

**Genetic Variability and Character Association Study for Yield  
and Quality Traits in Groundnut (*Arachis hypogea* L.)**

मूँगफली (*अरेचिस हाइपोजिया* एल.) में उपज एवं गुणवत्ता सम्बन्धी लक्षणों के  
लिए आनुवांशिक विविधता और सहसम्बन्ध का अध्ययन

**BAJRANG LAL JAKHAR**

**THESIS**

**Master of Science in Agriculture  
(Plant Breeding and Genetics)**



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**Department of Plant Breeding and Genetics  
College of Agriculture, Bikaner  
Swami Keshwanand Rajasthan Agricultural  
University,  
Bikaner (Raj).**

**Genetic Variability and Character Association Study for Yield and Quality Traits in Groundnut (*Arachis hypogea* L.)**

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**THESIS**

Submitted to the  
Swami Keshwanand Rajasthan Agricultural  
University, Bikaner  
in partial fulfillment of the requirement for  
the degree of

**Master of Science in Agriculture  
(Plant Breeding and Genetics)**

By

**BAJRANG LAL JAKHAR**

**2018**

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## Chapter- 1

### INTRODUCTION

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Groundnut (*Arachis hypogaea*) is an allotetraploid ( $2n=4x=40$ ) legume crop, which belongs to tribe *Aeschynomeneae* sub tribe *Stylosanthinae* of the family Fabaceae, (Tarawali and Quee, 2014). The groundnut flowers are cleistogamous in nature; therefore, crop is highly self-pollinated. However, extent of out-crossing has reported up to 3.9 per cent.

After fertilization, stalk of ovary elongates and forms peg, which contains fertilized ovules at the tip. The growth of peg is positively geotropic and ovary starts to develop as pod, which contain kernel, each kernel enclosed in papery testa. (Ramanathan, 2001). Groundnut recognized around the world by different names like peanut, African nut, Chinese nut, Manila nut, Kipper nut, Hawks nut, Jar nut, Earth chestnut, Monkey nut, Gobber nut, Ground pea and Ground bean (Johnson, 1964).

The production of oil seed is great importance in both developing as well as developed countries, because of a huge gap in demand and supply of edible oils. Groundnut crop is grown primarily for human consumption either as whole seed or processed, to make groundnut butter, oil, flour and other products like dry roasted peanut, boiled peanut, protein cake, animal feed and fuel. It is considered as highly nutritious foodstuff. Roasted groundnuts are desirable food product with a pleasant aroma and unique flavor. The characteristic nutty flavor of roasted groundnuts has largely resulted from the interaction between reducing sugar liberated from sucrose and free amino acids. In the international market Indian groundnuts are highly valued for the characteristic flavor and aroma. Groundnut shells are a cheap source of fuel, bedding material for poultry and also find a place in the cardboard manufacture industry. The protein of shells is also

used in industrial applications like enzyme production and alcohol extraction, is becoming increasingly popular.

Groundnut kernels are rich in protein, carbohydrate, fiber, unsaturated fat and minerals such as phosphorous (p), calcium (ca), magnesium (mg), vitamin E, B complex and vitamin K. (Settaluri *et al.* 2012). It contains 44-56 per cent oil, 22-30 per cent protein and 9.5-19 per cent carbohydrate. It is also one of the richest sources of thiamine (B<sub>1</sub>) and niacin. This is important as diets in semi-arid regions, which contain limited amounts of essential amino acids like tryptophan and niacin, can be substituted by thiamine.

Commercially, groundnut is the world's fourth most important source of edible oil and third most important source of vegetable protein. It is a predominant oil seed crop in India, rank first among the edible oilseed groups. Groundnut oil is considered as stable and nutritive as it contains the right proportions of saturated and unsaturated fatty acids. Since fatty acids make up the major portion of the weight of an oil molecule. The physical and chemical properties of the oil tend to be determined by the properties of the fatty acids, which predominate in their makeup. Oleic acid, a monounsaturated fatty acid and linoleic acid, a polyunsaturated fatty acid, both accounts for 75-80 per cent of the total fatty acids in the groundnut oil. The higher ratio of oleic/linoleic acid in groundnut oil, which ranges from 0.75 to 5.50 imparts stability and improves its shelf life by delaying the development of rancidity (O'Keefe *et al.*, 1993, Mazingo *et al.*, 2004), thus improves its cooking quality. Oil content, protein content and oil quality with respect to its fatty acid composition are most important quality traits, both for oil and confectionery purposes. Seed oxidative stability is closely associated with oil composition.

Groundnut seed with high oleic acid content and oleic acid/linoleic acid (O/L) ratio have improved stability against lipid peroxidation with higher shelf life can be achieved as compared to low

O/L ratio because oleic acid, the 18-carbon monounsaturated fatty acid and a precursor to linoleic acid, which is less reactive with oxygen (Azharudheen *et al.* 2013)

Now a day, the use of groundnut meal is becoming more recognized, not only as a dietary supplement for children of protein poor, cereal based diets in economically underdeveloped countries, but also an effective treatment for children of protein malnutrition. The nutritional value can be further improved by fortifying groundnut with animal protein such as skim milk powder or plant proteins, which can complement or supplement it. Groundnut cake contains 44 to 69 % of protein, which is extensively used in livestock feed concentrates and mixtures.

Groundnut is grown on nearly 25 million hectares around the world with an annual production of 34 million tonnes of nuts-in-shell. The major producers are China, India, Indonesia, and USA, which together account for two thirds of the world output. Other important producers are Nigeria, Senegal, Sudan and Argentina. Developing countries, account for 82 per cent of the total groundnut area and 79 per cent of the production of the world. Among the developing countries, production is mainly concentrated in Asia and Africa, Asia accounting for 51 per cent of global area and 60 per cent of production. India occupies 30 per cent of global area (7.6 million hectares) and 22 per cent (7.8 million tonnes) of total groundnut production. Conversely, China with 66 per cent of India's area shares about 42 per cent of total World groundnut production and ranks first. Africa accounts for 19 per cent of the global groundnut area with only 19 per cent of the total world output.

In India groundnut occupied an area of 4.75 million hectares with the production of 6.67 million tonnes and productivity 1.4 tonnes (Anonymous, 2016a). Gujarat, Andhra Pradesh, Karnataka, Rajasthan, Tamil Nadu, Maharashtra, Madhya Pradesh, Uttar Pradesh, Odisha,

Punjab and some part of Haryana are major groundnut growing states of the country. Rajasthan occupies 4<sup>th</sup> position in both, area (0.50 million hectares) as well as in production (1.02 million tonnes), with a productivity 2.02 tonnes (Anonymous, 2016b). Major Groundnut producing districts of Rajasthan are Bikaner, Jodhpur, Churu, Jaipur, Hanumangarh, Sikar, Dausa, Nagaur and Tonk etc.

The success of any crop improvement programme largely depends on the variability present in the population. Heritability coupled with genetic advance will using out the genetic gain expected from selection. Understanding the association among various characters with path coefficient analysis has the main importance in framing an efficient breeding programme. Correlation coefficient measures the degree of association, genotypic or phenotypic relationship between two or more characters, which is the basis for selection. Correlation estimates between yield and other characters are useful in selecting desired plant types, in designing an effective breeding programme. Path coefficient analysis (Wright, 1921) is an important tool for partitioning the correlation coefficient into direct and indirect effects of variables on the dependent variable. The path coefficient analysis provides the partitioning of correlation into direct & indirect effects, giving the relative importance of each character of economic important character.

The present study was undertaken to determine the variance, heritability, genetic advance, correlation between various characters and direct, indirect effect towards pod yield with the following objectives.

- 1) To estimate variability parameters for yield and quality character in groundnut.
- 2) To study the nature and magnitude of association among the traits.
- 3) To determine direct and indirect effects of different characters on seed yield.

## Chapter- 2

### REVIEW OF LITERATURE

---

The research on groundnut is very extensive and is being used to maximize not only groundnut production, but also to improve the quality of the produce. For a meaningful breeding programme, information about the genetic makeup of morphological and quality traits, that are important in enhancing the targeted traits, help in making important decisions about the choice of parental material and selection criteria in a breeding population for developing new varieties with desirable genetic makeup. The available literature pertinent to the present investigation has been reviewed and presented as under:

2.1 Genetic Variability, Heritability and Genetic Advance

2.2 Correlation and Path Coefficient

#### **2.1 Genetic Variability, Heritability and Genetic Advance**

The progress of any breeding programme depends upon the extent of the genetic variability present in the population. The genetic variability along with heritability gives a reliable picture of genetic advance to be expected for selection (Burton, 1952) while the heritability coupled with genetic advance predicts the effectiveness of selection based on phenotypic performance.

In a study, conducted by Nadaf, Habib (1987) and Prakash *et al.* (2000), low variability for oil content in parents and progeny lines was observed.

A moderate estimate of heritability for pod yield in a segregating population of Spanish groundnut was reported by Sumathi and Ramanathan (1995).

A wide range of genetic variability for days to 50 percent flowering in advanced generations of Spanish strains of groundnut with high phenotypic coefficient variation (PCV) and genotypic coefficient variation (GCV) was reported by Singh *et al.* (1996). They also reported higher PCV than GCV with significant difference between them indicates that there is a much effect of environment on the traits.

A high estimate of heritability with high genetic advance for 100-kernel weight indicating the presence of additive gene action was reported by Yadav *et al.* (1998).

In a study conducted by Rudraswami *et al.* (1999) reported low PCV for characters, number of primary branches, number of secondary branches, number of immature pods, number of mature pods, pod yield per plant, number of kernels per plant, 100- kernel weight, dry weight of plant and shelling per cent. They also reported moderate to high heritability and moderate genetic advance for number of immature pods, dry weight of plant, shelling per cent, pod yield and kernel yield in the six crosses of groundnut.

Naazar Ali *et al.* (2000) reported higher PCV and GCV estimates and high heritability along with high genetic advance as per cent of mean for number of pods per plant, kernel yield, dry pod yield, hundred kernel weight, dry haulm yield, indicating the role of additive gene in expression of these traits. Similar results of high heritability combined with high genetic advance were also reported by Darshora *et al.* (2002) and Shinde *et al.* (2010).

Venkataramana *et al.* (2001) in a studied of Spanish bunch type observed high genetic variability for seed index.

Nath and Alam (2002) observed higher magnitude of phenotypic coefficients for pods per plant, harvest index and pod yield per plant.

Characters *viz.* pods per plant, 100-pods weight, shelling per cent, harvest index and pod yield per plant showed high heritability in his study.

Suneetha *et al.* (2004) through a studied with 23 genotypes reported high heritability and moderate genetic advance for days to 50 % flowering, total dry matter per plant, 100 pod weight, 100-kernel weight and pod yield per plant.

Golakia *et al.* (2005) observed higher magnitude of PCV and GCV for pod yield, kernel yield and sound mature kernel per cent in both runner and bunch habit groundnut. High heritability coupled with high genetic advance was recorded for pod yield, kernel yield and sound mature kernel per cent.

Mahalakshmi *et al.* (2005) observed high heritability estimates coupled with high genetic advance for number of secondary branches, number of mature pods, number of total pods, shelling per cent and 100-kernel weight, in their study, involving 57 groundnut genotypes, indicating that these characters are governed by additive genes, hence, there is a possibility of further improvement of these traits through simple selection.

Parameshwarappa and Girish (2007) observed major role of non-additive gene action in the inheritance of pod yield, shelling per cent, number of pods and number of mature pods in groundnut and concluded that shelling per cent and 100-kernel weight were found to be governed by both additive as well as non-additive gene effects in different genetic backgrounds.

Venkateshwaralu *et al.* (2007) reported both additive and non-additive gene action in the expression of yield traits *viz.*, shelling per cent, pod yield and kernel yield per plant.

John *et al.* (2007) reported that number of secondary branches per plant, number of mature pods per plant, pod yield per plant, kernel yield

per plant, haulm yield per plant and harvest index showed high estimates of GCV and PCV, heritability and genetic advance as per cent of mean. The role of additive gene action seems to be significant in the inheritance of these traits.

Hariprasanna *et al.* (2008) reported a predominance of additive gene action in the expression of shelling per cent, 100-seed weight, while non additive gene action played an important role in the inheritance of seed yield.

Kavera *et al.* (2008) observed greater magnitude of variations for stearic acid, oleic acid, linoleic acid content and oleic/linoleic acid ratio in groundnut. On the basis these results, they reported that seed yield, oil content and protein content were unaffected by selection for changes in oleic acid content in groundnut. The results of their findings and reports from earlier workers indicated that selection for increased oleic acid was not associated with other undesirable agronomic traits. Thus, it would be possible to extend the shelf life of oil and enhance oil quality by genetically altering the fatty acid composition.

Korat *et al.* (2009) observed higher PCV and GCV estimates for number of secondary branches per plant and number of aerial pegs per plant. They also reported high heritability along with high genetic advance as per cent of mean for number of secondary branches per plant and number of aerial pegs per plant, indicating that these traits are mainly governed by additive gene action and responsive to selection for further improvement.

Zaman *et al.* (2011) observed high genetic coefficient of variation for kernel yield per hectare, followed by kernel yield per plant and mature nuts per plant and 100-kernel weight. The highest heritability was observed in kernel yield per cent, followed by kernel yield per hectare,

100-kernel weight, and mature nuts per plant, and 100-nut weight, while higher values of genetic advance were obtained in all the characters except days to maturity and days to 50% flowering.

Cholin *et al.* (2011) on the basis of morphophysiological traits for quality traits showed significant variation in the population and environment, genotype x environment interaction with high heritability was observed for all the traits studied. Low GCV for days to 50 per cent flowering in F<sub>2</sub> population of groundnut varieties was reported by Vasanthi *et al.* (2012) in his study.

John *et al.* (2011) evaluated 28 F<sub>2</sub> population for genetic parameters of 23 morphological, physiological, yield and yield attributes characters of during spring seasons and reported high heritability and high genetic advance per cent of mean for the number of branches per plant, while high heritability and moderate genetic advance percent of mean was observed for days to 50 per cent flowering. They also reported that these characters are under additive genetic control, therefore selection for these traits will be worthwhile and may rapidly contribute to pod and kernel yields.

Azharudheen and Gowda (2013) studied a mapping population segregating for the important nutritional quality traits (protein content, oil content and fatty acid profile), for evaluation of genetic variability and correlation among the traits. The population exhibited significant variation among the genotypes, seasons and G x E interaction. Moderate magnitude of variability followed by higher heritability was observed for most of the quality traits.

Yadlapalli (2014) carried out an investigation to assess the genetic parameters i.e. genetic variability, heritability and correlation coefficients among different yield components. The highest genetic coefficient of

variation was observed for no. of pods per plant followed by pod yield, 100 seed weight, no. of branches per plant and days to 50 % flowering. The highest heritability was observed for 100 seed weight followed by pod yield, no. of pods per plant, no. of branches per plant and days to 50 % flowering. High values of genetic advance were obtained in all the characters except days to 50% flowering.

Mukri *et al.* (2014a) studied groundnut population consisting of 268 recombinant inbred lines (RILs) for genetic variability for yield, nutritional and oil quality traits under two consecutive seasons at two locations. Analysis showed that variability exists in the population for the nutritional and oil quality as well as for yield component traits. The majority of the yield components and oil quality traits were governed by additive effects. The nutritional and oil quality traits were not affected by environmental factors and simple phenotypic selection ensures increased performance of the genotypes. Yield components showed moderate to high heritability with great influence of environment.

Mukri *et al.* (2014b) carried out an investigation in groundnut to elucidate the information on genetic variability for yield, yield component, nutritional and oil quality traits in Recombinant Inbred Lines (RILs) population derived from crosses TAG24 x GPBD4. Analysis of variance showed significant variation among the genotypes of RILs population for yield, yield components nutritional and oil quality traits. Transgresses segregation observed in both direction indicated the contribution of favorable alleles from both the parent.

Rao *et al.* (2014) observed higher magnitude of PCV while GCV was moderate to high for number of pods per plant and plant height, kernel yield, dry pod yield and hundred kernel weights. High heritability coupled with high genetic advance as per cent of mean was observed for

100- kernel weight, dry pod yield, kernel yield and number of pods per plant indicating the role of additive gene in expressing these traits.

Ramana *et al.* (2015) observed higher magnitude of PCV and GCV for kernel yield per plant, pod yield per plant, number of kernels per plant and harvest index. High heritability coupled with high genetic advance as per cent of mean for traits, days to 50% flowering, harvest index, kernel yield per plant and number of kernels per plant indicate that these are predominantly influenced by additive gene action and the possibility of improvement through phenotypic selection in early generations. High heritability coupled with moderate genetic advance as per cent of mean for number of primary branches per plant and moderate heritability coupled with moderate genetic advance as per cent of mean for 100-kernel weight indicate the role of both additive and non-additive gene action with preponderance of additive genetic variance and selection would be effective to some extent.

Krishnamurthy *et al.* (2015) observed high genotypic and phenotypic variation for pod yield and shelling per cent. Highly significant positive correlation was observed between 100-seed weight and pod yield per plant in both the populations, indicating that breeding for high yield can be achieved without compromising the large seed size, which is a preferred trait for confectionery groundnut.

Patil *et al.* (2015) observed highest genetic coefficient of variation for secondary branches per plant followed by immature pods, mature pods, pod yield and kernel weight per plant. The highest heritability was observed in matured pods per plant and days to 50 per cent flowering followed by kernel weight per plant, 100-kernel weight, oil content and secondary branches.

Rathod *et al.* (2015) in their study reported that pod yield per plant exhibited positive significant association with number of pods per plant, kernel yield, test weight, harvest index, oil content and shelling per cent.

Dewangan *et al.* (2015) estimated genetic variability in 50 groundnut genotypes. The variance was significant for characters, days to 50% flowering, number of branches per plant, days to maturity, number of pods per plant, number of grain per pod (g), seed index (100 seed weight), seed yield per plant (g), and shelling (%), indicating that these traits could be used for selection for crop improvement. High heritability was observed for seed index (94%) and pod yield/ plant (83%) while a moderate value of genetic advance was observed for seed index (18.07), followed by shelling per cent (12.67).

Balaraju and Kenchanagoudar (2016) observed high genetic variability for major yield contributing characters *viz.* secondary branches, number of pods per plant, pod yield (kg/ha), harvest index and high heritability was observed for days to maturity, days to 50% flowering, protein content, oil content, number of secondary branches per plant, pod yield (kg/ha), shelling per cent, kernel yield, test weight and harvest index in both seasons.

Yusuf *et al.* (2017) observed high to moderate estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for all the characters studied except for shelling per cent and number of seeds per plant indicating that those characters could be used as selection indices for crop improvement in groundnut. High heritability was observed for 100 seed weight (91.2%), above ground biomass per plant (90.3%), number of branches per plant (90.2%), plant height (89.4%), number of mature pods per plant (86.8%), number of seeds per pod (85.7%), harvest index (83.7%) and kernel yield (79.7%) accompanied by high genetic advance indicating the predominant role of

additive gene action and the possibilities of effective selection for the improvement of groundnut genotypes based on these characters. Low broad sense heritability and low genetic advance was observed only for shelling per cent and number of seeds per plant, indicating low genetic potentials for these characters due to non-additive gene effects.

Aparna *et al.* (2018) investigated 168 lines with five checks of groundnut and revealed that the presence of ample amount of genetic variation for all the characters among the entries. The traits; number of immature pods per plant, kernel yield per plant, number of primary branches per plant, number of mature pods per plant, pod yield per plant, number of pegs per plant and number of pods per plant were recorded higher estimates of GCV and PCV. High heritability coupled with high genetic advance as percent of mean were registered by number of immature pods per plant followed by days to 50% flowering, number of primary branches per plant, shelling per cent, number of pods per plant, number of mature pods per plant, plant height and 100 kernel weight.

Bhakal and Lal (2018) observed the highest genotypic coefficient of variation for plant height at 20 DAS and high heritability coupled with high genetic advance was observed for plant height at 60 DAS and kernel uniformity in groundnut.

Hampannavar *et al.* (2018) were studied 144 groundnut genotypes for genetic parameters like variability, heritability and genetic advance as the per cent of mean. They recorded that plant height (cm), number of primary branches per plant, number of mature and immature pods per plant, kernel yield per plant, hundred kernel weight (g), haulm yield per plant and dry pod yield per plant had high GCV, PCV, heritability and genetic advance as the per cent of mean, indicating the presence of considerable genetic variation and additive gene effects. Hence, the

improvement of these characters could be effective through phenotypic selection.

Wadikar *et al.* (2018) recorded significant differences among genotypes for all the characters indicating the presence of a considerable amount of variability in groundnut. Higher PCV and GCV values observed for kernel yield per plant followed by pod yield per plant, no. of pods per plant indicating a good amount of variation for these characters. High heritability coupled with high genetic advance as per cent of mean has been noticed for kernel yield per plant, no. of pods per plant, pod yield per plant.

## **2.2 Correlation and Path Coefficient Studies**

A thorough understanding of the association of plant characters with yield and among themselves is essential for successful crop improvement programme. The inter-relationship among the yield components can be analyzed with the help of path coefficient analysis which permits the separation of the correlation coefficient into direct and indirect effects.

Emirglu and Mortuary (1984) observed positive correlation of oil content with oleic and linoleic acid in groundnut. Similar results were obtained by Mollers and Schierholt (2002). In contrast to these a negative correlation was reported by Raheja *et al.* (1987) for oleic and linoleic acid with oil content in a mutant population of 4 groundnut genotypes.

Alam *et al.* (1985) observed in groundnut, positive association of pod yield per plant with the number of pods per plant, days to maturity and plant height. They also reported that selling per cent was negatively associated with 100-Kernel weight. Oil content was negatively associated with all characters except days to maturity and 100-Kernel weight.

Nadaf and Habib (1989) observed positive correlation of oil content with pod yield in  $F_2$  population of interspecific crosses in groundnut.

Abraham (1990) reported that kernel yield exhibited significant positive correlation with pods per plant, kernels per plant, 100-kernel weight and shelling per cent in a study involving 42 bunch type groundnut varieties.

Vaddoria and Patel (1992) through path analysis study on 50 Virginia runner groundnut genotypes indicated positive direct effects of number of pods per plant and seed size on pod yield.

Sah *et al.* (2000) studied  $M_7$  generations of 21 genotypes of mutant cultures of groundnut and reported that pod yield per plant had positive and significant phenotypic correlation with number of pods per plant, 100-seed weight, harvest index, seed yield per plant and oil yield per plant.

Azad and Hamid (2000) in their character association study in nine breeding lines of groundnut together with their parents reported significant positive genotype and phenotypic correlations of pod yield with kernel yield.

Venkataravana (2001) observed significant positive genotypic correlation between kernel yield and 100-kernel weight, sound mature kernel per cent, oil content and oil yield in 30 genotypes of groundnut.

Singh and Singh (2001) reported that number of primary branches had a maximum positive direct effect on pod yield followed 100-kernel weight, harvest index and number of fruiting nodes. Plant height had a high negative direct effect on pod yield in their study on groundnut.

Makhan Lal *et al.* (2003) studied 67 lines of groundnut and reported that plant height had a significant positive correlation with leaf length, leaf

width and number of mature pods, whereas yield per plant had positive correlation with days to maturity and number of mature pods.

Nagda *et al.* (2004) reported on groundnut, a positive and significant correlation of dry pod yield with harvest index at both genotypic and phenotypic levels. Haulm yield was positively and significantly correlated with shelling out turn but negatively correlated with harvest index at both genotypic and phenotypic levels.

Suneetha *et al.* (2004) reported high and significant positive association of pod yield per plant with number of mature pods, total dry matter per plant and harvest index. In the study on groundnut, days to 50 per cent flowering with days to maturity, number of mature pods with total dry matter per plant and 100 pod weight with 100-kernel weight showed significant and positive correlation among them.

Lakshmiddevamma *et al.* (2004) reported on groundnut a high direct effect of kernel yield and oil content on pod as well as oil yield, suggested to lay due emphasis on the selection of these characters for rapid improvement in pod and oil yield. He also reported that number of primary branches had a highest positive direct effect on pod yield followed by number of mature pods per plant, while plant height exhibited negative direct effect on pod yield.

Suvarna *et al.* (2004) in their study reported that pod yield exerted significant and positive correlation with 100-kernel weight and sound mature kernel per cent.

Golakia *et al.* (2005) observed significant and positive correlation of pod yield per plant with developed pods per plant, biomass yield per plant and harvest index, indicating that the simultaneous selection for these characters might bring an improvement in pod yield in groundnut.

Gomes and Lopes (2005) in their study on fifteen groundnut genotypes, reported that splitting of the genotypic correlations in to direct and indirect effects, showed that the grain yield was positively influenced by the number of pods per plant and weight of 100 seeds, while negatively influenced by the number of pods per plant.

Kalmeshwar *et al.* (2006) reported that pod yield per plant had a positive association with number of pods per plant, shelling per cent and sound mature kernel per cent at three locations. The characters number of pods per plant, shelling per cent and sound mature kernel per cent had the maximum direct effect on pod yield per plant.

Studies conducted by Kumar (2006) in groundnut revealed that there was a positive association of pod and kernel yield with each other. These traits also had positive association with number of pods per plant, number of mature pods per plant and sound mature kernel per cent.

Yashoda *et al.* (2007) reported a negative correlation for oil content and protein content in groundnut. Similar results of significant negative correlation between oil content and protein content was also observed by Noubissie *et al.* (2012) in his study for 12 promising groundnut genotypes.

Mane *et al.* (2008) observed that pod yield per plant had positive and significant correlation with sound mature kernel per cent, number of pegs per plant, number of pods per plant and shelling per cent. However, it showed negative but non-significant correlation with 100-kernel weight and days to 50 per cent flowering. The path analysis revealed that shelling per cent and number of pods plant recorded the high magnitude of direct positive effects, suggesting the importance of these characters for improving the yield of plant while direct negative effects were observed for number of pegs per plant and days to 50 per cent flowering on groundnut.

Korat *et al.* (2010) observed that the highest positive direct effects of biological yield per plant and harvest index towards pod yield. 100-kernel weight contributed indirectly via biological yield per plant and harvest index. Based on correlation and path analysis, biological yield per plant, 100-kernel weight and harvest index were identified as the most important yield contributing characters in groundnut.

Cholin *et al.* (2010) reported that oil exerted negative correlation between oil and protein content, oleic and linoleic acid indicated their antagonistic nature in groundnut.

Vaithiyalingan *et al.* (2010) estimated correlation and path coefficients in groundnut and found that pod yield exhibited significant positive association with pods per plant, dry matter production, kernel weight and harvest index. Path analysis revealed the maximum direct effect of pods per plant followed by dry matter production and kernel weight on pod yield.

Zaman *et al.* (2011) reported that number of mature nuts per plant had a high positive direct effect on seed yield per hectare followed by shelling per cent, days to 50% flowering and days to maturity. Therefore, mature nuts per plant, days to 50% flowering, shelling per cent and days to maturity were identified as important characters and could be used in selection for yield improvement in groundnut.

Rao *et al.* (2012) reported direct positive effect of kernel yield, shelling per cent, no of pods per plant and 100-kernel weight on pod yield, hence, a direct selection should be followed for the traits *viz.*, no of pods per plant and 100- kernel weight to improve the pod yield in groundnut.

Narasimhulu *et al.* (2012) through a correlation study on groundnut revealed that pod yield per plant had a significant positive association with

kernel yield per plant and shelling per cent at both genotypic and phenotypic levels.

Babariya and Dobariya (2012) estimated correlation coefficients and direct and indirect effects through path analysis in groundnut. They observed that pod yield per plant was significantly and positively correlated with days to maturity, plant height, number of pods per plant, kernel yield per plant, number of mature pods per plant, 100-kernel weight, biological yield per plant and harvest index. Biological yield per plant and harvest index exhibited high and positive direct effects on pod yield per plant.

Nandini and Savithamma (2012) observed significant negative association for pod yield per plant with days to 50 % flowering and shelling per cent in groundnut. Among these characters kernel yield per plant recorded maximum direct effect on pod yield per plant, whereas all other characters recorded low direct effects.

Makinde and Ariyo (2012) reported on groundnut that the number of pods per plant showed significant positive correlation with yield per plant in both environments, also had the highest direct positive effect on yield per plant.

Shoba *et al.* (2012) reported on groundnut that a kernel yield was significantly and positively correlated with number of pods per plant, pod yield per plant, shelling per cent and hundred kernel weight. The path analysis indicated that among the nine traits studied, pod yield per plant exerted maximum positive direct effect on kernel yield per plant. When both direct and indirect positive contributions were considered, number of pods per plant and pod yield per plant influenced kernel yield per plant.

Kumar *et al.* (2012) estimated correlation and path co-efficient analysis for pod yield and its component characters in 50 genotypes of

groundnut. They found that the genotypic correlation coefficients were relatively higher magnitude than the corresponding phenotypic correlation coefficients, indicating strong inherent association between the characters. Pod yield displayed significant positive association with kernel yield per plant, mature pods per plant, total pods per plant, harvest index and 100-seed weight. Path co-efficient analysis revealed high direct effects of kernel yield per plant and harvest index on pod yield. Hence, it would be rewarding to give due importance to the selection of these characters for rapid improvement in pod yield of groundnut.

Kwaga (2013) estimated path coefficient analysis of the yield attributes in groundnut, showed that number of pods plant exhibited the highest per cent yield contribution of 41.46% to kernel yield, followed by 100-kernel weight contribution of 13.80%. The highest combined contribution of 6.23% of 100-kernel weigh and haulm yield was reported.

Azharudheen *et al.* (2013) reported in groundnut that oil content showed positive correlation with eicosenoic acid, behenic acid and lignoceric acid while negative correlation with stearic acid in both the seasons. Negative correlation found between oleic and linoleic acid, palmitic and oleic acid, oleic/linoleic acid ratio and linoleic acid.

Azharudheen and Gowda (2013) studied on groundnut and observed positive correlation between protein and oil content, whereas, negative correlation found between oleic and linoleic acid, indicating their antagonistic nature.

Maurya *et al.* (2014) reported high estimates of GCV and PCV for by kernel yield (q per ha), pod yield (q per ha), pod yield per plant (g), indicating that these character could be used as selection indices for groundnut crop improvement.

In a study conducted by Pandey *et al.* (2014) on path analysis at genotypic and phenotypic levels indicated high positive direct effects of harvest index, number of primary branches, number of pods per plant, and shelling per cent at both levels. They also reported the direct effect of days to 50 per cent flowering was negative at genotypic level and low at phenotypic level, the direct effect of per cent of sound mature kernel and 100-kernel weight at both genotypic and phenotypic levels was negative.

Kahate *et al.* (2014) reported that the kernel yield per plant, harvest index, test weight and oil content exhibited significant positive association with pod yield. The path analysis study revealed that kernel yield per plant had a positive direct effect on pod yield. Harvest index, test weight showed a positive indirect effect on pod yield through kernel yield in groundnut.

Rathod *et al.* (2015) reported on groundnut that kernel yield, test weight, days to maturity and oil content exerted a positive direct effect on pod yield, whereas, shelling per cent and harvest index had maximum indirect direct effects on pod yield per plant.

Krishnamurthy *et al.* (2015) reported high significant and positive correlation between protein and oil content in GPBD 4 x TG 49 population, but a negative correlation in the TG 49 x GPBD 4 population of groundnut.

Patil *et al.* (2015) observed that pod yield per plant showed high significant and positive association with number of mature pods per plant, kernel weight per plant and days to 50 per cent flowering. The number of mature pods per plant had a high positive direct effect on pod yield per plant.

Gupta *et al.* (2015) estimated sixty diverse genotype of Virginia groundnut were evaluated *kharif* 2013 for genetic parameters *viz.* for correlation and path analysis. They observed that genotypic correlation

coefficients were higher than the corresponding phenotypic correlation coefficients. The pod yield per plant had high significant and positive correlation at phenotypic level with number of mature pods per plant, 100-pod weight, shelling out-turn, kernel yield per plant, biological yield per plant and harvest index. Path analysis revealed that the biological yield per plant and harvest index had high and positive direct effects on pod yield per plant.

Kiranmai *et al.* (2016) reported a strong positive association between pod yield per plant and kernel yield per plant, oil yield per plant in all the environments. Pod yield was also correlated with 100- kernel weight and oil content in the environment III only.

Raghuwanshi *et al.* (2016) reported that the pod yield per plant showed high significant and positive correlations at both genotypic and phenotypic level with kernel yield per plant, number of mature pods per plant, harvest index, biological yield per plant, 100-kernel weight, days to 50% flowering, and shelling out-turn. Path analysis revealed high and positive direct effects of kernel yield per plant, while moderate and positive direct effects of number of mature pods per plant and harvest index on pod yield per plant. Days to 50% flowering and shelling out-turn contributed moderate and negative direct effects, but significant indirect effects along with 100-kernel weight for pod yield per plant. These results suggest that kernel yield per plant, number of mature per plant, harvest index, 100-kernel weight, days to 50% flowering and shelling per cent, as useful traits for developing high yielding groundnut varieties.

Rao (2016) reported that the dry pod yield was significant positively correlated with kernel yield, no of pods per plant, hundred kernel weight and SPAD chlorophyll meter reading (SCMR). Path coefficient analysis indicated that number of pods per plant and hundred kernel

weight were essential traits, to be considered for realizing the improvement in yield.

Dhakar *et al.* (2017) observed that the dry pod yield per plant showed positive and significant correlation at both genotypic and phenotypic levels with kernel yield per plant, 100-kernel weight, sound mature kernels and biological yield per plant. Correlation for dry pod yield per plant was divided into direct and indirect effects of different characters. Highest positive direct effect on dry pod yield was exhibited by kernel yield per plant (2.28) followed by days to maturity (0.57), oil content (0.31) and days to 50% flowering (0.22). This indicates that increase in kernel yield per plant, 100-kernel weight and sound mature kernels would improve the dry pod yield per plant of groundnut.

Bhakar and Lal (2018) reported in groundnut that phenotypic and genotypic correlation analysis revealed that plant height at 40 DAS (0.9215 and 0.8915) was significantly and positively correlated with pod yield q/ha (0.2897 and 0.2637). 100-kernel weight (0.8981 and 0.4804) was positively correlated with pod yield/plant. Path analysis indicated highest positive direct effect on pod yield per plant followed by kernel yield q/ha and kernel uniformity (0.0128).

Hampannavar *et al.* (2018) observed that kernel yield per plant, mature pods per plant, sound mature kernel and haulm yield per plant had a significant positive correlation with dry pod yield per plant. The kernel yield had a high direct effect on dry pod yield in groundnut.

Wadikar *et al.* (2018), through a study in groundnut for character association indicated that high significant positive association of kernel yield per plant followed by harvest index, no. of pod per plant and test weight with pod yield at both genotypic and phenotypic level.



## Chapter-3

### MATERIALS AND METHODS

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The present investigation entitled “**Genetic Variability and Character Association Study for Yield and Quality Traits in Groundnut (*Arachis hypogea* L.)**” was carried out during *Kharif-2017* at Research Farm, Agriculture Research Station, Swami Keshwanand Rajasthan Agricultural University, Beechwal, Bikaner. The experimental farm is situated between 28.10' N latitude and 73.28' E longitude at an altitude of 235.00 meters above sea level.

Soils of the center are sandy (92% sand) in texture and Aeolian in nature, having a high permeability at the surface and very low in fertility with respect to almost all nutrients. The nutrient and water retention capacity of the soil is also very low. Considerable area has hard pan at varying depths. The mean daily temperature goes up to 48<sup>0</sup>C during summers and relative humidity also goes below 4.00 per cent. Minimum temperature goes as low -3.5<sup>0</sup>C during winters. The average rainfall of the center is 262 mm and the area is characterized by strong southwest winds during summer with frequent dust storms. The details of experimental materials and methods/techniques used for the investigation are as under.

#### 3.1 Experimental materials

The experimental material consisted of 100 groundnut genotypes were procured from All India Coordinated Research Project on Groundnut, ARS Bikaner. The material had released varieties, local collection from farmer's field of different villages of Rajasthan, along with advance lines procured from DGR, Junagarh, Gujarat, International Crops Research Institute for Semi Arid Tropics, Hyderabad, India.

## 3.2 Experimental methodology

The experiment was laid out in Randomized Block Design with three replications during *Kharif-2017* at Agriculture Research Station Bikaner. Each genotype was grown with a spacing of 30 cm between rows and 10 cm between plants within the row. Uniform agronomic practices were followed during the crop season to raise a good crop as recommended package and practices for the zone IC. The experimental material were sown on June 28, 2017 and harvested on November 10, 2017.

## 3.3 Characters studied and observations recorded

The observations were recorded on the five randomly selected plants from each replication for thirteen characters *viz.* number of branches per plant, number of pods per plant, number of seeds per pod, shelling per cent, 100-kernel weight, biological yield per plant, seed yield per plant, harvest index (%), oil content (%), protein content (%) and Fatty acids (%). Days to 50 % flowering and days to maturity recorded on the plot basis in each replication. A detailed procedure adopted to record the observations for each character is given below:

**1. Days to 50% flowering:** The number of days from the date of sowing to the date, at which 50% plants start flowering in each plot was recorded as days to 50% flowering.

**2. Days to maturity:** The number of days taken from the date of sowing to the date of physiological maturity of the plants in whole plot was recorded as days to maturity.

**3. Number of branches per plant:** The number of branches of five randomly select plants arising from main shoot was counted and averaged to represent number of branches per plant.

**4. Number of pods per plant:** Number of pods of five randomly select plants were counted and averaged to represent number of pods per plant.

**5. Number of seeds per pod:** Number of kernels of five randomly selected pods from the selected plants were counted and averaged to represent number of seeds per pods.

**6. Shelling per cent:** The mass of kernels obtained from the mass of pods, that was randomly drawn from the bulk sample of the plants used to calculate shelling per cent.

$$\text{Shelling per cent \%} = \frac{\text{Kernel weight (g)}}{\text{Pod weight (g)}} \times 100$$

**7. 100-seed weight:** Well dried 100 seed were randomly taken from pod yield of selected plants and weight on electrical balance to represent 100-seed weight.

**8. Biological yield per plant:** Total biomass of five selected plants excluding roots were weight and averaged to represent biological yield per plant.

**9. Seed yield per plant:** The five randomly selected plants were threshed together, weighed and averaged to obtain grain yield per plant.

**10. Harvest index (%):** Harvest index was computed by using following formula as suggested by Singh and Stoskoff (1971).

$$\text{Harvest index \%} = \frac{\text{Kernel yield per plant (g)}}{\text{Biological yield per plant (g)}} \times 100$$

**11. Oil content (%):** A soxhlet semi automatic method was used to extract the total oil form groundnut samples with petroleum.

**12. Protein content (%):** Near Infrared Reflectance Spectroscopy (NIRS) was used to rapidly and nondestructively analyze the protein content concentration present in groundnut kernels samples.

**13. Fatty acids (%):** Near Infrared Reflectance Spectroscopy (NIRS) was used to rapidly and non destructively analyze the fatty acid concentration present in groundnut kernels samples.

Samples of individual entry were analyzed at ICRISAT, Hyderabad for protein content (%), oil content (%) and fatty acids (Palmitic acid, Steaic acid, Oleic acid and Linoleic acid (%)).

### 3.4 Statistical methods

The overall mean values of different characters were subjected to statistical analysis according to the method given below:

#### 3.4.1 Analysis of variance

Analysis of variance was done by subjecting the data to the statistical method based on Randomized Block Design (RBD) described by Panse and Sukhatme (1978). The analysis of variance including source of variations, degree of freedom, along with the expectations of mean square are given in Table 3.1.

**Table 3.1 Structure of ANOVA**

Source of variation	D.F	M.S (Mean sum of squares)	Expected M.S
Replication	(r-1)	MSr	$\sigma^2e + g\sigma^2 r$
Genotypes	(g-1)	MSg	$\sigma^2e + r\sigma^2 g$
Error	(g-1)(r-1)	MSe	$\sigma^2e$

Where,

- r = Number of replications
- g = Number of genotypes
- p = Number of plot
- MSr = Mean sum square due to replication
- MSg = Mean sum square due to genotypes
- MSe = Mean sum square due to error
- $\sigma^2 r$  = Variance due to replication

$\sigma^2 g$  = Variance due to genotypes

$\sigma^2 e$  = Variance due to error

Standard error of mean was calculated as follows:

$$SE(m) = \sqrt{\frac{MSe}{r}}$$

Standard error of differences between treatment means was calculated as

$$SE(\text{diff.}) = \sqrt{\frac{2MSe}{r}}$$

Where,

MSe = Error mean square and

r = Number of replications

Coefficient of variation was calculated as

$$CV = \sqrt{\frac{MSe}{\bar{X}}} \times 100$$

Where,

CV = Coefficient of variation

$$\text{Population mean} = \frac{\sum_{i=1}^g \sum_{j=1}^r X_{ij}}{Rg}$$

### 3.4.2. Genetic variability parameters

Estimation of components, coefficient of variation, broad sense heritability and genetic advance were calculated separately for each character.

### 3.4.2.1. Variance

#### (i) Genotypic variance

Genotypic variances were calculated according to Johanson *et al.* (1955) from the expectations of mean squares by using ANOVA table from each character as per the following formulae:

$$\text{Genotypic variance } (\sigma^2g) = \frac{\text{MSg} - \text{MSe}}{R}$$

Where,

MSg = Mean sum of square due to genotypes

MSe = Mean sum squares due to environment

r = Replications

#### (ii) Phenotypic variance

Phenotypic variances were calculated according to Comstock and Robinson (1952) from the expectations of mean squares by using ANOVA table for each character as per the following formulae:

$$\text{Phenotypic variance } (\sigma^2p) = \sigma^2g + \sigma^2e$$

Where,

$\sigma^2g$  = Genotypic variance

$\sigma^2e$  = Environmental variance

### 3.4.2.2. Coefficient of variation

The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated as per the formula suggested by Burton (1952) and Johanson *et al.* (1955).

$$\text{G.C.V. (\%)} = \frac{\sqrt{\sigma_g^2}}{\bar{X}} \times 100$$

$$\text{P.C.V. (\%)} = \frac{\sqrt{\sigma_p^2}}{\bar{X}} \times 100$$

Where,

$\bar{X}$  = General Mean

$\sigma^2g$  and  $\sigma^2p$  = Genotypic and phenotypic variances, respectively.

### 3.4.2.3 Heritability (Broad sense)

Heritability was estimated by the formula as suggested by Johanson *et al.* (1955) and Hanson *et al.* (1956).

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

Where,

$\sigma^2g$  = Genotypic variance

$\sigma^2e$  = Environmental variance

### 3.4.2.4 Genetic advance (G.A.)

Improvement in the mean genotypic value (performance) of selected plants (progeny or lines) over the parental population (base population) is known as “genetic advance”. The expected genetic advance for each character was calculated according to the formulae suggested by Johanson *et al.* (1955).

$$\text{G.A.} = K \times h^2 (b) \times \sigma p$$

$$\text{Genetic advance as percent of mean} = \frac{\text{G.A.}}{\bar{X}} \times 100$$

Where,

$h^2$  = Heritability in broad sense

$K$  = Selection differential. It is a constant for a given selection intensity. It is taken as 2.06 at 5% selection intensity in the present investigation.

$\sigma_p$  = Phenotypic standard deviation

$\bar{X}$  = General mean of the character

### 3.4.3 Correlation analysis

The character associations between different pairs of characters at the phenotypic and genotypic levels were calculated from the phenotypic, genotypic and environmental components of variance and co-variances as described by Singh and Chaudhary (1985).

The components of variances and co-variances were calculated from the expectations of mean sum of squares. The expectations of mean of cross products given in are similar to those for mean sum of squares given earlier.

**Table 3.2: Analysis of covariance between characters X and Y**

Source	D.F.	M.S.P.	Expectations of mean sum of cross products
Replication	(r-1)	MSP <sub>r</sub>	$COVe_{xy} + g COVr_{xy}$
Genotypes	(g-1)	MSP <sub>g</sub>	$COVe_{xy} + r COVg_{xy}$
Error	(r-1)(g-1)	MSP <sub>e</sub>	$COVe_{xy}$
Total	rg - 1		

### Correlation coefficients

Correlation coefficients were worked out as suggested by Dewey and Lu (1959). Correlation is the relationship between two variables such that change in one variable result change in another variable. Correlation coefficient is the measure of degree of relationship between two variables. The following formulae were used for

calculating the phenotypic ( $r_p$ ) and genotypic ( $r_g$ ) coefficient of variation using the appropriate variance and co-variance components.

(i) Genotypic correlation coefficients between character X and Y

$$r_{xy}(g) = \frac{\text{Cov}_{xy}(g)}{\sqrt{V_x(g) \cdot V_y(g)}}$$

(ii) Phenotypic correlation coefficients between character X and Y

$$r_{xy}(p) = \frac{\text{Cov}_{xy}(p)}{\sqrt{V_x(p) \cdot V_y(p)}}$$

(iii) Environmental correlation coefficients between character X and Y

$$r_{xy}(e) = \frac{\text{Cov}_{xy}(e)}{\sqrt{V_x(e) \cdot V_y(e)}}$$

Where,

$r_{xy(g)}$ ,  $r_{xy(p)}$  and  $r_{xy}(e)$  denote genotypic, phenotypic and environmental correlation coefficients between X and Y characters, respectively.

$\text{Cov}_{xy(g)}$ ,  $\text{Cov}_{xy(p)}$  and  $\text{Cov}_{xy}(e)$  denote genotypic, phenotypic and environmental co-variances between X and Y characters, respectively.

$V_{x(g)}$ ,  $V_{x(p)}$  and  $V_x(e)$  denote genotypic, phenotypic and environmental variances for characters X, respectively.

$V_{y(g)}$ ,  $V_{y(p)}$  and  $V_y(e)$  denote genotypic, phenotypic and environmental variances for characters Y, respectively.

The significance of correlation coefficient was tested at 5% and 1% level of significance against the expected value from Fisher "r" table at (n-2) degree of freedom (Fisher and Yates, 1935).

### 3.4.4 Test of significance

The significance of correlation was tested using the following

formula:  $-t_{(n-2)} = r \sqrt{\frac{n-2}{1-r^2}}$

Where,

$r$  = Correlation coefficient

$t$  = Students 't' value, and

$n$  = Total number of observations.

### 3.4.5 Path coefficient analysis

Path analysis is standardized partial regression coefficient analysis, which splits the correlation coefficients into the measures of direct and indirect effects of a set of independent variables on the dependent variable (yield).

The estimates of direct and indirect effects were calculated through path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959) both at phenotypic and genotypic levels.

The following equations were solved for estimating the various direct and indirect effects.

$$r_{1y} = P_{1y} + r_{12}P_{2y} + \dots + r_{1p}P_{py}$$

$$r_{2y} = r_{21}P_{1y} + P_{2y} + \dots + r_{2p}P_{py}$$

.....

.....

$$R_{py} = r_{p1}P_{1y} + r_{p2}P_{2y} + \dots + P_{py}$$

Where,

$P_{1y}, P_{2y}, \dots, P_{py}$  are direct effects of character 1,2, .....p on y and  $r_{1y}, r_{2y}, \dots, r_{py}$  denote correlation coefficient between independent characters 1,2, .....p and dependent character 'Y'.

### 3.4.6 Residual effect (R)

Residual effect was calculated as suggested by Singh and Chaudhary (1985) using the following formula:

$$1 = P^2R_y + \sum P_{iy}R_{iy}$$

---

$$P_{Ry} = \sqrt{1 - (P_{1y}r_{1y}) - (P_{2y}r_{2y}) \dots (P_{iy}r_{iy})}$$

Where,

$P_{Ry}$  is the residual effect

## Chapter– 4

## RESULTS

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The result of the investigation entitled “**Genetic Variability and Character Association Study for Yield and Quality Traits in Groundnut (*Arachis hypogea* L.)**” carried out during *Kharif-2017* at Research Farm, Agriculture Research Station, Bikaner are presented below in this chapter. Data pertaining to various field and laboratory observations on groundnut were statistically analyzed and presented under the following heads:

- 4.1 Analysis of variance
- 4.2 Analysis of Genetic variability
- 4.3 Character association analysis
- 4.4 Path coefficient analysis

### 4.1 ANALYSIS OF VARIANCE

The analysis of variance revealed that significant genotypic variance for days to 50 per cent flowering, days to maturity, number of branches per plant, number of pods per plant, number of seeds per pod, shelling per cent, 100-seed weight, biological yield per plant, seed yield per plant, harvest index per cent, linoleic acid per cent, oil per cent, oleic acid per cent, palmitic acid per cent, protein per cent and stearic acid per cent were present, indicating that sufficient variability exist in the material used for the study. The mean sum of squares of different characters for replication, genotypes and error are given in Table 4.1.

### 4.2 ANALYSIS OF GENETIC VARIABILITY

The mean performance of the genotypes for different morphological and quality characters are presented in appendix II. Heritability estimates was high (>70 per cent) for days to 50 per cent flowering, number of branches per plant, number of pods per plant,

shelling per cent, 100-seed weight, biological yield per plant, seed yield per plant, harvest index, oil per cent, linoleic acid per cent, oleic acid per cent, stearic acid per cent and protein per cent, moderate (50-70) for days to maturity and palmitic acid per cent, low (<50 per cent) for number of seeds per pod. Expected genetic advance as per cent of mean was high (>20 per cent) for biological yield per plant and 100-seed weight, moderate (10-20 per cent) for number pods per plant, shelling per cent, seed yield per plant, harvest index, linoleic acid per cent and oleic acid per cent. Low genetic advance as per cent of mean for (<10 per cent) days to 50 per cent flowering, oil content per cent, days to maturity, protein content per cent, stearic acid per cent, number of seeds per pod, number of branches per plant and palmitic acid per cent was observed.

The estimates for both phenotypic coefficient of variance (PCV) and genotypic coefficient of variation (GCV) were high (>20 per cent) for number of branches per plant, number of pods per plant, 100-seed weight, biological yield per plant, seed yield per plant, and harvest index, moderate (10-20 per cent) for stearic acid per cent, linoleic acid per cent, oleic acid per cent and shelling per cent were observed. The estimate was moderate for number of seeds per pod at phenotypic level but low genotypic level. PCV and GCV both were low (<10 per cent) for protein content per cent, palmitic acid per cent, oil content per cent, days to 50 per cent flowering and days to maturity.

The results with regard to overall mean, range, Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), heritability in broad sense ( $h^2$ ) and expected Genetic Advance as per cent of Mean (GAM) for the genotype are presented character wise in Table 4.2.

**Table-4.1 Analysis of variance for different characters in groundnut**

S. No.	Characters	Mean sum of square		
		Replication (df= 2)	Genotype (df=99)	Error (df=198)
1	Days to 50 per cent flowering	42.30	10.86*	1.99
2	Days to maturity	10.90	9.34*	3.21
3	Number of branches /plant	13.85	8.04*	0.89
4	Number of pods /plant (g)	22.21	272.08*	8.84
5	Number of seed / pod (g)	0.31	0.11*	0.06
6	Shelling per cent	135.22	124.51*	10.93
7	100-seed weight (g)	436.34	702.05*	8.47
8	Biological yield / plant (g)	1022.09	3706.34*	58.11
9	Seed yield / plant(g)	87.78	220.93*	8.68
10	Harvest index per cent	0.59	108.88*	10.15
11	Linoleic acid per cent	578.13	153.25*	7.51
12	Oil per cent	446.06	19.82*	5.16
13	Oleic acid per cent	118.49	139.40*	6.15
14	Palmitic acid per cent	25.72	3.25*	1.28
15	Protein per cent	222.04	11.67*	2.46
16	Stearic acid per cent	4.14	0.63*	0.16

\* Level of significance at 5 per cent,

#### **4.2.1 Days to 50 per cent flowering**

Days to 50 per cent flowering showed mean value of 33.82 days with a maximum of 39 days and a minimum of 30 days in the genotypes. Early flowering was found in TG-37, local lines 5, 26, 21(b), ICMS-4, 6, 43, 104, ICGV-15017 while late flowering was observed in variety GIRNAR-3, RS-578, HPS-1 and local line 15(b).

The estimation of GCV (5.08), and PCV (5.62) were low within the genotypes. High heritability (81.67) coupled with low genetic advance as per cent of mean (9.46) was recorded in the population.

#### **4.2.2 Days to maturity**

Days to maturity showed mean value of 132.29 days, which ranges from 129.29 to 133.36 days. Early maturity (129 days) was found in ICMS-79, ICMS-101, local lines 10), 8b and UTRAKASH, GG-20, while late maturity was observed in GIRNAR-3 (136 days), HPS-1 (136 days), ICMS-36 (135 days) and ICMS-149 (135 days).

The estimation of GCV (1.08) and PCV (1.33) were low. The heritability was moderate (65.67) with low genetic advance as per cent of mean (1.80) in the population.

#### **4.2.3 Number of branches per plant**

Number of branches per plant varied from 4.50 to 13.75 with the mean value of 7.23 branches per plant in the population. The maximum number of branches per plant was found in variety GJG-18, HNG-69, K-7 and line ICMS-4, while local lines 17, 2, 26, and ICMS-89 had a minimum number of branches per plant.

The estimation PCV (22.66) and GCV (21.37) were high, coupled with high heritability (88.92) and high genetic advance as per cent mean (41.50) was observed in the population.

#### **4.2.4 Number of pods per plant**

Wide range of variation was observed for number of pods per plant with a minimum of 11.10 and a maximum of 58.43 with a mean value of 27.78 in the population. The maximum number of pods per

plant was found in GG-20, GG-21, K-9 and line ICMS-82, while local line 12(a) and 8 (a) had a minimum number of pods per plant.

The estimates of GCV (33.72) and PCV (34.28) in the population were found high. High heritability (96.75) coupled with high genetic advance as per cent of mean (68.32) was observed in the population.

#### **4.2.5 Number of seeds per pod**

Number of seeds per pod exhibited mean value of 1.60 with a minimum of 1.23 and a maximum of 2.13 in the population. High mean value of seeds per pod was recorded in local lines 27, 25, 19, and ICMS-37 line while, low value was found for line ICMS-25, 101 and ICGV-06420.

This character exhibited a low (8.45) GCV and moderate (12.19) PCV along with low heritability (48.09) coupled with moderate genetic advance as per cent of mean (12.07) in the population.

#### **4.2.6 Shelling per cent**

Wide range of variation was observed for shelling per cent with a minimum of 37.80 per cent and a maximum of 69.05 per cent with a mean value of 56.96 per cent. The maximum shelling per cent was found in local lines 8(a), 17, 26 and HNG-169, while RG- 559, HNG-69, K-9 and line ICGV-06420 had minimum shelling per cent.

The estimates of GCV (10.80) and PCV (11.31) were moderate in the genotypes. High heritability (91.22) coupled with high genetic advance as per cent of mean (21.25) was recorded in the population.

#### **4.2.7 100-seed weight**

The overall mean of 100-seed weight was 56.45 g which ranges from 28.26 g to 96.25 g. High mean value was recorded in lines ICMS-3 (90.8 g), ICMS-12(96.25 g), ICMS-20(91.44 g), and ICMS-81(90.06 g), while low mean value was observed in local lines 9a (28.26 g), 14(29.67 g) and line ICMS-50(31.44 g).

The GCV and PCV recorded 26.94 and 27.10 per cent respectively. The heritability (98.79) and genetic advance as per cent of mean (55.15) were high in the population.

#### **4.2.8 Biological yield per plant**

The overall mean of biological yield per plant was 91.39 g, which ranged from 23.81g to 195.65 g. High mean value was recorded in K-7 (195.65 g), K-9 (186.98 g), GJG-18 (177.62 g) and GG-20 (171.76 g), while a low mean value for the character was observed in local lines 14 (23.81 g), 17 (30.64 g) and 12a (39.17 g).

The GCV and PCV were 38.16 and 38.46 per cent, respectively. The heritability was high (98.43) with high genetic advance as per cent of mean (77.98) in the population.

#### **4.2.9 Seed yield per plant**

Seed yield per plant exhibited mean value of 20.85 g with minimum of 4.84 g and maximum of 50.52 g in the population. High seed yield per plant was found in GG-20 (50.52 g), HNG-169 (42.76 g), K-7 (41.80 g) and line ICMS-20 (41.66 g), while a low mean value for the character was observed in line ICMS-13 (4.84 g) and local line 3 (7.46 g).

The character exhibited a high GCV (40.35) and PCV (41.16) along with high heritability (96.07) coupled with high genetic advance as per cent of mean (81.46) in the population.

#### **4.2.10 Harvest index**

The overall mean of harvest index was 21.29 per cent and ranged from 9.69 to 41.11 per cent. High harvest index per cent was recorded in local lines 21b (41.11%), 6 (32.46%), and K-7 (39.97%), while a low mean value for harvest index per cent was observed in lines ICMS-13 (9.69%), ICMS- 32 (9.88%), ICMS-37 (10.25%) and ICMS-59 (10.51%).

The GCV and PCV were 26.94 and 28.29 respectively. The heritability was high (90.68) with high genetic advance as per cent of mean (52.85) in the population.

#### **4.2.11 Protein content (%)**

Protein content ranged from 19.92 to 30.06 per cent with a mean value of 24.56 per cent. The minimum protein content was found in line ICMS-16 (19.92 %), ICMS-43 (20.85 %) and maximum in line ICMS-13 (29.06 %), ICMS-100 (30.06 %) and K-6 (29.38 %).

The trait exhibited a moderate GCV (7.13) with high PCV (8.03) and high heritability (78.88) coupled with moderate genetic advance as per cent of mean (13.05) in the population.

#### **4.2.12 Oil content (%)**

High variability was observed for the trait, oil content ranged from 43.41 to 54.30 per cent with the overall mean of (49.72 %). The maximum per cent of oil content was found for line ICMS-13 (54.30 %), ICMS-114 (54.00 %) and K-H (54.22 %), while local lines 21a (43.73 %), 18 (43.41 %), 5 (43.86 %) had minimum per cent oil content.

Low GCV (4.45) and PCV (5.17) were recorded. The heritability was high (73.99) with low genetic advance as per cent of mean (7.88) in the population.

#### **4.2.13 Palmitic acid (C16:0) (%)**

The analysis of variance revealed highly significant variation for palmitic acid in the population with a mean of 10.68 per cent and range from 7.96 to 14.82 per cent. The maximum palmitic acid was found in line ICMS-17 (12.37 %), ICMS-3 (13.01%) and HNG-123 (14.82 %), while low palmitic acid was found in local lines 10 (7.96 %), 26 (8.82 %) and ICMS-37 (8.07 %), ICMS-124 (8.89) and ICMS-142 (8.22 %).

**Table 4.2: Estimation of genetic parameters variation for different characters in groundnut**

Character	Mean	Range	G.C.V. per cent	P.C.V. per cent	Heritability %	Genetic advance	GA per cent of Mean
Days to 50 per cent flowering	33.82	29-39	5.08	5.62	81.67	3.20	9.46
Days to maturity	132.29	129-133.36	1.08	1.33	65.67	2.39	1.80
Number of branch per plant	7.23	4.50-13.75	21.37	22.66	88.92	3.00	41.50
Number of pods per plant (g)	27.78	11.10-58.43	33.72	34.28	96.75	18.98	68.32
Number of seeds per pod (g)	1.60	1.23-2.13	8.45	12.19	48.09	0.19	12.07
Shelling per cent	56.96	37.80-69.05	10.80	11.31	91.22	12.11	21.25
100-seed weight (g)	56.45	28.26-96.25	26.94	27.10	98.79	31.13	55.15
Biological yield per plant (g)	91.39	23.81-195.65	38.16	38.46	98.43	71.27	77.98
Seed yield per plant (g)	20.85	4.84-50.52	40.35	41.16	96.07	16.98	81.46
Harvest index per cent	21.29	9.69-41.11	26.94	28.29	90.68	11.25	52.85
Linoleic acid per cent	37.88	15.63-51.66	18.40	18.87	95.10	14.00	36.96
Oil per cent	49.72	43.41-54.30	4.45	5.17	73.99	3.92	7.88
Oleic acid per cent	39.75	28.37-64.56	16.77	17.15	95.59	13.42	33.77
Palmitic acid per cent	10.68	7.96-14.82	7.58	9.74	60.64	1.30	12.16
Protein per cent	24.56	19.92-30.06	7.13	8.03	78.88	3.20	13.05
Stearic acid per cent	2.44	1.58-3.88	16.24	18.78	74.79	0.71	28.94

The GCV and PCV recorded for the trait were low with a value of 7.58 and 9.74 per cent respectively. Moderate heritability (60.64) and moderate genetic advance (12.16) as per cent mean was recorded in the population.

#### **4.2.14 Stearic acid (C18:0) (%)**

The stearic acid ranged from 1.58 to 3.88 per cent with a mean value of 2.44 per cent. The lowest stearic acid found in local lines 9a (1.71 per cent), 14 (1.58 per cent), HNG-123 and the highest in lines ICMS-82 (3.88 %), ICMS-114 (3.84 %). Both genotypic (16.24) and phenotypic (18.78) coefficients of variability estimates were moderate with relatively high heritability (74.79) and high genetic advance as per cent of mean (28.94) were recorded.

#### **4.2.15 Oleic acid (C18:1) (%)**

Oleic acid ranged from 28.37 to 64.56 per cent with mean value of 39.75 per cent. High mean value was recorded in local line 10 (64.56) per cent, released varieties GG-21 (59.33) per cent and ICGV-15017 (61.87) per cent, while low mean value was observed for local line 16 (29.28) per cent and ICMS-3 (28.37) per cent, ICMS-33 (29.36) per cent and ICMS-83 (29.34) per cent.

The GCV (16.77) and PCV (17.15) were moderate with high heritability (95.59) and high genetic advance as per cent of mean (33.77) for oleic acid in the population.

#### **4.2.16 Linoleic acid (C18:2) (%)**

Significant variability in linoleic acid content with a mean of 37.88 per cent was present. It ranged from 15.63 to 51.66 per cent. Lowest linoleic acid was recorded in local lines 10 (15.63 %) & GG-21 (21.52 %), while highest in lines ICMS-3 (51.66 %), ICMS-13 (49.15 %), ICMS-88 (49.43 %), ICM-144 (49.45 %) and released varieties K-H (49.88 %).

The GCV (18.40) and PCV (18.87) recorded were moderate, however, high heritability (95.10) and high genetic advance as per cent of mean (36.96%) were recorded in the lines.

### **4.3 CORRELATION COEFFICIENT**

The breeder is always concerned with the selection of superior genotypes on the basis of phenotypic expression. Often selection based on phenotypic performance does not lead to the expected genetic advance mainly due to the presence of genotype and environmental interactions as well as due to an undesirable association between component characters at genotypic level. Thus, knowledge of correlations between complex characters like seed yield and its components is of prime importance. With this view, correlation coefficients were worked out among the component characters as well as with seed yield per plant.

Character association was computed for different pairs of morphological and quality attributes including seed yield per plant at genotypic as well as phenotypic level. In general, the estimates of genotypic correlation coefficients were higher than the phenotypic coefficient for most of the characters. The results of phenotypic and genotypic correlation coefficients between yield and its components are given in table 4.3 and described as follows.

#### **4.3.1 Days to 50 per cent flowering**

Days to 50 per cent flowering had positive and significant correlation with days to maturity (0.173\*\*), biological yield per plant (0.128\*) and seed yield per plant (0.149\*\*) while, negative significantly correlated with stearic acid (-0.128\*) at phenotypic level.

The character also showed positive significant correlation with days to maturity (0.283\*\*), biological yield per plant (0.157\*\*), seed yield per plant (0.184\*\*) at genotypic level while, negative significantly correlated with number of seeds per pod (-0.193\*\*), linoleic acid (-0.129\*) and stearic acid (-0.202\*\*).

#### **4.3.2 Days to maturity**

Days to maturity showed negative and significant association with shelling per cent (-0.135\*) at phenotypic level.

The character had positive and significant correlation with oil per cent (0.173\*\*), linoleic acid (0.120\*) and palmitic acid (0.177\*\*) while, negative significant correlation with number of pods per plant (-0.154\*\*), number of seeds per pod (-0.164\*\*), shelling per cent (-0.159\*\*) and seed yield per plant (-0.147\*) at genotypic level.

#### **4.3.3 Number of branches per plant**

Number of branches per plant had a significant and positive association with number of pods per plant (0.407\*), 100-seed weight (0.338\*\*), biological yield per plant (0.639\*\*), seed yield per plant (0.393\*\*) respectively while, negative significant correlation with shelling per cent (-0.355\*) at phenotypic level.

Number of branches per plant had a positive and significant association with number of pods per plant (0.474\*\*), 100-seed weight (0.389\*\*), biological yield per plant (0.753\*\*), seed yield per plant (0.438\*\*) while, negative significant correlation with number of seeds per pod (-0.143\*), shelling per cent (-0.459\*\*), oil per cent (-0.238\*\*), stearic acid (-0.114\*) at genotypic level.

#### **4.3.4 Number of pods per plant**

Number of pods per plant exhibited a significant and positive correlation with 100-seed weight (0.130\*), biological yield per plant (0.679\*\*), seed yield per plant (0.643\*\*), harvest index (0.188\*\*), oleic acid (0.153\*\*), stearic acid (0.133\*) while it had negative and significant association with shelling per cent (-0.173\*\*) at phenotypic level. It also showed positive and significant correlation with 100-seed weight (0.135\*), biological yield per plant (0.724\*\*), seed yield per plant (0.687\*\*), harvest index (0.222\*\*), oil (126\*), oleic acid (0.186\*\*), protein (0.125\*), stearic acid (0.158\*\*) while negative significant association with shelling per cent (-0.223\*\*), palmitic acid (-0.171\*\*) at genotypic level.

#### **4.3.5 Number of seeds per pod**

Number of seeds per pod had positive and significant correlation with shelling per cent (0.178\*\*), oleic acid (0.116\*) but negative and significant association with biological yield per plant (-0.129\*), linoleic acid (-0.126\*) at phenotypic level. However, this character showed a positive and significant association was with shelling per cent (0.314\*\*), harvest index (0.113\*) and oleic acid (0.181\*\*) while, negative and significant correlation with 100-seed weight (-0.226\*\*), biological yield per plant (-0.298\*\*), seed yield per plant (-0.129\*), linoleic acid (-0.308\*\*), oil per cent (-0.174\*\*) at genotypic level.

#### **4.3.6 Shelling per cent**

Shelling per cent exhibited positive significant association with harvest index (0.366\*\*) and negative significant correlation with 100-seed weight (-0.251\*\*), biological yield per plant (-0.354\*\*), at phenotypic levels. Shelling per cent had a positive and significant association with harvest index (0.383\*\*) and negative significant correlation with 100-seed weight (-0.299\*\*), biological yield per plant (-0.407\*\*), palmitic acid (-0.180\*\*), protein per cent (-0.129\*) at genotypic level.

#### **4.3.7 100-seed weight**

100-seed weight had positive and significant correlation with biological yield per plant (0.486\*\*), seed yield per plant (0.481\*\*), harvest index (0.120\*) and linoleic acid (0.132\*) but negative significant correlated with oleic acid (-0.164\*\*) at phenotypic level. However, this character showed positive and significant association was found with biological yield per plant (0.505\*\*), seed yield per plant (0.504\*\*), harvest index (0.143\*), linoleic acid (0.144\*), palmitic acid (0.148\*) while, negative significant correlation with oleic acid (-0.169\*\*) at genotypic level.

#### **4.3.8 Biological yield per plant**

Biological yield per plant had a positive and significant association with seed yield per plant (0.635\*\*) at both phenotypic and

genotypic level. It also showed a positive significant association with protein per cent (0.124\*) at genotypic level only.

#### **4.3.9 Seed yield per plant**

Seed yield per plant was found to have positive significant correlation with harvest index (rp 0.651\*\* & rg 0.537\*\*) at both phenotypic and genotypic level. Seed yield per plant had negative and significant correlated with palmitic acid (-0.158\*\*), protein per cent (-0.118\*) at phenotypic level only.

#### **4.3.10 Harvest index (%)**

The correlation coefficient of Harvest index was positive and significant with oleic acid (0.136\*) but negative significant association with linoleic acid (-0.145\*) at both phenotypic and genotypic level.

It also negative significant association with palmitic acid (-0.142\*) and protein per cent (-0.185\*\*) at genotypic level.

#### **4.3.11 Linoleic acid (%)**

There was a positive and significant correlation of linoleic acid with oil content (rp 0.315\* & rg 0.437\*\*), palmitic acid (rp 0.388\*\* & rg 0.703\*\*), stearic acid (rp 0.123\* & rg 0.217\*\*) at both phenotypic and genotypic level. While the association of linoleic acid with oleic acid (rp -0.708\*\* & rg -0.813\*\*) was negative and significant at both phenotypic and genotypic levels.

#### **4.3.12 Oil content (%)**

The correlation coefficient of oil content was positive and significant with stearic acid (rp 0.386\*\* & rg 0.537\*\*) at both phenotypic and genotypic level. It also showed a positive significant association with palmitic acid (0.131\*) but negative significant association with oleic acid (-0.116\*) at genotypic level.

**Table 4.3: Phenotypic and Genotypic correlation coefficient for different characters in groundnut**

Character	Days to 50 per cent flowering	Days to maturity	No. of branches/ plant	No. of pods / Plant (g)	No. of Seed /pod (g)	Shelling per cent	100-seed weight (g)	Biological yield / Plant (g)	Seed yield / Plant (g)	Harvest index per cent	Linoleic acid per cent	Oil per cent	Oleic acid per cent	Palmitic acid per cent	Protein per cent	Stearic acid per cent
Days to 50 per cent flowering	<b>1.000</b>	0.173**	0.106	0.064	-0.073	-0.018	0.067	0.128*	0.149**	0.039	-0.078	-0.050	0.008	-0.042	-0.006	-0.128*
Days to maturity	0.283**	<b>1.000</b>	0.021	-0.072	-0.040	-0.135*	-0.031	-0.021	-0.077	-0.100	0.094	0.066	-0.097	0.070	-0.056	0.006
No. of branch /plant	0.091	-0.012	<b>1.000</b>	0.407**	0.043	-0.355**	0.338**	0.639**	0.393**	-0.014	0.112	-0.104	-0.043	-0.028	0.025	-0.063
No. of pods /plant(g)	0.100	-0.154**	0.474**	<b>1.000</b>	-0.059	-0.173**	0.130*	0.679**	0.643**	0.188**	-0.063	0.074	0.153**	-0.107	0.068	0.133*
No. of seeds /pod(g)	-0.193**	-0.164**	-0.143*	-0.105	<b>1.000</b>	0.178**	-0.087	-0.129*	-0.038	0.076	-0.126*	-0.081	0.116*	-0.034	0.035	-0.023
Shelling per cent	-0.022	-0.159**	-0.459**	-0.223**	0.314**	<b>1.000</b>	-0.251**	-0.354**	0.014	0.366**	0.023	-0.022	-0.007	-0.103	-0.062	0.040
100-seed weight (g)	0.073	-0.036	0.389**	0.135*	-0.226**	-0.299**	<b>1.000</b>	0.486**	0.481**	0.120*	0.132*	0.009	-0.164**	0.094	-0.031	-0.012
Bio. yield/ plant(g)	0.157**	-0.066	0.753**	0.724**	-0.298**	-0.407**	0.505**	<b>1.000</b>	0.635**	-0.027	0.067	-0.019	0.007	-0.044	0.084	0.061
Seed yield / plant(g)	0.184**	-0.147*	0.438**	0.687**	-0.129*	-0.005	0.504**	0.681**	<b>1.000</b>	0.651**	-0.084	-0.036	0.096	-0.158**	-0.118*	0.021
Harvest index per cent	0.098	-0.071	-0.042	0.222**	0.113*	0.383**	0.143*	-0.018	0.537**	<b>1.000</b>	-0.145*	-0.079	0.136*	-0.027	-0.101	0.019
Linoleic acid per cent	-0.129*	0.120*	0.101	-0.073	-0.308**	-0.008	0.144*	0.073	-0.064	-0.204**	<b>1.000</b>	0.315**	-0.708**	0.388**	0.082	0.123*
Oil per cent	-0.073	0.173**	-0.238**	0.126*	-0.174**	-0.037	0.005	-0.029	-0.036	-0.091	0.437**	<b>1.000</b>	-0.065	0.094	-0.022	0.386**
Oleic acid per cent	-0.017	-0.103	-0.066	0.186**	0.181**	-0.014	-0.169**	0.017	0.080	0.139*	-0.813**	-0.116*	<b>1.000</b>	-0.448**	-0.040	0.093
Palmitic acid per cent	-0.001	0.177**	0.029	-0.171**	-0.107	-0.180**	0.148*	-0.062	-0.097	-0.142*	0.703**	0.131*	-0.760**	<b>1.000</b>	0.085	-0.101
Protein per cent	-0.019	-0.032	0.033	0.125*	-0.010	-0.129*	-0.042	0.124*	-0.088	-0.185**	0.072	-0.108	-0.108	0.136*	<b>1.000</b>	0.002
Stearic acid per cent	-0.202**	-0.066	-0.114*	0.158**	-0.021	-0.028	-0.012	0.057	0.020	-0.033	0.217**	0.537**	0.132*	-0.203**	0.066	<b>1.000</b>

\* Level of significance 5 per cent, \*\* level of significance 1 per cent at

Genotypic correlation coefficient below diagonal, Phenotypic correlation coefficient Above diagonal.

#### **4.3.13 Oleic acid (%)**

Oleic acid had a significant negative association with palmitic acid (rp -0.448\*\* & rg -0.760\*\*) at both phenotypic and genotypic levels. While, character show that positive and significant association with stearic acid (0.132\*) at genotypic level.

#### **4.3.14 Palmitic acid (%)**

Palmitic acid had a positive and significant association with protein per cent (0.136\*) and negative significant association with stearic acid (-0.203\*\*) at genotypic level.

#### **4.3.15 Protein content (%)**

The positive and non significant association of protein per cent with stearic acid (rp 0.002 & rg 0.066) at both phenotypic and genotypic level were found.

### **4.4 PATH COEFFICIENT ANALYSIS**

The Path coefficient analysis allows separation of the direct effect and their indirect effects through other attributes by partitioning the correlations (Wright, 1921). Hence, for this objective the present investigation was undertaken. Based on the data recorded on the genotypes in the present investigation, the phenotypic and genotypic correlations were estimated to determine direct and indirect effects of yield and yield contributing characters.

Path-coefficient analysis was used to partition the genotypic correlation coefficient of sixteen characters studied with seed yield per plant into direct and indirect effects. Since correlation studies alone are not adequate to establish a clear relationship between the characters, therefore, the assessment of a real contribution of individual character towards the seed yield became essential. Path-coefficient provides a clearer and more realistic picture of complex situation that exists at correlation levels. It measures the direct as well as indirect effects of independent variables (characters) on the dependent variable through other traits. The direct and indirect effects of various characters along

with genotypic correlation coefficient with seed yield per plant are presented in Table 4.4.

At genotypic level, highest direct positive effect on seed yield was observed of biological yield per plant (0.583), harvest index (0.572), number of pods per plant (0.203), 100-seed weight (0.152), linoleic acid (0.099), number of seed per pod (0.036) and days to 50 per cent flowering (0.034) while, highest direct negative effect was recorded for number of branches per plant (-0.159), palmitic acid (-0.103), protein content (-0.098), stearic acid (-0.052), days to maturity (-0.038), oil content (-0.033), oleic acid (-0.032) and shelling per cent (-0.020).

#### **4.4.1 Days to 50 per cent flowering.**

The days to 50 per cent flowering had a direct positive effect (0.034) on seed yield per plant along with significant positive correlation with seed yield per plant (0.184\*\*). It showed a positive in direct contribution through number of pods per plant (0.020), 100-seed weight (0.011), biological yield per plant (0.091), harvest index (0.056), oil content (0.001), oleic acid (0.001), protein content (0.002) and stearic acid (0.010).

#### **4.4.2 Days to maturity**

The days to maturity had a direct negative effect (-0.038) on seed yield per plant and significant negative correlation with seed yield per plant (-0.147\*). It showed a negative indirect contribution through number of pods per plant (-0.031), number of seeds per pod (-0.006), 100-seed weight (-0.006), biological per plant (-0.038), harvest index (-0.040), oil content (-0.006) and palmitic acid (-0.018).

#### **4.4.3 Number of branches per plant**

Number of branches per plant had positive and significant correlation with seed yield per plant (0.438\*\*) and negative (-0.159) direct effect on number of branches per plant. Positive correlation with seed yield per plant was due to its positive indirect effect through days to 50 per cent flowering (0.003), number of pods per plant (0.096),

shelling per cent (0.009), 100-seed weight (0.059), biological yield per plant (0.439), linoleic acid (0.010), oil content (0.008), oleic acid (0.002) and stearic acid (0.006).

Its negative indirect effects were found for number of seeds per pod (-0.005), harvest index (-0.024), palmitic acid (-0.003) and protein content (-0.003).

#### **4.4.4 Number of pods per plant**

The number of pods per plant had a direct positive effect (0.203) on seed yield per plant along with a significant positive correlation with seed yield per plant (0.687\*\*). It showed a positive indirect contribution through days to 50 per cent flowering (0.003), days to maturity (0.006), shelling per cent (0.004), 100-seed weight (0.021), biological yield per plant (0.422), harvest index (0.127) and palmitic acid (0.018).

#### **4.4.5 Number of seeds per pod**

Number of seeds per pod had a negative, significant correlation with seed yield per plant (-0.129\*) and negative correlation with seed yield per plant was due to positive indirect effect through number of branches per plant (0.023), harvest index (0.065) and palmitic acid (0.011).

Its negative indirect effect was found for shelling per cent (-0.006), 100-seed weight (-0.034), biological yield per plant (-0.174), linoleic acid (-0.030), oleic acid (-0.006), number of pods per plant (-0.021) and days to 50 per cent flowering (-0.007).

#### **4.4.6 Shelling per cent**

Shelling per cent had negative and non-significant correlation with seed yield per plant (-0.005) with direct negative effect (-0.020). It showed a positive indirect contribution through harvest index (0.219), oil content (0.001), palmitic acid (0.019), protein content (0.013), straric acid (0.001), number of seeds per pod (0.011), number of branches per plant (0.073) and days to maturity (0.006).

It had a negative indirect contribution through 100-seed weight (-0.046), biological yield per plant (-0.237), linoleic acid (-0.001), number of pods per plant (-0.045) and days to 50 per cent flowering (-0.001).

#### **4.4.7 100-seed weight**

100-seed weight showed a positive direct effect on seed yield per plant (0.152) and significant positive correlation with seed yield per plant (0.504\*\*). The positive indirect contribution of biological yield per plant (0.294), harvest index (0.082), linoleic acid (0.014), oleic acid (0.005), protein content (0.004), stearic acid (0.001), number of pods per plant (0.028), shelling per cent (0.006), days to 50 per cent flowering (0.002) and days to maturity (0.001) were responsible for the positive correlation with seed yield per plant.

#### **4.4.8 Biological yield per plant**

Correlation of biological yield with seed yield per plant was positive and significant (0.681\*\*) due to its positive direct effect of biological yield per plants (0.583) and positive indirect effect on seed yield per plant through number of pods per plant (0.147) and 100-seed weight (0.077).

#### **4.4.9 Harvest index per cent**

Harvest index exhibited significant and positive correlation with seed yield per plant (0.537\*\*) due to its direct positive effect (0.572) and indirect positive effect viz. palmitic acid (0.015), protein content (0.018), number of branches per plant (0.045) and 100-seed weight (0.022).

Harvest index indicated negative indirect effect through linoleic acid (-0.020), oleic acid (-0.004) shelling per cent (-0.008) and biological yield per plant (-0.010).

#### **4.4.10 Linoleic acid (%)**

The linoleic acid had a direct positive effect (0.099) on seed yield per plant and non-significant negative correlation (-0.064). It

showed a positive indirect contribution through oleic acid (0.026), 100-seed weight (0.022) and biological yield per plant (0.042).

#### **4.4.11 Oil content (%)**

The oil content had a direct negative effect (-0.033) on seed yield per plant and non-significant negative correlation with seed yield per plant (-0.036). The oil content indicated negative indirect effect through palmitic acid (-0.14), stearic acid (-0.028) biological yield per plant (-0.017), harvest index (-0.052), number of seeds per pod (-0.006), days to maturity (-0.007) and days to 50 per cent flowering (-0.002).

#### **4.4.12 Oleic acid (%)**

Oleic acid had positive and non-significant correlation with seed yield per plant (0.080) and its direct effect on oleic acid was negative (-0.032). Positive correlation with seed yield per plant was due to its negative indirect effect through 100-seed weight (-0.026), linoleic acid (-0.080), stearic acid (-0.007) and days to 50 per cent flowering (-0.001).

The indirect positive contribution of oleic acid with palmitic acid (0.079), protein content (0.011), number of pods per plant (0.038), harvest index (0.080), biological yield per plant (0.010), number of branches per plant (0.011), number of seeds per pod (0.007) and oil content (0.004).

#### **4.4.13 Palmitic acid (%)**

The palmitic acid had a direct negative effect (-0.103) on seed yield per plant and correlation between the it two characters found negative and non-significant (-0.097). It showed negative indirect effects for protein content (-0.013), harvest index (-0.081), biological yield per plant (-0.036), number of pods per plant (-0.035), days to maturity (-0.007), number of branches per plant (-0.005), number of seeds per pod (-0.004) and oil content (-0.004).

**Table 4.4: Direct and indirect effects of different characters on seed yield per plant in groundnut**

Characters	Days to 50 per cent flowering	Days to maturity	No. of branches /plant	No. of pods /plant(g)	No. of Seed /pod(g)	Shelling per cent	100-seed weight(g)	Bio. yield /plant (g)	Harvest index per cent	Linoleic acid per cent	Oil per cent	Oleic acid per cent	Palmitic acid per cent	Protein per cent	Stearic acid per cent	Seed yield /plant
Days to 50 per cent flowering	<b>0.034</b>	-0.011	-0.014	0.020	-0.007	0.000	0.011	0.091	0.056	-0.013	0.002	0.001	0.000	0.002	0.010	<b>0.184**</b>
Days to maturity	0.010	<b>-0.038</b>	0.002	-0.031	-0.006	0.003	-0.006	-0.038	-0.040	0.012	-0.006	0.003	-0.018	0.003	0.003	<b>-0.147*</b>
No. of branch / plant	0.003	0.000	<b>-0.159</b>	0.096	-0.005	0.009	0.059	0.439	-0.024	0.010	0.008	0.002	-0.003	-0.003	0.006	<b>0.438**</b>
No. of pods /plant (g)	0.003	0.006	-0.075	<b>0.203</b>	-0.004	0.004	0.021	0.422	0.127	-0.007	-0.004	-0.006	0.018	-0.012	-0.008	<b>0.687**</b>
No. of seeds /pod(g)	-0.007	0.006	0.023	-0.021	<b>0.036</b>	-0.006	-0.034	-0.174	0.065	-0.030	0.006	-0.006	0.011	0.001	0.001	<b>-0.129*</b>
Shelling per cent	-0.001	0.006	0.073	-0.045	0.011	<b>-0.020</b>	-0.046	-0.237	0.219	-0.001	0.001	0.000	0.019	0.013	0.001	<b>-0.005</b>
100-seed weight (g)	0.002	0.001	-0.062	0.028	-0.008	0.006	<b>0.152</b>	0.294	0.082	0.014	0.000	0.005	-0.015	0.004	0.001	<b>0.504**</b>
Bio. yield/ plant (g)	0.005	0.003	-0.120	0.147	-0.011	0.008	0.077	<b>0.583</b>	-0.010	0.007	0.001	-0.001	0.006	-0.012	-0.003	<b>0.681**</b>
Harvest index percent	0.003	0.003	0.007	0.045	0.004	-0.008	0.022	-0.010	<b>0.572</b>	-0.020	0.003	-0.004	0.015	0.018	0.002	<b>0.537**</b>
Linoleic acid per cent	-0.004	-0.005	-0.016	-0.015	-0.011	0.000	0.022	0.042	-0.117	<b>0.099</b>	-0.014	0.026	-0.073	-0.007	-0.011	<b>-0.064</b>
Oil per cent	-0.002	-0.007	0.038	0.026	-0.006	0.001	0.001	-0.017	-0.052	0.043	<b>-0.033</b>	0.004	-0.014	0.011	-0.028	<b>-0.036</b>
Oleic acid per cent	-0.001	0.004	0.011	0.038	0.007	0.000	-0.026	0.010	0.080	-0.080	0.004	<b>-0.032</b>	0.079	0.011	-0.007	<b>0.080</b>
Palmitic acid per cent	0.000	-0.007	-0.005	-0.035	-0.004	0.004	0.022	-0.036	-0.081	0.069	-0.004	0.024	<b>-0.103</b>	-0.013	0.011	<b>-0.097</b>
Protein per cent	-0.001	0.001	-0.005	0.025	0.000	0.003	-0.006	0.073	-0.106	0.007	0.004	0.003	-0.014	<b>-0.098</b>	-0.003	<b>-0.088</b>
Stearic acid per cent	-0.007	0.003	0.018	0.032	-0.001	0.001	-0.002	0.033	-0.019	0.021	-0.018	-0.004	0.021	-0.007	<b>-0.052</b>	<b>0.020</b>

Residual effect 0.0603

Direct effect = Diagonal, Indirect effect = Non-diagonal

#### **4.4.14 Protein content (%)**

Protein content had a negative direct effect (-0.098) and a negative, non-significant correlation with seed yield (-0.088), whereas, the association for protein content with seed yield per plant was mainly due to negative indirect effects *viz.* harvest index (-0.106), palmitic acid (-0.014), stearic acid (-0.003), 100-seed weight (-0.006), number of branches per plant (-0.005) and days to 50 per cent flowering.

Its positive indirect effects were found through biological yield per plant (0.073), number of pods per plant (0.025), linoleic acid (0.007), oil content (0.004) and oleic acid (0.003).

#### **4.4.15 Stearic acid (%)**

Stearic acid had a negative direct effect on seed yield per plant (-0.052) with non-significant positive correlation (0.020). It showed a positive indirect effect contribution through number of pods per plant (0.032), biological yield per plant (0.033), linoleic acid (0.021), palmitic acid (0.0021), number of branches per plant (0.018) and days to maturity (0.003).

Stearic acid indicated negative indirect effect through harvest index (-0.019), oil content (-0.018), protein content (-0.007), days to 50 per cent flowering (-0.007), oleic acid (-0.004) and number of seeds per pod (-0.001).

#### **Residual factors**

The low residual effect at genotypic (0.0603) level indicated that all the characters had good contribution towards seed yield.

## Chapter–5

### DISCUSSION

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The success of any plant breeding programme depends on the choice of appropriate germplasm lines. The improvement of pod yield largely depends on the magnitude of genetic variability and extent to which seed yield determining characters are heritable. A thorough knowledge of the nature of magnitude of genetic variability and the extent of association between pod yield and its components is essential before launching a breeding program. Similarly, heritability and genetic advance estimates are also helpful in selecting superior individuals.

In oil seed crops, fatty acid composition determines the nutritional qualities and oxidative stability of the oil. Groundnut is the major oilseed crop grown in India. Unlike in other groundnut producing countries, nearly 80 per cent of the produce is crushed for extraction of edible oil and it constitutes 34 per cent of the total oil produced in the country. There are very limited efforts for genetic improvement of oil content and oil quality traits in most of the oil seed crops like groundnut.

In the present investigation, 100 genotypes of groundnut were raised during *kharif*, 2017 at Research Farm, Agriculture Research Station, Bikaner. The material was planted in Random Block Design with three replications. The genotypes were evaluated to obtain information about the extent of the genetic variability present among the genotypes, extent of heritability and genetic advance, genotypic and phenotypic correlations among seed yield per plant and other characters. The sixteen characters for which the data were recorded are days to 50 % flowering, days to maturity, number of branches per plant, number of pods per plant, number of seeds per pod, shelling per cent, 100-seed weight, biological yield per plant, seed yield per plant ,

harvest index, protein content, oil content, palmitic acid, stearic acid, oleic acid and linoleic acid. The results obtained from the present investigation are discussed in under following head.

### **5.1. GENETIC VARIABILITY PARAMETERS**

Information about genetic variation existing within the genetic material is vital in assessing the potential for the successful selection and breeding for higher, seed yield because genetic variability is essential to realize the response to selection pressure. Thus, genetic variability was estimated for seed yield and its components. Analysis of variance indicated highly significant differences among the genotypes for all the characters studied, which indicated that the material used had enough genetic variability.

Wide range of difference for GCV was observed, which varied from 1.08 per cent (days to maturity) to 40.35 per cent (seed yield per plant) indicating considerable amount of variability present among the genotypes. In general, the phenotypic coefficient of variation (PCV) was higher than their corresponding genotypic coefficient of variation (GCV). This suggested the role of environment in the expression of these characters.

High estimates of PCV and GCV were observed for characters seed yield per plant (40.35 & 41.16), biological yield per plant (38.16 & 38.46), number of pods per plant (33.72 & 34.28), harvest index (26.94 & 28.29), 100-seed weight (26.94 & 27.10) and number of branches per plant (21.37 & 22.66). Such high genetic variation was also reported by earlier workers Ramana *et al.* (2015) for harvest index and seed yield per plant, John *et al.* (2007) for biological yield per plant, Rao *et al.* (2014), Dashora *et al.* (2002) and Naazar *et al.* (2000) for number of pods per plant and 100-seed weight, Wadikar *et al.* (2018) for number of branches per plant, see index. The difference between estimates of PCV and GCV is also indicative of heritability, since the characters with moderate differences between PCV and GCV shelling

per cent (10.80 & 11.31), oleic acid (16.77 & 17.15), linoleic acid (18.40 & 18.87) and stearic acid (16.24 & 18.75) as similar findings by Vasanthi *et al.* (2012) with number branches per plant. However, in the present investigation, number of seeds per pod had moderate PCV and low GCV in the germplasm, indicating less response to selection.

Low estimates of PCV and GCV were observed for characters days to 50% flowering, days to maturity, protein content, oil content and palmitic acid would be useful. It indicates the narrow range of variability for these characters and restricting the scope of selection. Such low variation for above characters have also been reported earlier by Maurya *et al.* (2014), Nadaf and Habib (1987), Venkataraman *et al.* (2001), Kavera *et al.* (2008), Cholin *et al.* (2011) for the traits oil content and protein content, Wadikar *et al.* (2018) for days to 50 % flowering and days to maturity.

In crop improvement, only genetic components of variation are important, since only this component is transmitted to the next generation. Heritability indicates the effectiveness with a selection of genotypes can be done on the basis of its phenotypic variation, because the individual's phenotype is determined by their genotype. These heritability estimates serve as a useful guide for the breeder because selection would be fairly easy for the characters with high heritability. This is because there would be a close correlation between the genotype and the phenotype due to a relatively small contribution of the environment to phenotype but for a character with low heritability, selection may not be very effective due to the masking effect of environment on genotypic effect.

The heritability estimates were high for the characters, harvest index (90.68%), biological yield per plant (98.43%), number of pods per plant (96.75%), seed yield per plant (96.07%) and number of branches per plant (88.92%). Similar results have been reported by John *et al.* (2007), Yadav *et al.* (1998) and Suneetha *et al.* (2004) for 100-seed

weight, Rudraswami *et al.* (1999) and Mahalakshmi *et al.* (2005) for shelling per cent, Yadlapalli *et al.* (2014) for number of branches per plant and number of pods per plant, Suneetha *et al.* (2004) for days to 50 % flowering, Zaman *et al.* (2011) for seed yield per plant and 100-seed weight, Nazzar *et al.* (2000), Rao *et al.* (2014), for number of pods per plant and 100-seed weight, Patil *et al.* (2015) for 100-seed weight and oil content.

The heritability estimates were moderate for the characters days to maturity (65.67%) and palmitic acid (60.64%). Thus, based on the present study, characters Days to 50% flowering, number of branches per plant, 100-seed weight, harvest index, biological yield per plant, shelling per cent, number of pods per plant, seed yield per plant, linoleic acid, oleic acid, protein content, oil content and stearic acid will aid in a selection programme owing to their high heritability value.

Genetic advance is the improvement in the mean values of selected families over the base population. It is also expressed as the shift in gene frequency towards superior side on selection pressure. Genetic advance when expressed as per cent of mean is called genetic gain. Genetic advance under selection depends upon the phenotypic variability among different plants or families in the base population. The present study, the expected genetic advance showed wide range from 0.19 (number of seed per pod) to 71.27 (biological yield per plant) and 1.80 (days to maturity) to 81.46 (seed yield per plant).

Genetic advance as per cent of mean was highest for seed yield per plant (81.46), biological yield per plant (77.98), number of pods per plant (68.32), 100-seed weight (55.15), harvest index (52.85), number of branches per plant (41.50), linoleic acid (36.96), oleic acid (33.77), protein content (28.94) and shelling per cent (21.25). Seed yield per plant (81.46) followed by biological yield per plant (77.98), number pods per plant (68.32) and harvest index (52.85). This result also supported by Wadikar *et al.* (2018) for number of branches per plant,

100-seed weight, number of pods per plant and seed yield per plant. Similar findings by John *et al.* (2007), Nazzar *et al.* (2000) for number of pods per plant, Ramana *et al.* (2015) for harvest index and seed yield per plant and Mahalakshmi *et al.* (2005) for shelling per cent.

The estimates of genetic advance as per cent of mean were moderate for the character protein content (13.05) followed by palmitic acid (12.16) and number of seeds per pod (12.07). Similar results reported by Wadikar *et al.* (2018) for number of seed per pod. It was low for days to 50% flowering (9.46), oil content (7.88) and days to maturity (1.80), this result relevance Yadlapalli (2014) for days to 50% flowering, Noubissie *et al.* (2012), Cholin *et al.* (2010) and John *et al.* (2011) for oil content. Wadikar *et al.* (2018) for days to maturity and oil per cent.

High estimates of coefficient of variation along with high heritability and genetic advance as per cent over mean for number of pods per plant, 100-seed weight, biological yield per plant, seed yield per plant and harvest index are indicated of additive gene action for these four characters which are amenable in population improvement programme in groundnut.

## **HERITABILITY AND GENETIC ADVANCE**

Heritability in broad sense being the ratio of genotypic variability to the phenotypic variability indicates heritable component thus, it aids in estimating the extent of variation due to genetic and non- genetic factors. High heritability in broad sense does not always better response to selection, since it is also an inclusive of non-additive genetic factors. Thus, estimation of genetic advance furnishes clue to the nature of gene effects and its response to selection can be easily predicted.

The high genetic advance coupled with high heritability was observed for the characters 100-seed weight and biological yield per

plant suggested the importance of additive genetic variance and improvement of these characters could be made by simple phenotypic selection. These results were also in agreement with the findings of Kavera *et al.* (2008), Rao *et al.* (2012), Zaman *et al.* (2011) and Wadikar *et al.* (2018) for 100-seed weight in groundnut.

In contrast, a low magnitude of variation (PCV, GCV) with moderate heritability and lower genetic advance for days to maturity as well as palmitic acid. It indicated more influence of non-additive gene effects, so direct selection for these traits will be less effective. In such a case, recurrent selection and di-allele selective mating design may be followed.

The results of the present study clearly indicated that a significant amount of variability was present in the genotypes.

## **5.2 CORRELATION COEFFICIENT**

As discussed earlier success of any breeding programme depends upon the efficiency of the selection. Correlation provides information about the degree and direction of association between two characters. The magnitude and direction of correlation help in judging, how, improvement of one character will cause simultaneous changes in another character. Correlation coefficients among different characters, including seed yield were calculated at phenotypic as well as genotypic level. The knowledge of character association is imperative, as it facilitates quick assessment of high yielding genotypes in the selection programme in addition to the available information on variability and heritability exhibited within the material. Hence, the study of correlation is needed to measure the association between seed yield and yield contributing characters pod per plant which helps in identification of the important characters to be considered as a selection criterion in a breeding programme.

Hence, under the present investigation the phenotypic and genotypic correlation coefficients were worked out for seed yield per plant and other characters. In the present study, the analysis of genotypic and phenotypic correlation coefficients among seed yield and other characters revealed that the phenotypic correlation coefficient were higher than genotypic ones. It showed the strong inherent relationship for two correlated characters in genotypes which act as masking effect of environment in modifying the total expression of the genotypes.

Seed yield per plant showed significant and positive correlation with days to 50% flowering, number of branches per plant, number of pods per plant, 100-seed weight, biological yield per plant, harvest index. Similar results have been reported by Mahalakshmi *et al.* (2005) for number of pods per plant, 100-seed weight, harvest index and biological yield per plant, Wadikar *et al.* (2018) for days to 50% flowering and Gupta *et al.* (2015) for biological yield per plant and harvest index.

Day to 50% flowering exhibited positive significant association with days to maturity and biological yield per plant, these results are in accordance with Suneetha *et al.* (2004) for days to maturity and biological yield per plant. The number of branches per plant showed a significant positive association with number of pods per plant, 100-seed weight and biological yield per plant. Similar results were found by Hampannavar *et al.* (2018) for biological yield per plant.

Number of pods per plant exhibited a positive and significant correlation with 100-seed weight, biological yield per plant, harvest index, oleic acid and stearic acid. Earlier worker also reported Yaddapali (2014) for biological yield per plant, Yaddapali (2014) and Wadikar (2018) for harvest index, Khate (2014) and Yaddapali (2014) for stearic acid. Number of seeds per pod positively and significantly associated with shelling per cent and oleic acid. Number seeds per pod

showed significant negative association with biological yield per plant and linoleic acid.

The 100-seed weight exhibited significant association in a positive direction with biological yield per plant, harvest index and linoleic acid. Similar finding was reported by Rao *et al.* (2012) and Wadikar (2018) for harvest index. Harvest index showed positive and significant correlation with oleic acid. Linoleic acid positively and significantly associated with oil content, palmitic acid and stearic acid. Similar finding was reported by Raheja *et al.* (1987) and Kavera (2008). Oil content showed a significant positive association with linoleic acid and stearic acid. Similar finding was reported by Emeirglu and Mortuary (1984) for stearic acid.

### **5.3 PATH COEFFICIENT ANALYSIS**

The correlation analysis does not provide a clear picture of interrelationship of different characters influencing seed yield. The expression of a complex character like seed yield depends upon the interplay of a number of component characters. According to Falconer (1981), it is often assumed that association between two characters is an evidence of pleiotropy rather than linkage hence under such complex situations; path coefficient analysis is a powerful tool for analyzing character association. Thus, Path analysis was carried out by taking seed yield as the dependent variable to partition the correlation coefficient into the measures of direct and indirect effects in order to determine the contribution of different characters towards seed yield. The path coefficient analysis has been discussed here in view of the available literature.

Direct and positive effect on seed yield per plant was observed by different characters viz. harvest index, linoleic acid, number pods per plant, number of seeds per pod, days to 50% flowering, biological yield per plant, linoleic acid and 100-seed weight. Hence, a direct selection should be followed for these traits to improve the seed yield.

Similar results were reported earlier by Rathod *et al.* (2015), Vaddoria and Patel (1992) for number of pods per plant, Babariya & Dobariya (2012) and Korat *et al.* (2010) for biological yield per plant and harvest index, Rao *et al.* (2012) for 100-seed weight, Singh & Singh (2001) for 100-seed weight and harvest index.

Negative direct effects on seed yield were also exhibited by some characters *viz.* number of branches per plant, shelling per cent, stearic acid, oil content, oleic acid, palmitic acid, protein content and days to maturity. Similar findings were also reported by Rathod *et al.* (2015) for shelling per cent, stearic acid and days to maturity. Patil *et al.* (2015), Nandini and Savithamma (2012), Lakshmiddevamma *et al.* (2004) and Kahate *et al.* (2014) for shelling per cent and Bhakal and Lal (2018) for days to maturity and number of branches per plant.

Positive association and negative direct effects on seed yield were also exhibited by some characters *viz.* number of branches per plant, shelling per cent, protein content and stearic acid. Similar results were reported by Shobha *et al.* (2012) and Dhakar *et al.* (2017) for number of branches per plant, Rao (2016) for shelling per cent. Negative association and positive direct effects on seed yield were also exhibited by some characters *viz.* number of seeds per pod and harvest index.

The residual effect observed in path analysis was low, indicating that the characters included in the present study were able to explain the most effects on seed yield.

Thus, from the above results it becomes clear that direct selection based on days to 50 % flowering, number of pods per plant, 100-seed weight, biological yield per plant and linoleic acid, which can help in the improvement of seed yield in groundnut. Positive association and negative direct effects on seed yield were also exhibited by some characters *viz.* number of branch per plant, shelling per cent, protein per cent and stearic acid, hence considered in simultaneous selection.

## Chapter-6

### SUMMARY AND CONCLUSION

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The present investigation entitled “**Genetic Variability and Character Association Study for Yield and Quality traits in Groundnut (*Arachis hypogea* L.)**” carried out during Kharif-2017 at Research Farm, Agriculture Research Station, Bikaner to study the variability and character association for yield and quality characters viz. oil content, protein content and oil quality in groundnut. A total of 100 genotypes were evaluated in randomized block design with three replications. In the experiment twelve quantitative morphological and four oil quality characters were assessed and the data recorded were analyzed with appropriate statistical methods.

**The major findings of the present investigation are as follows:**

1. Analysis of variance indicated that sufficient amount of genetic variability was present among the genotypes for all the characters under study.
2. Phenotypic coefficient of variation was higher in magnitude than the genotypic coefficient of variation in respect of all the characters including oil quality parameters. For the characters, number of branches per plant, number of pods per plant, 100-seed weight, biological yield per plant, seed yield per plant and harvest index recorded high GCV and PCV, whereas, for shelling per cent, linoleic acid, oleic acid and stearic acid recorded moderate GCV and PCV. On the other hand days for 50% flowering, days to maturity, protein content, oil content and palmitic acid recorded low GCV and PCV.
3. Heritability in broad sense and genetic advance as per cent of mean were higher for number of branches per plant, number of pods per plant, shelling per cent, 100-seed weight, biological yield per plant, seed yield per plant, harvest index, linoleic acid, oleic acid

and stearic acid, which indicating that simple selection scheme would be effective for these characters to bring genetic improvement in desired direction. Moderate heritability in broad sense coupled with low genetic advance as per cent of mean was observed for days to maturity.

4. Heritability in broad sense was high but genetic advance as per cent of mean moderate for protein content. This indicates that the characters under additive genetic control and selection for genetic improvement will be worthwhile. Moderate heritability and genetic advance as per cent of mean for palmitic acid.
5. Six characters, days to 50 % flowering, number of branches per plant, number of pods per plant, 100-seed weight, biological yield per plant and harvest index had positive and significant correlation with seed yield per plant. Strong association of these characters with seed yield per plant revealed that selection for these characters would ultimately improve the seed yield.
6. Oleic acid was positively correlated with seed yield per plant, while linoleic acid was correlated negatively with seed. The quality of oil depends on the O/L ratio; the O/L ratio had significant positive correlation with oleic acid and significant negative correlation with linoleic acid. Therefore, selection of genotypes for oil quality with high oleic acid content and low linoleic acid is possible to achieve genetic improvement for oil quality.
7. Superior genotypes GG-20, HNG-169 and K-7 for 100-seed weight; ICMS-12, ICMS-20 and ICMS-3 for seed yield per plant; ICMS-13, KH and ICMS-114 for oil content, Local line-10, GG-21 and ICGV-15017 for oleic acid were identified.
8. The results of path coefficient analysis revealed that the characters, days to 50% flowering, number pods per plant, number of seeds per pod, 100-seed weight, biological yield per plant, harvest index and linoleic acid had direct positive effect with seed yield per plant. Whereas days to maturity, number of branches per plant, shelling

per cent, oil content and fatty acids had direct negative effect with seed yield per plant.

9. The magnitude of residual effects was low which indicated that major portion of contribution towards seed yield may be explained on the basis of characters included in the study.

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**Genetic Variability and Character Association Study  
for Yield and Quality Traits in Groundnut  
(*Arachis hypogea* L.)**

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**ABSTRACT**

The present investigation was carried out to estimate genetic variability, heritability, genetic advance, correlation, and path analysis for yield and quality traits in groundnut (*Arachis hypogea* L.). These genotypes were evaluated in random block design during *kharif* 2017 at ARS, Bikaner. Among all the characters, high GCV and PCV were observed for number of branches per plant, number of pods per plant, 100-seed weight, biological yield per plant, seed yield per plant and harvest index. Aggregately high PCV, GCV, heritability and genetic advance as percent of mean found for number of branches per plant, number of pod yield per plant (g), 100-seed weight (g), biological yield per plant (g), seed yield per plant (g) and harvest index (%). Therefore, a selection of these characters would also be effective.

The result from character association indicated that seed yield per plant (g) was a positive significant correlated with days to 50 % flowering, number of branches per plant, number of pods per plant, 100-seed weight, biological yield per plant and harvest index (%). Path co-efficient analysis revealed high direct effects of days to 50% flowering, number of pods per plant, number of seeds per pod, 100-seed weight, biological yield per plant, harvest index (%) and linoeic acid (%) on seed yield per plant. Hence, it would be rewarding to give due importance to the selection of these characters for rapid improvement of seed yield in groundnut.

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# मूँगफली (अरेचिस हाइपोजिया एल.) में उपज एवं गुणवत्ता सम्बन्धी लक्षणों के लिए आनुवांशिक विविधता और सहसम्बन्ध का अध्ययन

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(मुख्य सलाहकार)

## अनुक्षेपण

वर्तमान अनुसंधान कार्य मूँगफली (अरेचिस हाइपोजिया एल.) में आनुवांशिक विविधता, आनुवांशिकता, आनुवांशिक अग्रिम, लक्षण सहसम्बन्धता एवम् पथ विश्लेषण उपज और गुणवत्ता सम्बन्धी लक्षणों का आंकलन करने के लिए किया गया। इन जीनप्ररूपों को कृषि अनुसंधान केन्द्र, बीकानेर में खरीफ ऋतु, 2017 के दौरान यादृच्छिक ब्लॉक अभिकल्पना में उगाया गया। प्रति पौधा बीज उपज, प्रति पौधा शाखाओं की संख्या, 100 बीजों का वजन, प्रति पौधा फलियों की संख्या, प्रति पौधा जैविक उपज और फसल सूचकांक ने उच्च स्तरीय प्ररूपी विभिन्नता गुणांक और आनुवांशिक विभिन्नता गुणांक दर्शाया। सम्पूर्ण रूप से उच्च आनुवांशिक विभिन्नता गुणांक, प्ररूपी विभिन्नता गुणांक, उच्चस्तरीय वंशानुगति व उच्च आनुवांशिक लाभ मान प्रति पौधा शाखाओं की संख्या, 100 बीजों का वजन, प्रति पौधा फली उपज, प्रति पौधा बीज उपज, प्रति पौधा जैविक उपज और फसल सूचकांक के लिए प्राप्त हुआ। अतः इन लक्षणों का चयन प्रभावी हो सकता है।

लक्षण साहचर्यता से ज्ञात हुआ कि प्रति पौधा दाना उपज 50 प्रतिशत पुष्पीकरण के दिन, प्रति पौधा शाखाओं की संख्या, प्रति पौधा फली उपज, प्रति पौधा बीजों की संख्या, 100 बीजों का वजन, प्रति पौधा जैविक उपज और फसल सूचकांक के साथ प्रबल धनात्मक साहचर्यता में था। पथ गुणांक से ज्ञात हुआ कि प्रति पौधा फली उपज मुख्यतया 50 प्रतिशत पुष्पीकरण के दिन, प्रति पौधा फलियों की संख्या, प्रति फली बीजों की संख्या, फसल सूचकांक और लिनोइक अम्ल से प्रत्यक्ष रूप से प्रभावित थी। इसलिए मूँगफली की बीज उपज में तेजी से सुधार के लिए इन लक्षणों के चयन पर उचित महत्व देना फायदेमंद होगा।

\*स्नाकोत्तर छात्र, पादप प्रजनन एवं आनुवंशिकी विभाग, कृषि महाविद्यालय, स्वामी केशवानन्द राजस्थान कृषि विश्वविद्यालय, बीकानेर।

\*\*पादप प्रजनन एवं आनुवंशिकी में स्नातकोत्तर (कृषि) की आंशिक आवश्यकता की पूर्ति के संदर्भ में प्रस्तुत शोध ग्रन्थ डा. एम. एम. शर्मा प्राध्यापक कृषि अनुसंधान केन्द्र, स्वामी केशवानन्द राजस्थान कृषि विश्वविद्यालय, बीकानेर, के निर्देशन में।

## Appendix – I

Meteorological observation (weekly mean) of *kharif*, 2017

Standard Week	Temperature (°C)		R.H. (%)		Total Rainfall (mm.)	No. of Rainy days**	Wind Velocity (km./hr.)	Evaporation (mm/day)	BSSH
	Max.	Min.	Max.	Min.					
26	37.6	27.3	78.4	49	44.2	2	5.9	7.1	8.6
27	38.6	28.1	71.6	42.6	0	0	10.8	10.3	10.1
28	38.6	28.1	73.7	43.4	0	0	10.7	9.1	9.3
29	38.6	27	82.6	48.4	11.7	2	4.6	6.9	7.4
30	38.5	27.7	83.1	49.6	15.8	1	6.4	8.6	9.4
31	36	26.3	84.3	53.9	0	0	11.6	6.3	5.8
32	37.5	27.8	70.9	45.1	4.4	1	11.2	7.9	6.3
33	38.6	26.6	72.1	36.1	0	0	12	8.9	10
34	38.6	26.4	73	52	59.8	2	6.6	9.7	8.5
35	34	25.5	85.9	60.7	26.4	1	6.6	4.6	5.7
36	36.5	25.4	78.1	46.3	2	0	7.4	6.3	8.2
37	37.6	24.8	77.7	42.3	4	0	4.6	6.4	9
38	40.1	22.3	65.9	23.6	0	0	3.4	6.6	8.3
39	39.3	23.5	61.4	24.4	0	0	6.5	8	9.7
40	39.4	21	53.4	20.4	0	0	4.8	7.1	9.9
41	39.8	19.9	51.6	16.7	0	0	3.7	6.3	9.6
42	40.2	16.8	44.7	23.4	0	0	3.3	6.9	10.3
43	36.8	16.9	47.1	21.9	0	0	3.4	5.1	9.8
44	35.6	15.4	51	20.9	0	0	3.3	5.4	9.5
45	33.4	13.6	78.1	24	0	0	2.3	4	8.4
average	37.8	23.5	69.2	37.2	8.4	0.5	6.5	7.1	8.7

## Appendix-II

### Mean values of different characters in groundnut

S. No.	Genotype	Days to 50 % flowering	Days to maturity	No. of branches /plant	No. of pods /plant	No. of Seeds /pod	Shelling %	100- seed weight (g)	Bio. yield /plant (g)	Seed yield /plant (g)	Harvest index (%)	Linoleic acid (%)	Oil (%)	Oleic acid (%)	Palmitic acid (%)	Protein (%)	Stearic acid (%)
1	1	31.67	133.33	5.66	21.20	1.73	59.44	54.92	59.13	21.35	30.97	33.62	49.08	40.86	10.16	28.37	2.00
2	2	34.67	130.33	4.50	22.94	1.47	56.81	73.18	97.80	25.57	24.99	31.26	46.80	44.44	10.69	25.95	3.09
3	3	32.00	130.33	6.43	27.86	1.80	47.62	58.41	81.66	7.46	10.66	27.55	51.56	44.40	11.33	22.32	2.32
4	4	34.33	134.33	5.76	24.03	1.57	55.84	47.89	66.79	21.62	21.35	38.59	50.11	37.18	10.31	24.04	2.02
5	5	30.33	132.67	7.01	26.20	1.77	54.19	60.09	77.51	21.19	22.48	29.08	43.86	44.82	9.68	26.78	2.22
6	6	35.00	131.33	5.41	22.80	1.63	64.05	55.31	57.48	21.83	32.46	32.73	47.68	37.65	11.02	24.76	3.16
7	7	32.33	133.67	8.72	21.84	1.33	53.37	64.56	101.96	20.25	19.01	38.17	50.84	37.28	10.70	22.86	2.16
8	8a	31.67	134.00	5.72	11.10	1.97	69.05	38.18	40.52	9.60	19.13	32.17	49.12	43.57	11.25	24.16	3.12
9	8b	37.67	129.00	8.97	22.68	1.93	58.99	53.44	70.86	22.13	27.85	32.07	46.20	42.49	9.45	23.68	2.15
10	9a	33.67	130.33	5.78	19.50	1.50	54.74	28.26	51.70	12.30	15.43	30.92	44.18	36.06	11.54	26.31	1.71
11	9b	32.33	132.33	7.51	23.04	1.57	42.63	48.97	64.14	8.30	12.66	34.17	52.02	40.63	10.08	22.88	2.21
12	10	34.67	129.33	6.20	34.19	1.47	59.75	31.03	128.18	17.02	12.55	15.63	49.85	64.56	7.96	27.81	2.32
13	11	34.33	132.33	5.58	12.77	1.37	64.20	41.56	44.04	13.79	21.05	37.12	48.24	32.23	10.33	25.32	2.29
14	12a	34.33	132.33	6.97	11.62	1.73	63.30	43.11	39.17	12.15	23.30	32.65	48.98	41.41	10.93	21.93	2.15
15	12b	38.00	132.33	6.35	28.75	1.63	60.29	48.87	97.80	24.38	21.51	32.66	49.28	40.15	10.24	25.52	2.23
16	13	36.33	133.00	6.50	19.18	1.50	65.28	51.15	49.11	14.71	24.41	32.33	48.57	40.17	11.05	22.07	2.17
17	14	36.33	133.00	5.03	16.39	1.70	62.34	29.67	23.81	8.86	23.75	33.82	47.61	41.00	11.20	23.94	1.58
18	15a	35.00	134.33	6.63	33.42	1.80	64.41	53.54	79.29	25.76	28.19	32.77	49.47	39.49	11.19	23.22	2.09
19	15b	39.00	131.33	5.47	20.90	1.50	62.37	48.47	61.67	20.75	24.74	30.60	46.22	43.52	10.48	24.94	1.93
20	16	34.00	132.33	9.38	41.08	1.40	64.84	43.83	109.04	29.80	24.87	47.47	50.31	29.28	11.48	25.97	2.24
21	17	32.33	130.33	4.51	15.46	1.40	65.50	48.23	30.64	11.35	22.18	32.87	49.42	37.56	11.40	23.59	2.17
22	18	32.00	132.00	8.27	23.26	1.70	56.91	82.63	95.24	24.77	22.55	33.14	43.41	39.78	9.61	22.34	2.24

23	19	32.67	131.00	5.51	19.31	2.03	63.25	45.78	51.44	16.16	22.06	22.14	49.40	53.57	9.19	24.67	2.12
24	20a	33.67	130.00	7.76	17.26	1.87	50.21	63.60	78.87	15.07	17.33	37.38	44.01	34.85	10.82	24.49	2.17
25	20b	33.00	134.67	7.92	34.17	1.43	55.44	51.87	99.47	26.90	24.14	35.48	49.93	39.76	10.86	21.85	2.35
26	21a	34.00	130.33	8.73	20.56	1.27	53.72	75.18	97.66	21.29	20.22	39.39	43.73	35.85	11.40	25.90	2.26
27	21b	30.00	130.00	5.16	36.29	1.73	61.08	41.15	61.78	25.83	41.11	29.44	51.26	48.16	10.01	24.17	2.39
28	22	34.00	132.00	6.84	25.92	1.70	64.52	50.02	87.79	26.72	25.87	28.59	48.96	45.78	9.36	23.32	2.04
29	23a	35.00	132.00	5.58	21.85	1.60	59.57	46.35	61.87	21.55	26.66	36.62	50.44	38.04	12.60	24.69	2.13
30	23b	32.00	132.67	6.55	38.15	1.83	59.81	41.39	105.47	26.78	20.52	34.02	50.56	38.81	10.55	26.31	2.61
31	24	32.33	130.33	5.66	19.44	1.60	62.48	46.76	47.52	15.19	24.82	37.42	47.56	39.51	11.29	20.95	2.11
32	25	31.67	134.33	7.39	19.26	2.13	52.54	37.49	48.78	12.44	22.52	30.21	45.77	42.35	12.01	23.57	2.09
33	26	31.00	131.00	4.71	23.23	1.80	65.49	48.28	70.78	22.02	22.60	31.28	49.55	46.12	8.82	22.64	2.30
34	27	36.00	131.33	8.50	19.73	2.03	60.47	67.07	100.3	15.15	15.74	41.05	49.19	31.44	10.57	24.82	2.26
35	CSMG-2003	32.33	130.00	7.68	32.46	1.77	51.36	68.36	95.23	27.97	26.24	32.79	52.13	41.42	10.47	22.18	2.98
36	GIRNAR-3	39.00	136.33	6.94	33.77	1.67	62.66	55.52	82.87	26.71	27.78	28.39	49.63	43.71	10.49	23.21	2.09
37	RS-578	38.33	135.00	6.56	18.95	1.43	49.92	55.66	46.11	15.41	21.93	25.88	49.90	48.40	8.92	24.08	2.20
38	HPS-1	38.33	136.33	8.47	32.17	1.53	50.07	66.80	140.15	27.47	20.53	31.17	51.60	44.14	9.85	22.38	2.31
39	UTRAKASH	33.00	129.67	9.02	36.56	1.77	47.63	61.65	116.34	28.32	21.08	37.84	49.13	40.30	10.23	22.67	2.26
40	RG-559	37.33	133.67	7.03	48.00	1.57	42.74	71.71	122.91	29.26	23.24	28.75	49.43	49.34	10.48	23.08	2.45
41	GG-16	35.00	130.00	7.69	35.18	1.63	57.52	52.15	109.26	25.05	21.00	38.49	50.63	35.72	9.72	24.66	3.08
42	GG-21	33.67	131.33	7.78	52.55	1.70	60.88	47.31	88.48	31.65	31.63	21.52	48.31	59.33	8.99	25.60	2.10
43	GG-20	34.00	129.67	9.39	58.43	1.53	55.56	66.00	171.76	50.52	26.49	35.72	51.96	40.78	9.92	22.87	2.29
44	MALLIKA	34.00	134.33	7.54	25.95	1.47	44.04	65.30	117.47	22.54	18.70	31.63	49.43	44.36	9.40	23.57	2.14
45	ISL-16	36.33	134.33	7.34	36.50	1.60	51.67	67.89	152.09	32.96	22.88	33.01	44.99	40.32	10.56	24.76	2.20
46	GJG-18	34.67	134.00	13.75	41.35	1.50	49.63	53.65	177.62	29.05	20.81	38.67	46.70	35.97	11.23	22.52	2.13
47	HNG-69	35.67	132.00	12.13	30.19	1.37	41.63	80.97	158.12	22.85	12.93	33.63	48.48	40.08	9.57	26.75	2.29
48	K-H	34.33	131.67	4.98	21.90	1.57	53.68	54.19	71.31	18.54	22.79	49.88	54.22	30.10	12.04	22.96	3.27
49	K-8	34.33	130.33	9.90	36.30	1.67	51.60	71.13	136.16	27.76	20.75	34.74	46.66	44.56	10.41	28.76	2.23
50	HNG-169	34.67	130.00	8.84	46.42	1.53	68.26	76.79	136.45	42.76	31.13	45.09	51.59	34.35	10.85	24.91	2.81

51	K-7	34.00	133.00	13.18	44.41	1.63	56.51	69.78	195.65	41.80	39.97	42.04	45.84	38.79	10.29	25.75	1.86
52	K-9	33.33	132.33	9.44	56.40	1.50	42.22	56.25	186.98	25.18	13.69	39.50	51.17	40.88	11.54	25.25	3.14
53	TG-37	29.00	131.33	9.31	41.25	1.53	46.76	72.78	121.54	28.48	23.08	39.90	51.47	38.32	11.37	25.28	2.33
54	K-6	34.33	131.33	7.91	39.93	1.40	57.35	47.07	142.56	19.11	19.65	41.91	48.28	34.48	11.41	29.38	2.16
55	HNG-123	36.33	133.33	7.57	26.29	1.60	55.57	65.96	89.38	25.55	24.33	47.10	53.46	31.16	14.82	24.08	1.65
56	HNG-10	32.00	132.00	6.47	24.81	1.53	53.97	55.20	73.32	15.09	19.02	35.91	48.22	38.83	10.59	24.71	2.20
57	ICMS-3	32.33	134.00	9.65	19.31	1.57	49.10	90.82	122.72	19.25	16.07	51.66	51.05	28.37	13.01	24.94	2.36
58	ICMS-4	31.33	132.33	10.06	21.44	1.50	52.25	70.31	128.16	23.70	19.97	38.43	48.36	46.07	9.70	22.30	3.08
59	ICMS-6	31.33	132.67	7.99	24.26	1.63	58.34	51.95	71.07	13.28	18.76	29.88	50.72	49.13	10.41	26.13	3.17
60	ICMS-10	31.67	132.00	7.40	30.08	1.77	52.01	52.00	100.62	20.38	18.92	42.54	48.55	32.47	11.67	28.83	2.08
61	ICMS-12	33.00	133.67	6.62	17.16	1.80	56.89	96.25	104.09	18.43	18.78	40.29	50.64	38.54	12.08	27.21	2.25
62	ICMS-13	32.33	134.00	6.49	28.28	1.37	37.80	48.96	58.73	4.84	9.69	49.15	54.30	30.45	11.69	29.06	3.76
63	ICMS-16	33.33	130.33	6.32	24.15	1.33	56.63	84.92	99.53	28.26	27.93	45.09	51.28	32.53	11.42	19.92	2.31
64	ICMS-17	32.33	133.67	6.51	17.01	1.63	50.20	78.56	71.50	16.18	21.67	40.15	49.61	38.69	12.37	26.15	2.04
65	ICMS-20	32.00	132.00	7.53	29.87	1.43	59.98	91.44	140.37	41.66	25.56	42.87	54.03	35.32	10.23	23.37	2.79
66	ICMS-25	35.33	133.33	6.67	32.12	1.24	62.58	61.66	99.08	27.09	24.00	36.31	50.78	45.70	9.24	22.88	3.19
67	ICMS-26	34.67	130.00	8.41	31.07	1.46	60.26	87.81	130.87	22.44	18.90	32.84	49.50	40.83	10.72	26.18	2.27
68	ICMS-28	34.00	131.67	7.09	22.39	1.60	61.12	52.90	73.04	15.05	18.21	40.05	50.83	41.23	9.44	25.49	2.80
69	ICMS-32	35.00	131.67	6.88	23.02	1.73	60.15	43.96	121.77	9.95	9.88	47.14	50.64	31.69	11.45	25.91	2.46
70	ICMS-33	32.00	130.67	8.27	28.46	1.90	62.71	48.60	69.45	16.99	20.94	47.47	50.83	29.36	11.74	25.68	2.62
71	ICMS-36	33.67	135.33	5.70	28.65	1.63	60.44	40.11	72.70	15.80	18.66	48.83	50.19	30.34	12.25	27.01	2.53
72	ICMS-37	31.67	131.00	6.17	21.77	1.97	63.97	36.49	73.94	7.59	10.25	33.78	52.35	48.59	8.07	23.40	3.24
73	ICMS-43	30.33	130.33	6.47	25.19	1.58	64.93	59.85	64.09	21.68	25.20	40.26	53.16	40.22	10.54	20.85	2.30
74	ICMS-50	34.00	132.67	7.82	20.40	1.50	59.78	31.44	51.98	14.65	24.33	47.05	49.61	33.88	10.91	25.58	2.78
75	ICMS-58	33.33	132.33	7.49	29.12	1.53	58.57	54.10	86.59	12.53	15.10	48.20	49.58	30.59	11.57	25.99	2.26
76	ICMS-59	33.67	132.67	6.53	38.34	1.43	56.63	59.85	130.66	13.30	10.51	35.60	51.50	46.37	10.37	26.23	3.06
77	ICMS-71	34.00	132.67	6.37	25.46	1.90	61.75	43.09	80.15	21.79	21.00	40.80	51.82	37.53	10.29	24.75	2.55

78	ICMS-79	35.00	129.00	8.44	34.17	1.80	55.12	60.78	99.92	17.43	13.80	48.69	49.34	30.56	11.56	25.39	2.80
79	ICMS-81	35.33	131.67	8.59	39.78	1.53	54.11	90.06	126.95	40.69	22.17	39.79	48.97	41.95	10.71	24.79	2.08
80	ICMS-82	33.00	132.67	6.79	50.11	1.87	60.21	62.54	131.51	36.86	30.14	41.32	50.64	41.67	10.58	22.05	3.88
81	ICMS-83	34.67	133.33	5.78	21.60	1.30	57.49	49.52	91.17	14.48	16.08	51.28	51.07	29.34	10.92	24.96	2.56
82	ICMS-88	33.67	131.33	5.62	22.25	1.33	60.83	43.75	86.10	24.83	24.37	49.43	51.59	31.06	10.78	22.55	2.69
83	ICMS-89	34.00	132.00	4.51	22.59	1.43	64.66	54.87	42.99	14.47	27.63	46.91	52.83	36.87	10.60	23.09	2.83
84	ICMS-90	34.00	135.00	7.07	12.80	1.47	52.24	86.65	72.30	10.72	15.06	46.91	51.05	31.94	10.87	22.29	1.99
85	ICMS-91	32.00	133.00	7.46	23.41	1.37	53.16	42.81	81.35	12.07	12.39	42.25	48.72	40.46	10.82	22.52	1.98
86	ICMS-97	33.33	131.67	8.63	27.05	1.83	61.41	60.75	104.63	25.49	21.22	42.47	51.69	40.10	10.53	23.19	2.26
87	ICMS-100	32.00	130.00	6.65	24.55	1.63	55.09	70.31	87.65	20.79	22.34	41.21	47.96	36.38	11.02	30.06	2.73
88	ICMS-101	33.00	129.67	6.66	38.70	1.27	58.30	59.73	127.64	24.02	19.80	42.15	51.58	38.68	10.82	25.00	2.35
89	ICMS-104	31.33	132.67	6.05	22.58	1.50	62.02	52.38	81.43	15.36	19.78	48.99	48.84	31.88	11.27	25.23	2.03
90	ICMS-105	35.33	132.67	6.10	13.60	1.57	64.43	58.71	51.80	10.62	14.31	49.43	49.98	31.88	10.62	23.51	2.18
91	ICMS-114	35.00	134.00	6.88	22.26	1.57	58.56	44.01	52.01	15.15	30.63	39.68	54.00	46.87	10.27	25.85	3.84
92	ICMS-117	35.33	136.00	7.33	24.26	1.50	56.93	87.27	130.72	38.44	28.52	39.41	51.43	41.20	11.43	24.83	3.18
93	ICMS-124	35.00	134.67	6.43	32.43	1.80	60.86	51.26	82.12	22.31	25.89	39.21	51.99	40.64	8.89	28.57	2.50
94	ICMS-142	32.00	134.00	6.73	30.73	1.30	61.04	46.36	75.24	16.78	21.17	37.46	49.48	43.80	8.22	22.44	2.90
95	ICMS-144	35.00	135.67	6.84	25.37	1.87	62.85	42.61	77.74	8.94	11.14	49.45	50.94	32.00	11.53	24.52	2.02
96	ICMS-149	32.00	135.33	6.18	29.36	1.43	55.74	37.39	52.03	9.33	12.12	44.77	50.22	32.24	11.42	26.08	2.39
97	ICGV 00350	34.33	134.33	8.28	29.64	1.77	53.89	33.34	93.23	17.07	13.90	36.10	46.84	47.26	9.82	21.95	2.94
98	ICGV 06420	35.33	133.67	8.09	25.55	1.23	41.19	37.90	116.29	14.04	11.72	39.73	52.28	49.00	11.42	24.74	2.39
99	ICGV 15017	31.33	129.67	6.92	26.78	1.73	60.12	39.52	63.89	17.84	21.96	42.16	52.89	61.87	10.94	24.76	3.16
100	Local	32.00	131.67	6.57	26.14	1.30	54.09	44.67	88.60	18.21	19.53	33.06	44.85	40.94	11.52	24.07	2.18
	GM	33.82	132.29	7.23	27.78	1.60	56.96	56.45	91.39	20.85	21.29	37.88	49.72	39.75	10.68	24.56	2.44
	SEM	0.81	1.03	0.55	1.72	0.14	1.91	1.68	4.40	1.70	1.84	1.58	1.31	1.43	0.65	0.91	0.23
	CV%	4.17	1.35	13.06	10.70	15.21	5.80	5.16	8.34	14.13	14.96	7.24	4.57	6.24	10.58	6.39	16.33
	LSD	2.27	2.88	1.52	4.79	0.39	5.32	4.69	12.27	4.74	5.13	4.41	3.66	3.99	1.82	2.53	0.64



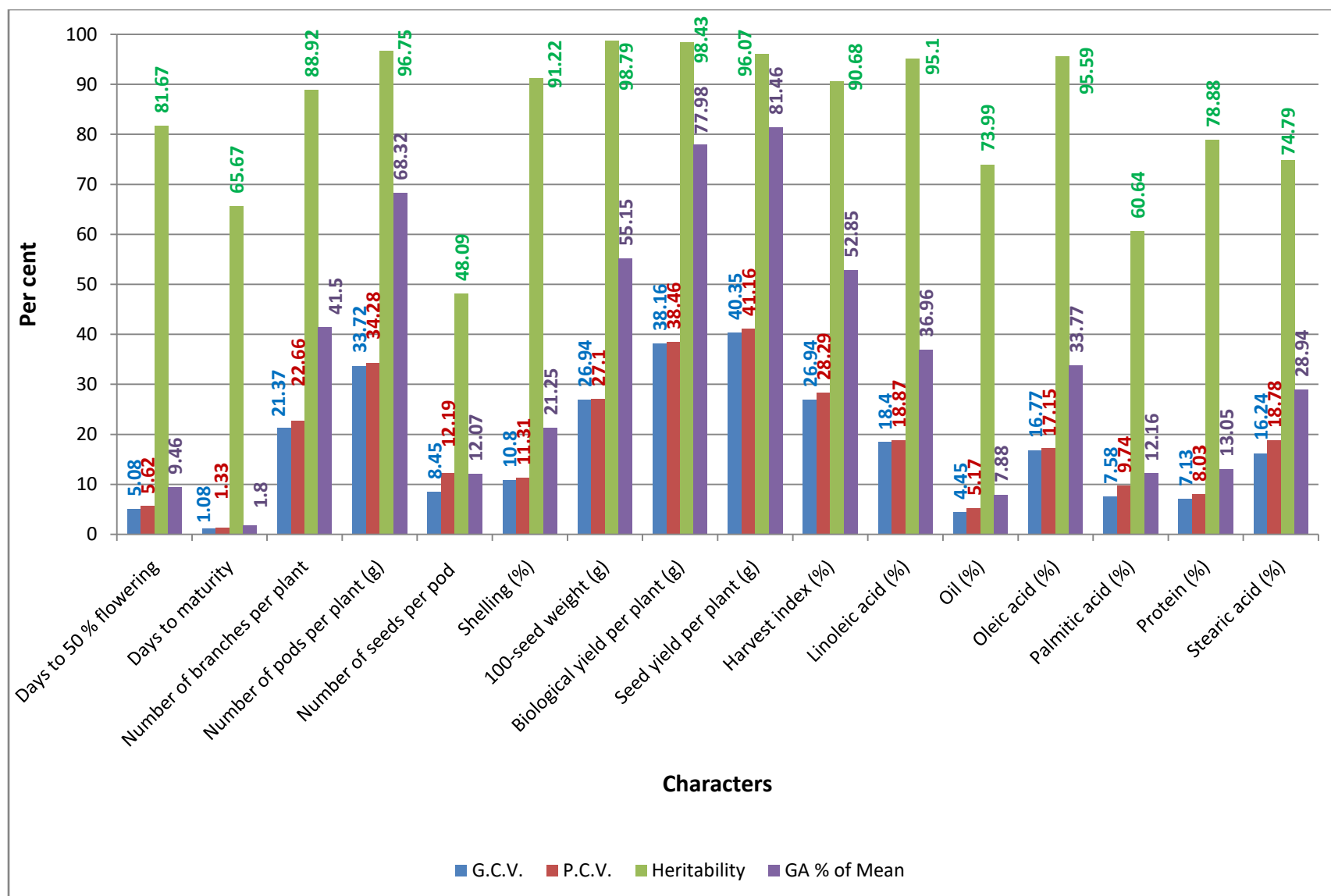


Fig 5.1: Estimation of parameters GCV, PCV,  $H^2$  and GAM variation for different character in groundnut