Legume Research*. 25(1): 37-40.

Prasanna, B. L., Rao, P.J. M., Murthy, K.G.K, and Prakash, K.K. (2013). Standardization of DNA extraction protocol in greengram [*Vigna radiata* (L.) Wilczek]. *International Journal of Applied Biology and Pharmaceuticals Techology*. 31(4): 1782-1788.

Rahim M.A., Mia, A.A., Mahmud, F., Zeba N. and Afrin, K.S. (2010). Genetic variability, character association and genetic divergence in mungbean (Vigna radiata L. Wilczek*). Plant Omics Journal*. 3:1-6

Ramakant, Singh, B. N. and Singh, G. (2009). Studies on genetic variability, correlations and path coefficients analysis in mung bean. *Crop Research*. Hisar. 38(1/3): 176-178.

Ramakant., Singh, B. N. and Singh, G. (2009). Studies on genetic variability, correlations and path coefficients analysis in mung bean [*Vigna radiata* (L.) Wilczek]. *Crop Research*. Hisar. 38(1/3): 176-178.

Ramesh Babu. (1998). Genetic variability in green gram [*Vigna radiata* (L.) Wilczek]. *Indian Journal of Agronomy*. 43: 261-263.

Ramesh Reddy, B. N. (2003). Variability, Path Analysis and Genetic Diversity in Green Gram [*Vigna radiata* (L.) Wilczek]. Mahatma Phule Krishi Vidyapeeth, Rahuri.

Rameshwari Netam, C.R., Pandey, R.L, and R.U. Khan. (2010). Estimation of relationship of seed yield with its attributing traits in urdbean (Vigna mungo L. Hepper). *Advances in Plant Sciences*. 23(1): 97-100.

Reddy, D.K.R., Venkateswarlu, O., Obaiah, M.C., and Jyothi, G.L.S. (2011). Studies on genetic variability, character association and path-coefficient analysis in green gram. *Legume Research.*. 34(3): 202-206.

Reddy, P. Ashok., Lavanya, G.R., Suresh, B.G., Sravan, T, and Reddy G. Eswara. (2014). Study on Heritability, Genetic Advance and Variability for Yield Contributing Characters in Mung Bean [*Vigna radiata*. (L.) Wilczek]. Sam Higginbottom Institute of Agriculture, Technology and Sciences, *Trends in Biosciences*. 7(15): 2021- 2023.

Rohman, M., and Hussain, I. (2003) Genetic variability, correlation and path analysis in mung bean [*Vigna radiata* (L.) Wilczek]. *Asian journal of Plant Sciences.*2 (17- 24): 1209-1211.

Roychowdhury, R., Datta, S., Gupta, P., and Tah, J., 2012, Analysis of genetic parameters on mutant populations of mungbean [*Vigna radiata* (L.) Wilczek] after ethyl methyl sulphonate treatment, *Notulae Scientia Biologicae*, 4(1): 137-143

Santha, S, and Paramasivam, K. (1999). Correlation and path analysis in rice fallow blackgram (*Vigna mungo*). *Madras Agricultural Journal*. 86 (7-9): 397-400, 1999

Sarbol, N. (1997). Mung bean [*Vigna radiata* (L.) Wilczek]: Past, Present and Future. In: *Proceedings of the National Mungbean Research Congress VII* held at Golden Grand Hotel, Thailand, 2-4 december 1997, pp: 1-20.

Sheetal, R. Patel., Patel, K. K, and Hitiksha, K. Parmar. (2014). Genetic Variability, Correlation and Path Analysis for Seed Yield and its Components in Green Gram [*Vigna radiata* (L.) Wilczek]. Anand Agricultural University, Anand. *The Bioscan.* 9(4): 1847-1852, 2014.

Siddique, M., Faisal, M., Anwar, M. and Shahid, I.A. (2006). Genetic divergence, association and performance evaluation of different genotypes of mungbean (*Vigna radiata*). *International Journal of Agricultural Biology.* 6: 793-795.

Singh, G., Aggarwal, N., and Khanna, V. (2010). Integrated nutrient management in lentil with organic manures, chemical fertilizers and bio-fertilizers. *Journal of Food Legumes*. 23: 149-151.

Souframanien, J and Gopalakrishna, T. (2008). Construction of a genetic linkage map of black gram, Vigna mungo (L.) Hepper, based on molecular markers and comparative studies. *Genome*. 51: 628–637.

Soundarapandian, G., Nagarajan R., Madhudeswaram, K, and Marappan, D.V. (1976). Genotypic and phenotypic correlation and path analysis in black gram. *Madras Agricultural Journal*. 63: 141- 147.

Sunil Kumar, B., Padmavathi, S., Prakash, M. and Ganesan, J. (2003). Correlation and path, analysis in blackgram [*Vigna mungo* (L.) Hepper]. *Legume Research*. 26 (1): 75-76.

Tabasum, A., Saleem, M. and Aziz, I. (2010). Genetic variability, trait association and path analysis of yield and yield components in mungbean [*Vigna radiata* (L.) Wilczek]. *Pakistan Journal of Botany*. 42:3915-3924.

Tah, P.R., Saxena, S. (2009). Induced synchrony in pod maturity in mungbean (*Vigna radiata*). *International Journal of Agricultural. Biology*. 11: 321–324.

Thippani, S., Eswari, K.B., and Rao, M.V.B. (2013). Character association between seed yield and its components in green gram [*Vigna radiata* L. Wilczek], *International Journal of Applied Biology and Pharmaceutical technology*, 4(4): 295-297.

Umadevi, M., and Meenakshi Ganesan, N. (2005). Correlation and path analysis for yield and yield components in black gram (*Vigna mungo* L. Hepper). *Madras Agricultural Journal.* 92(10-12): 731-734.

Veeramani., Venkatesan, N.M., Thangavel, P., Ganesan, J. (2005). Genetic variability, heritability and gentic advance analysis in segregating generation of black gram (*Vigna mungo* L. Hepper). *Legume research*. 28(1): 49-51.

Veeranjaneyulu, A., Eswari, K.B., Srinivasa Rao, V., and Ramana, J.V. (2007). Association analysis for yield and its components in black gram (*Vigna mungo* L. Hepper). *The Andhra Agricultural Journal.* 54(3-4): 134-138.

Venkateshwarlu, O. (2001). Genetic Variability in Green Gram [*Vigna radiata* (L.) Wilczek]. *Legume Research.* Volume 24 issue 1.

Wani, S.A., Zargar, G.H and Ahanger, H.U. (1992). Path coefficient analysis in mungbean [*Vigna radiata* (L.) Wilczek] *Advanced PI Sciences.* 5 (2) 554- 558.

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