Character Association and Path Analysis in Groundnut (*Arachis hypogaea* L.)

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SURBHI JAIN

Thesis

Master of Science in Agriculture

(Plant Breeding and Genetics)

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DEPARTMENT OF PLANT BREEDING AND GENETICS
RAJASTHAN COLLEGE OF AGRICULTURE
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
UDAIPUR-313001 (RAJ.)

Maharana Pratap University of Agriculture and Technology
Rajasthan College of Agriculture
Udaipur

CERTIFICATE-I

Dated: / /2016

This is to certify that **Ms. Surbhi Jain** has successfully completed the Comprehensive Examination held on / /2016 as required under the regulation for the degree of **Master of Science in Agriculture**.

Head
Department of Plant Breeding and Genetics
Rajasthan College of Agriculture, Udaipur

Maharana Pratap University of Agriculture and Technology
Rajasthan College of Agriculture
Udaipur

CERTIFICATE-II

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This is to certify that the thesis entitled "**Character Association and Path Analysis in Groundnut (*Arachis hypogaea* L.)**" submitted for the degree of **Master of Science in Agriculture** in the subject of **Plant Breeding and Genetics,** embodies bonafide research work carried out by **Ms. Surbhi Jain** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on / /2016.

(Mr. P. P. Sharma)
Major Advisor

Head
Department of Plant Breeding and Genetics

(Dr. Anila Doshi)
Dean
Rajasthan College of Agriculture
Udaipur

Maharana Pratap University of Agriculture and Technology
Rajasthan College of Agriculture
Udaipur

CERTIFICATE-III

Dated: / /2016

This is to certify that the thesis entitled **"Character Association and Path Analysis in Groundnut (*Arachis hypogaea* L.)"** submitted by **Ms. Surbhi Jain** to the Maharana Pratap University of Agriculture and Technology, Udaipur in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture** in the subject of **Plant Breeding and Genetics** after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination on her thesis has been found satisfactory; we therefore, recommend that the thesis be approved.

(Mr. P. P. Sharma)
Major Advisor

(Dr. Hemlata Sharma)
Advisor

(Dr. M. K. Kaushik)
Advisor

(Dr. S. L. Mundra)
DRI Nominee

Head
Deptt. of Plant Breeding & Genetics

(Dr. Anila Doshi)

Dean

Rajasthan College of Agriculture

Udaipur

Approved

(Dr. R.A. Kaushik)
Director Resident Instructions
Maharana Pratap University of Agriculture and Technology, Udaipur

Maharana Pratap University of Agriculture and Technology
Rajasthan College of Agriculture
Udaipur

CERTIFICATE-IV

Dated: / /2016

This is to certify that **Ms. Surbhi Jain**, student of **Master of Science in Agriculture**, Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, Udaipur has made all the corrections / modifications in the thesis entitled **"Character Association and Path Analysis in Groundnut (*Arachis hypogaea* L.)"** which were suggested by the external examiner and the advisory committee in the oral examination held on / /2016. The final copies of the thesis duly bound and corrected were submitted on / /2016, are enclosed here with for approval.

(Mr. P. P. Sharma)
Major Advisor

Enclose: One original and three copies of bound thesis forwarded to the Director Resident Instructions, Maharana Pratap University of Agriculture and Technology, Udaipur through the Dean, Rajasthan College of Agriculture, Udaipur.

	(Dr. Anila Doshi)
Head	Dean
Department of Plant Breeding and Genetics	Rajasthan College of Agriculture
	Udaipur

ABSTRACT

Character Association and Path Analysis in Groundnut (*Arachis hypogaea* L.)

Surbhi Jain* (Research Scholar)

Mr. P. P. Sharma** (Major Advisor)

The present investigation entitled "Character Association and Path Analysis in Groundnut (*Arachis hypogaea* L.)" was conducted with 24 genotypes (including three checks namely UG-5 (Pratap Raj Mungphali), PM-2, GG-7) during *Kharif*- 2015 at the Instructional Farm, College of Technology and Engineering, Maharana Pratap University of Agricultural and Technology, Udaipur. The genotypes were planted in a randomized block design with three replications.

The observations were recorded for 12 characters viz., days to 50% flowering, days to maturity, plant height, number of pods per plant, dry pod yield per plant, kernel yield per plant, 100-kernel weight, sound mature kernel, shelling out turn, seed oil content, number of kernels per pod and weight of single pod on five randomly selected plants from each genotype in all the replications while days to 50% flowering and days to maturity which were recorded on plot basis and average value was subjected to analysis of variance, estimation of variability parameters, correlation and path coefficient.

The estimates of genotypic parameters revealed that differences between the estimates of GCV and PCV were found least for most of the characters. Higher estimates of GCV were observed for number of mature pods per plant. Maximum heritability was found for plant height. While, maximum genetic gain was observed for number of pods per plant followed by weight of single pod.

Association estimate revealed that dry pod yield per plant was positively correlated at both genotypic and phenotypic levels with kernel yield per plant , number of pods per plant, plant height, 100-kernel weight, sound mature kernels,

* Research Scholar, Department of Plant Breeding & Genetics, RCA, Udaipur

** Assoc. Prof., Department of Plant Breeding & Genetics, RCA, Udaipur

shelling percent and number of kernels per pod. Similarly, kernel yield per plant also showed positive correlation with dry pod yield, at both genotypic and phenotypic levels.

Present experimental findings revealed that characters, number of mature pods per plant and weight of single pod, showed high GCV, heritability and genetic gain. Hence, selection can be made for improvement of these characters.

Path coefficient analysis revealed maximum direct effect by kernel yield per plant (1.05) with dry pod yield per plant.

Such an association may used for more effective breeding programmes.

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1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.), the 'king' of oilseeds is commonly known as “peanut” or “monkey nut” or ‘wonder nut” or “poor man’s cashew nut”. It belongs to subfamily Papilionaceae of the family Fabaceae. It is a self-pollinated crop with basic chromosome number of 2n = 4x = 40 (Stebbins, 1957; Stalker and Dalmacio, 1986) and genome size 2800 Mb/lC (Guo *et al.* 2009). Peanut is grown for its high amount of edible oil (45-50%) and a reasonable amount of digestible protein (25-30%). It is the richest source of thiamine and also rich in niacin, which is low in cereals. Peanut is also valuable source of vitamins E, K and B (Encyclopaedia of Agricultural Science, 1994: Robertson, 2003).

Groundnut kernels are consumed as raw, boiled, roasted or fried products and also used in a variety of culinary preparations like peanut candies, butter, peanut milk and chocolates (Desai *et al.* 1999). Cake left after extraction of the oil is an excellent feed for livestock. Vegetative parts of groundnut like leaf and stem are also good source of nutritionally high quality fodder for farm animals.

Groundnut is believed to be originated from South America (Southern Bolivia/North West America region). Peanut is cultivated around the world in the tropical, sub-tropical and temperate climatic conditions between 40º South and 40º North of equator (Encyclopaedia of Agricultural Science, 1994). The crop is grown in more than 100 countries worldwide. The major groundnut producers are China, India, Nigeria, USA, Senegal, Myanmar, Indonesia and the Sudan (undivided). Groundnut is grown on nearly 20 million ha worldwide with an yield of 42316356 tonnes (FAOSTAT 2014). Developing countries account for over 97 per cent of world groundnut area and 95 per cent of total production.

India is the second largest groundnut producing nation in the world with an area of about 4.19 million hectare with a production and productivity of 6.68 million tones and 1591 kg/ha, respectively (Annual report of DGR Junagadh, 2015). Currently, six states viz., Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra and Rajasthan accounts for more than 90 per cent of the groundnut area and production of the country.

Under present scenario, the major area of groundnut in Rajasthan is represented by Chittorgarh, Bhilwara, Jaipur, Tonk, Sawai Madhopur, Dausa, Bikaner and Hanumangarh.

Cultivated groundnut belongs to the three sub-species, Valencia, Spanish and Virginia; the Virginia sub-species includes both bunch and runner types. Plant habit in groundnut varies from the compact bunch type with very little lateral spread to the spreading runner forms. Under better growing conditions the runner forms predominate. In India, the spreading virginia types are generally grown under rainfed conditions during kharif season while under irrigated winter or summer conditions, the spanish bunch types predominate. Some virginia bunch types are also grown during this season (Reddy et al., 1984). In Gujarat presently semi-spreading types also occupied large area during kharif season. But spanish bunch types are grown during summer season. Most of the characters of breeder's interest are complex and are the result of interaction of a number of components. Understanding the relationships among yield and yield components is of paramount importance for making the best use of these relationships in selection. The correlation coefficient may be confounded with indirect effect due to common association inherent in trait interrelationships. Therefore, information derived from the correlation coefficients can be augmented by partitioning correlations into direct and indirect effects by path coefficient analysis.

Yield is an important quantitative trait for any crop improvement programme. Genetic improvement for quantitative traits depends on the nature and amount of variability present in the genetic stock and the extent to which the desirable traits are heritable. Since, groundnut pods develop below the ground level hence, genotypes for yield cannot be screened or evaluated prior to harvest. Therefore, association studies are very important.

Groundnut (*Arachis hypogaea* L.) being one of the most important oilseed crops of India, still stands one of the lowest in terms of productivity. In groundnut, overall pod yield is constituted by different yield components which makes it a quantitatively inherited trait. Direct selection of pod yield would not be a reliable approach without giving due importance to its genetic nature, owing to its complex nature of inheritance. Information on the correlation co-efficients between the yield components and pod yield is a pre-requisite for crop improvement. Though the correlations give information about the component traits, they do not provide a true picture of relative importance of direct and indirect effects of these component traits on pod yield. Hence, the present study was carried out to obtain information on the magnitude of relationship of individual yield component traits on yield, interrelationships among themselves and to measure their relative importance.

Inheritance of quantitative traits is largely affected by the environmental factors. Therefore, selection made in field is not likely to be reliable.

Keeping in view the above facts, the present investigation was carried out to fulfil the present needs through the following objectives in ground nut (*Arachis hypogaea* L.):

- To estimate the nature and magnitude of variability with respect to yield and its component traits.
- To estimate genotypic and phenotypic correlations between different component traits.
- To determine the direct and indirect influences of various yield attributing characters through path coefficient analysis.

2. REVIEW OF LITERATURE

In the present investigation genetic variability, correlation and path coefficient studies carried out for yield and its component characters of selected genotypes in groundnut (*Arachis hypogaea* L.). The literature pertaining to objectives of this investigation have been reviewed briefly under the following sub-heads:

2.1 Variability parameters

2.2 Correlation coefficients & Path coefficient

2.1 VARIABILITY PARAMETERS

The existence of genetic variability is prerequisite for any crop improvement programme; however, degradation of locally adapted variable material has been rapid which, need to be maintained. The variability existing among homozygous genotypes/ population is generally considered as free variability, which can be exploited for genetic advancement through selection. This together with information on heritability and genetic advance would be rewarding in designing an effective breeding programme. The genetic variability is determined with the help of certain genetic parameters *viz.,* genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and heritability estimates.

Heritability is the heritable portion of phenotypic variance and it is a good index of extent of transmission of a character from parents to their off-springs. Heritability in broad sense is the ratio of genotypic variance to phenotypic variance. Its estimation is important because it determines the expressivity of genes being carried by a genotype. If the heritability of a character is high, the phenotypic value provides a fairly close measure of the genotypic value and thus breeder can base his selection on the phenotypic performance. Thereby the knowledge of heritability helps the plant breeder in pre-assessing the results of selection for a particular character. However, for predicting the effect of selection, heritability estimates along with genetic advance are more useful than the heritability estimates alone. The review of literature pertaining to variability parameters in groundnut is presented in the subsequent paragraphs.

Azad and Hamid (2000) observed very close estimation of GCV and PCV for all the characters under study except primary branches per plant. High values of GCV and PCV together with high heritability and genetic advance as per cent of mean were observed for plant height, pods number and kernel as well as pod yield.

Chishti *et al.* (2000) evaluated 16 early maturing genotypes of groundnut to estimate variability parameters. They observed significant variation for all the characters expect 100 kernel weight. The estimates of PCV were higher than those of GCV for all the characters except days taken to flowering and maturity; for these characters those were at par with high heritability estimates.

Ali *et al.* (2000) studied genetic variability, heritability, genetic advance and correlation coefficients with sixteen groundnut varieties, high values of GCV and PCV were observed for kernel weight, pod length and pod yield. High heritability coupled with high genetic advance as percent of mean was observed for kernel weight and pod length revealing an importance of additive gene effect for these traits and selection pressure on these attributes would be effective for their improvement.

Prakash *et al.* (2000) studied variability parameters in ninety one spreading groundnut cultivars and observed that genotypic coefficient of variation was the highest for pod yield per plant and it was the lowest for oil content. Heritability in broad sense was high for pod yield per plant, oil content and 100 kernel weight. High genetic advance as per cent of mean was observed for pod yield per plant, pods per plant and 100 kernels weight.

Venkatramana (2001) evaluated thirty groundnut genotypes including twenty spanish bunch and ten virginia bunch for genetic variability parameters and reported that estimates of PCV were higher than corresponding GCV for all the characters under study. However, both PCV and GCV estimates were high for 100 kernel weight and kernel yield as well as oil yield. Whereas, heritability in broad sense was high for oil content, 100 kernel weight and sound mature kernel percentage. Moderate heritability coupled with high genetic advance as per cent of mean was observed for kernel yield and oil yield. Additive gene effect could be preponded for 100 kernel weight as it had high heritability estimates along with high genetic advance.

Venkataramana *et al.* (2001) studied genetic variability in one hundred forty four groundnut germplasm lines. High genotypic and phenotypic coefficients of variation were observed for plant height, oil percentage, 100 kernel weight and kernel yield per plant. They noticed high heritability coupled with high genetic advance as per cent of mean for plant height, pod yield per plant, 100 kernel weight and oil percentage. They suggested that characters like pod yield per plant, 100 kernel weight, plant height and oil percentage would be improved effectively through simple selection.

Dashora and Nagda (2002) evaluated twenty two germplasm lines with one local check (TAG-24) to estimate variability parameters and revealed that dry pod yield, 100 kernel weight and kernel yield had high genetic advance, genetic gain and heritability estimates suggesting preponderance of additive gene effect. High heritability was accompanied with low genetic advance as percent of mean for days to 50% flowering, days to maturity, shelling percent, 100-kernel weight and oil content revealing preponderance of non-additive gene effect.

Nath and Alam (2002) evaluated fifteen exotic groundnut genotypes procured from ICRISAT along with a local check (Dhaka-1)and genetic variability parameters were studied for yield and yield contributing characters. The estimates of PCV were in accordance with those of GCV for days to flowering, plant height, pods per plant, 100 pod weight, shelling per cent and harvest index. However, heritability estimates were higher for all the characters studied and GA as per cent of mean was also high for all the characters except days to flowering. Therefore, direct selection would be effective for improvement of all the characters except days to flowering.

Prasad *et al.* (2002) evaluated thirty spanish bunch groundnut genotypes to estimate the variability parameters, they reported that PCV and GCV estimates were high for harvest index; while, magnitude of these parameters was moderate for pod yield per plant, primary branches per plant, height of main axis, pods per plant and 100 kernel weight. High estimates of heritability and genetic advance as per cent of mean were observed for harvest index, pod yield per plant, height of main axis and pods per plant indicating prime role of additive gene effect for the inheritance of these characters.

Lal *et al*. (2003) studied genetic variation and selection response for twelve attributes using sixty seven groundnut lines and cultivars. They reported higher values of PCV than GCV for all the characters studied except days to maturity; however, estimates of GCV were low to moderate for all the characters. The heritability estimates were high along with high GA as per cent of mean for plant height and 100 pod weights.

Kumar and Rajamani (2004) observed highly significant differences among twelve genotypes for seed yield and other characters. For plant height, pod yield, 100 kernel weight and percentage of sound mature kernels, GCV and PCV estimates were high whereas, those were moderate for shelling percentage. The values of PCV were higher than GCV indicating an influence of environment in expression of all the characters.

Parmeshwarappa *et al.* (2004) studied nature and magnitude of genetic variability in forty four released varieties of groundnut. The characters pod yield per plant, kernel yield per plant, shelling out-turn and sound mature kernels showed high values of genetic coefficient of variation. An extent of heritability was moderate for days to maturity and high for days to 50% flowering as well as 100-kernel weight. High heritability coupled with high genetic advance as percent of mean was expressed by pod yield, kernel yield and shelling out-turn; hence, improvement in these traits could be brought by applying selection pressure on *per se* performance of genotypes.

Mothilal *et al.* (2004) reported that values of GCV and PCV were high for mature pods per plant and pod yield per plant and moderate to low for plant height, branches per plant, shelling out-turn, 100-pod weight, 100-kernel weight and sound mature kernels in groundnut. These characters also exhibited high magnitude of heritability. However, genetic advance as percent of mean was high for pods per plant and it was moderate for branches per plant, plant height and 100-kernels weight, indicating that weightage should be given to these characters to improve yield potential of groundnut.

Wani *et al.* (2004) reported high value of genotypic coefficient of variation for mature pods per plant and harvest index. High heritability was observed for days to maturity, number of branches per plant, 100-kernel weight, days to first flower, 100-pod weight and shelling out-turn. High heritability coupled with high genetic advance as percent of mean was observed for days to maturity, 100-pod weight and 100-kernel weight revealing that selection would be effective for improvement in these characters.

Golakia *et al.* (2005) evaluated twenty four spanish bunch groundnut genotypes to study variability parameters. They noticed close correspondence between PCV and GCV estimates for all the eleven characters studied suggesting that characters studied were less influenced by environmental factors. They also estimated high GCV and PCV for all the characters, except shelling out-turn and oil content. High heritability coupled with high genetic advance as percent of mean was observed for plant height, pods per plant, 100 kernel weight and kernels as well as pods yield per plant. High heritability along with low genetic advance as percent of mean was observed for shelling out-turn. For oil content heritability was moderate. All these indicated that large portion of non-additive gene action was responsible for expressions of shelling out-turn and oil content.

Mahalaxmi *et al.* (2005) studied genetic variability parameters in fifty seven genotypes of groundnut. They reported higher value of PCV than corresponding value of GCV for all the characters under study. However, estimates of PCV and GCV were high for number of mature as well as immature pods, pod yield per plant and oil content; whereas, those were low for plant height, shelling percentage and 100 kernel weight. However, heritability estimates were high for all the characters except oil content. All the characters except days to first flowering, days to 50% flowering, plant height, number of primary branches and oil content registered high heritability along with high values of GA as percent of mean.

John *et al.* (2006 b) studied variability parameters in groundnut and reported that estimates of PCV were in accordance with estimates of GCV for plant height and number of primary as well as secondary branches; whereas, PCV estimates were high than those of GCV for number of mature as well as immature pods, pod length, pod width, pod weight, shelling out-turn and kernel yield. However, both the estimates were high for number of secondary branches and number of immature pods. The broad sense heritability was high for all characters except number of mature pods, pod length, pod weight and shelling out-turn, for these traits it was moderate; most of the characters studied had moderate to high estimates of GA as percent of mean except pod width and shelling out-turn.

Kadam *et al.* (2007) studied forty groundnut genotypes of different botanical groups to assess the amount of genetic variation, heritability and genetic advance with respect to pod yield and other agronomic characters. The genotypic coefficient of variation was high for kernel yield, pod yield, number of pods, number of branches, plant height and harvest index. High heritability coupled with high genetic advance was also observed for pod yield and kernel yield.

John *et al.* (2008) reported close correspondence between GCV and PCV values for days to maturity, pod yield per plant, shelling percent and 100-kernel weight; whereas, value of PCV was higher than corresponding GCV for days to initial flowering, number of primary branches and kernel yield per plant. All the characters had high estimates of broad sense heritability, but GA as per cent of mean was high for shelling percent and kernel yield per plant, hence improvement in these characters would be effective on the *per se* performance of the individual.

John *et al.* (2009) evaluated sixty genotypes of groundnut to study variability parameters for seventeen characters and they reported high GCV and PCV values for all the characters except for plant height, shelling percentage and 100 kernel weight. However, low GCV and PCV values were observed for days to initiation of flowering, days to 50% flowering and number of primary branches. In general estimates of PCV were high than those of GCV for respective character. The broad sense heritability estimates were high for all the characters and estimates of GA as per cent of mean were also high for all the characters except growth attributes, days to initiation of flowering as well as 50% flowering, plant height and number of primary branches per plant.

Korat *et al.* (2009) evaluated eighty diverse genotypes of bunch groundnut for variability parameters. The estimates of PCV and GCV were high for number of secondary branches per plant and number of aerial pegs per plant; whereas, for rest of the characters those were low to moderate. The broad sense heritability estimates were high for all the characters, but genetic advance as percent of mean was high for pod yield per plant, number of primary branches, number of secondary branches per plant, plant height and 100-kernel weight indicating that these traits predominantly governed by additive gene action and responsive to selection for their further improvement.

Shoba *et al.* (2009) evaluated three F_2 cross derivatives and their four parents to study their mean performance, genetic variability, heritability and genetic advance as percentage of mean for yield and contributing characters. Among the crosses, TMV

2 x COG 0437 had higher mean performance for all the characters followed by TMV 2 x COG 438. Higher PCV and GCV values were also exhibited by this cross. The cross TMV 2 x COG 0437 had high heritability and high to moderate GAM for most of the characters followed by TMV 2 x COG 0438. Hence, based on mean and variability parameters, TMV 2 x COG 437 is adjudged as best cross combination for further selection programme to evolve a promising progeny.

Cholin *et al.* (2010) evaluated two spanish bunch groundnut genotypes for variability parameters and results revealed that magnitude of variation (PCV, GCV) was low to moderate. For the protein content (%), genetic advance as percent of mean was moderate with high heritability indicating the role of additive gene action in controlling these traits and for oil content lower magnitude of variation with higher heritability and lower genetic advance was reported.

Dolma *et al.* (2010) evaluated thirty three advanced breeding lines and genotypes of groundnut to study the variability parameters, correlations and path coefficients for thirteen metric traits. Significant genotypic differences were observed for all the traits studied indicating the considerable amount of variation among genotypes for each character. The highest genotypic and phenotypic coefficient of variation was observed for late leaf spot (LLS) score at 80 days after sowing followed by LLS score at 90 days after sowing, kernel yield per plant, plant height, pod yield per plant and test weight. Similarly, high heritability coupled with high genetic advance was observed for these traits indicating the scope for their improvement through selection.

Shinde *et al.* (2010) evaluated fifty elite genotypes of virginia bunch groundnut for variability parameters and observed that GCV and PCV estimates were higher for pod yield per plant, number of immature pods per plant, number of mature pods per plant and biological yield per plant. High heritability was associated with high genetic advance for pod yield per plant and number of mature pods per plant. These characters were mainly under the influence of additive gene action and there is ample scope for improvement in these traits through simple selection.

Nandini *et al.* (2011) studied variability parameters through one hundred ninety six F_8 recombinant inbred lines for water use efficiency in groundnut during *kharif* season and reported higher PCV than GCV for all the characters. Pod yield per plant showed maximum GCV followed by kernel yield per plant, number of pods per plant, sound mature kernel percentage, specific leaf area, number of branches per plant, shelling percentage, plant height, SCMR and days to fifty percent flowering. A moderate to high degree of heritability and genetic advance was observed for pod yield per plant, kernel yield per plant, pods per plant, sound mature kernel percentage, plant height, number of branches per plant and SLA.

Zaman *et al.* (2011) evaluated thirty four genotypes for estimation of genetic variability, genetic parameters and correlation coefficient among different yield components. Highly significant variations were observed among the genotypes for all the characters studied. The highest genetic coefficient of variation was observed for kernel yield per hectare. The highest heritability was observed in kernel yield per pant (95.08%) while high values of genetic advance were obtained in all the characters except days to maturity and days to 50% flowering. The number of mature nuts per plant had high positive direct effect on seed yield per hectare followed by nut size, shelling percentage, days to 50% flowering and days to maturity. Therefore, branches per plant, plant height, nuts per plant, nut size, kernel size, days to 50% flowering, shelling percentage and days to maturity were identified to be the important characters which could be used in selection for yield.

John *et al.* (2012) evaluated twenty eight F_2 populations for genetic parameters of 23 characters of morphological, physiological, yield and yield attributes during spring 2009. High genotypic coefficient of variation was observed for the number of secondary branches per plant. High heritability and high GAM was recorded for the number of secondary branches per plant, high heritability and moderate GAM were observed for days to 50% flowering. The leaf area index, number of well-filled and mature pods per plant, dry haulms yield per plant and harvest index showed moderate heritability and high GAM. This indicates that these characters are under additive genetic control and selection for genetic improvement will be worthwhile and may rapidly contribute to pod-and kernel yields.

Madhura *et al.* (2012) conducted an experiment using groundnut minicoreset, comprised of 182 accessions representing hypogaea bunch (42), hypogaea runner (39), Spanish bunch (63) and fastigiata (38) obtained from NRCG, Junagadh with nine cultivars (GPBD-4, JL-24, Mutant-III, TGLPS-3, DSG-1, Gangapuri, ICGS-44, GAUG-10 and Kadiri-3) during Kharif 2005. High genetic advance was observed for test weight pod yield per plant, moderate for shelling per cent, sound mature kernel and oil content and for days to 50 per cent flowering and days to maturity it was low.

Upadhyaya *et al.* (2012) studied variability for nutritional traits in the mini core collection of peanut, 184 mini core accessions and four control cultivars were evaluated for agronomic traits. Significant genotypic and genotype x environment interactions were observed for all the nutritional and agronomic traits in the entire mini core collection.

Vishnuvardhan *et al.* (2013) evaluated eight parent and twenty eight crosses for variability parameters and observed high GCV accompanied by high heritability and high GAM were obtained for number of secondary branches per plant, percentage of leaves affected by foliar diseases per plant and number of immature pods per plant. Rust severity, number of mature pods per plant and pod yield per plant recorded high GCV and moderate heritability and GAM. Moderate GCV, moderate to low heritability and GAM were registered for number of primary branches per plant, kernel weight per plant, shelling out-turn, late leaf spot and harvest index.

Patil *et al.* (2014) evaluated 58 spanish bunch groundnut genotypes for variability studies in 16 plant characters. Analysis of variance revealed significant differences among the genotypes for all the characters studied. Maximum broad sense heritability was recorded for days to 50% flowering followed by plant height and 100-kernels weight. The maximum genetic advance was found for seed dormancy followed by 100-kernels. In general, moderate to high heritability coupled with moderate to high genetic advance for days to 50% flowering, plant height, 100-pods weight, 100-kernels weight, shelling percent and harvest index, indicated the involvement of additive gene action and scope of improvement in these traits through selection.

Yadlapalli (2014) conducted an experiment at the Agricultural Research Station, Darsi, to genetic variability, genetic parameters and correlation coefficients among different yield components. Highly significant variations were observed among the genotypes for all the characters studied. The highest genetic coefficient of variation was observed for no. of pods/plant followed by pod yield, 100 seed weight, no. of branches per plant, plant height and days to 50% flowering. The highest heritability was observed in 100 seed weight (98.0%) followed by pod yield (96.0%), no. of pods per plant (94.0%), no. of branches per plant (89.0%), plant height (88.0%) and days to 50% flowering (79.0%). while high values of genetic advance were obtained for all the characters except plant height and days to 50% flowering. Selection for characters showing high heritability with high genetic advance, positive and high significant correlation and showing high direct effects will helpful in the improvement of yield in the groundnut

2.2 CORRELATION COEFFICIENTS & PATH COEFFICIENT

The knowledge of association between yield and its component characters is of immense value for breeder, because it forms a basis for selection. It is well known phenomenon that different components of yield very often exhibit considerable degree of association in both positive and negative directions among themselves and with yield as well. Therefore, understanding of correlation between characters would helpful to accumulate optimum combination of yield contributing characters in a single genotype.

The concept of correlation was given by Galton (1889), which was further elaborated by Fisher (1918) in order to initiate effective selection programme aimed at genetic improvement in economic yield of a crop. The degree of association between yield and component characters might vary with genetic make of the material under study. Hence, it is essential to measure the correlations at genotypic and phenotypic levels.

Some of the important research results obtained on correlation coefficients studies on various characters of groundnut are presented here.

Chishti *et al.* (2000) evaluated sixteen spanish groundnut genotypes and reported that at genotypic level all the characters *viz.*, days taken to flowering, number of pods per plant, shelling percentage, 100-kernel weight, number as well as weight of sound mature kernel and oil percent showed positive association with pod yield; whereas, pod yield depicted negative and significant association with days taken to maturity. However, sound mature kernel percent by weight, shelling percentage, days taken to flowering and number of pods per plant showed high positive direct effects on pod yield, while sound mature kernel percent by number, days to maturity contributed high negative effects on pod yield.

Jayalakshmi *et al.* (2000) observed significant and positive association between kernel yield and mature pods per plant, but significant and negative association between kernel yield and oil content was also reported.

Ali *et al.* (2000) reported that pod yield was significantly and positively correlated with kernel weight and oil content. Positive and highly significant correlation between pod length and kernel weight indicated that selection for larger kernel size could result in heavier kernel, which had close positive correlation with yield.

Mathews *et al.* (2001) reported that pod yield per plant had significant and positive genotypic correlation with days to flowering, days to 75% maturity, kernel yield per plant, plant height, haulm yield and 100-kernel weight. Dry pod yield showed positive and significant direct effect for kernel yield per plant.

Venkatramana (2001) evaluated thirty groundnut genotypes and found that genotypic correlation coefficients were, in general, marginally higher than the phenotypic correlation coefficients for all the five characters *i.e.* 100-kernel weight, SMK per cent, kernel yield, oil yield and oil content. Oil content was significantly and positively correlated with 100-kernel weight, sound mature kernel per cent, kernel yield and oil yield.

Dashora and Nagda (2002) reported that dry pod yield exhibited significant and positive association with shelling percentage and kernel yield. Path analysis revealed that shelling percentage and kernel yield were major components of dry pod yield.

Izge *et al.* (2004) evaluated sixteen groundnut genotypes to determine the correlation between pod yield and important yield traits and to determine their interrelationship through path analysis. The groundnut genotypes used represent the combinations of low and high levels of traits that are identified as important yield determinants, i.e. number of mature pods per plant, 100-seed weight and shelling percentage. The study suggests that the number of mature pods per plant and 100-seed weight are traits for possible consideration for selection as regards to pod yield in groundnut.

Kavani *et al.* (2004) evaluated fifteen genotypes of groundnut and reported that pod yield expressed significant and positive association with pods per plant, kernel yield per plant, 100-kernel weight and biomass yield. Kernel yield per plant had significant and positive association with pods per plant, 100-kernel weight and biomass yield per plant. Strong association between biomass and pod yield per plant indicated possibilities for simultaneous improvement in both the traits.

Nagda and Joshi (2004) evaluated fifty two genotypes of groundnut and observed significant and positive association between pod yield per plant and harvest index. Harvest index expressed high positive direct effect towards pod yield per plant. While 100-kernel weight influenced indirectly *via* harvest index, suggested that harvest index and 100-kernel weight should be considered as important traits in selection programme.

Suneetha *et al.* (2004) studied twenty three diverse genotypes for their character association and reported significant and positive correlation of pod yield per plant with mature pods per plant and harvest index. The character combinations of days to 50 percent flowering with days to maturity and 100-pod weight with 100-kernel weight showed significant and positive correlations between themselves. Days to 50 percent flowering and plant height expressed negative direct contribution. They also concluded that days to 50 percent flowering, plant height and mature pods per plant should be considered as selection criteria for improving pod yield in groundnut.

Golakia *et al.* (2005) observed strong association of pod yield per plant in both groups with mature pods per plant, kernel yield per plant, developed pods per plant, biomass yield per plant and harvest index, indicating that simultaneous selection for these characters might bring an improvement in pod yield.

Gomes and Lopes (2005) studied eight cultivars to estimate the genetic parameters of agronomic traits of groundnut and the genotypic correlation coefficients between seed yield and the primary components of the yield apportioned into direct and indirect effects. The highest estimates of the coefficient of genotypic determination were obtained for weight of 100 seeds, number of pods per plot, number of seeds per pod and pod yield. The splitting of the genotypic correlations into seed yield and the primary components, in direct and indirect effects, showed that the seed yield was positively influenced by the number of pods and weight of 100 seeds and negatively by the number of pod. Thus, the number of pods had the maximum direct influence on the seed yield.

Kotzamanidis *et al.* (2006) observed that pod yield per plant had significant and positive correlation with seed length, 100-pod weight, 100-seed weight, pod length, pod width and seed width. However, significant and positive correlation was found between 100-seed weight and 100-pod weight.

Patil *et al.* (2006) evaluated seventeen groundnut genotypes at six locations to study correlation and path analyses for yield and yield components. Pod yield per plant showed a highly significant and positive association at the genotypic and phenotypic levels at 3 locations (Dharwad, Sankeshwar and Nippani) with shelling percentage and sound mature kernel percentage. Correlation and path analyses revealed that the number of pods per plant, shelling percentage and sound mature kernel percentage were important yield-contributing traits irrespective of the environment. Thus, these traits should be considered during selection for the improvement of pod yield per plant in groundnut.

Sumathi *et al.* (2007) evaluated forty eight diverse genotypes of groundnut to analyse and determine that pod and kernel characters having greater interrelationship with pod yield. The pod yield per plant had significant positive association with kernel yield, sound mature kernel weight and 100-seed weight both at genotypic and phenotypic levels. The shelling percentage and oil content had negative association with pod yield per plant both at genotypic and phenotypic levels. In general, the genotypic correlations in most characters were higher than the phenotypic correlation coefficients thereby suggesting strong inherent association between genotypic and phenotypic levels. The inter correlations of kernel yield with sound mature kernel weight, 100-seed weight were also positive and significant at both genotypic and phenotypic levels.

Mane *et al.* (2008) performed correlation analyses to assess the relationship among different characters in summer bunch groundnut and reported that pod yield per plant exhibited significant and positive correlation with per cent sound mature kernel, number of pegs per plant, number of pods per plant and shelling percentage. However, it showed negative and non-significant correlation with hundred kernel weight and days to 50 per cent flowering.

John *et al.* (2009) reported that pod and kernel yields per plant showed significant and positive association with days to 50% flowering, plant height, number of secondary branches per plant, number of mature pods per plant, SMK weight, sound mature kernel number as well as weight and 100-kernel weight. So these characters were considered as selection indices for the improvement of kernel and pod yields per plant.

Awatade *et al.* (2010) carried out correlation analysis to assess the relationship among different characters in groundnut and reported that the phenotypic correlation coefficient was slightly higher than phenotypic correlation coefficient. The characters *viz.*, number of pods per plant, number of primary branches per plant, number of kernels per plant and kernel yield per plant showed significant and positive correlation with dry pod yield per plant.

Dhaliwal *et al.* (2010) studied direct and indirect effects by path analysis for dry pod yield and its components in groundnut. Dry pod yield had significant positive association with days to flowering, days to maturity, haulm yield per plant and kernel yield per plant. At genotypic level too these traits had high positive correlation with dry pod yield. Path analysis indicated high positive direct contribution of kernel yield per plant. Days to flowering, days to maturity and haulm yield per plant made indirect contribution to dry pod yield via kernel yield per plant. It was concluded that these traits must be given importance during selection in segregating generation for improvement of dry pod yield in groundnut.

Khanpara *et al.* (2010) carried out character association and path coefficient analysis in groundnut for pod yield. The correlation of pod yield per plant was associated significantly and positively with number of mature pods per plant, 100 kernel weight and number of primary branches per plant, but which was negative with days to 50 percent flowering and days to maturity. Number of mature pods per plant manifested maximum direct effect towards dry pod yield per plant followed by days to maturity, biological yield per plant and other characters had high indirect effects through number of mature pods per plant.

Raut *et al.* (2010) investigated F_2 generation for six crosses of groundnut, to study correlation coefficients among eleven yield and yield contributing traits with their path effects towards pod yield. The correlation coefficients of pod yield per plant were found positive and highly significant with kernel yield per plant, number of mature pods per plant and shelling out-turn. On the basis of correlations and direct, indirect effects, kernel yield per plant, number of mature pods per plant and shelling out turn were proved to be the outstanding characters influencing pod yield in groundnut and need to be given importance in selection to achieve higher pod yield.

Shinde *et al.* (2010) reported that the correlation of pod yield per plant was associated significantly and positively with number of mature pods per plant, 100-kernel weight and number of primary branches per plant, but which was negative with days to 50% flowering and days to maturity. Number of mature pods per plant manifested maximum direct effect towards the pod yield per plant followed by days to maturity, biological yield per plant and 100 kernel weight and other characters had high indirect effects through number of mature pods per plant.

Sonone *et al.* (2010) worked out character association with direct and indirect effects for forty genotypes of groundnut for fifteen characters. The correlation studies revealed that the genotypic correlation coefficients were slightly higher than the phenotypic correlation coefficients for most of the characters. The magnitude of genotypic and phenotypic correlation coefficients between dry pod yield per plant and kernel yield per plant was highest and positive followed by dry pod yield and number of pods per plant and number of kernels per plant. Positive correlation between dry pod yield per plant and days to first flowering, days to 50 percent flowering, days to maturity, number of primary branches per plant and 100-seed weight was also noticed. While, negative correlation with oil content, pod length and plant height was observed.

John *et al.* (2011) carried out correlation analysis to assess the relationship among different characters in F_2 population of groundnut and reported that SCMR had significant negative association with specific leaf area. Positive significant association of transpiration rate with photosynthetic rate and pod yield per plant, dry haulm yield per plant with harvest index. The high direct effect of pods per plant was appeared to be the main factor for its strong positive correlation with pod yield.

Vekariya *et al.* (2011) evaluated fifty diverse genotypes of bunch groundnut during *Kharif* 2009 for genetic parameter *viz.*, correlation and path analysis. The magnitudes of genotypic correlation coefficients were higher as compared to the corresponding phenotypic correlation coefficients. The pod yield per plant had highly significant and positive correlations at phenotypic levels with number of mature pods per plant, 100-pod weight, 100-kernel weight,kernel yield per plant, biological yield per plant and harvest index.

Babariya and Dobariya (2012) estimated correlation coefficients for pod yield per plant and its components by using 100 genotypes of Spanish bunch groundnut. The 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. Thus, these characters were identified as the most important yield components and due emphasis should be placed on these characters while selecting for high yielding genotypes in Spanish bunch groundnut.

Nandini *et al.* (2012) evaluated 196 F_8 recombinant inbred line population to study the correlation and path association for ten growth and physiological traits related to water use efficiency in groundnut. The studies on Phenotypic and genotypic correlation coefficients revealed that pod yield per plant had strong positive correlation with pods per plant, kernel yield per plant, sound mature kernel percentage indicating that improvement in these characters will lead to improvement in yield.

Shoba *et al.* (2012) estimated correlation coefficients among nine yield and yield attributing characters with their path effects towards kernel yield in F3 generation for three crosses of groundnut, on the basis of correlations and direct and indirect effects, number of pods per plant, pod yield per plant, hundred kernel weight and shelling percentage were proved to be the outstanding characters influencing kernel yield in groundnut and need to be given importance in selection to achieve higher kernel yield.

Mukhtar *et al.* (2013) conducted irrigated trial to study the performance of three groundnut (*Arachis hypogaea* L.) varieties as affected by basin size and plant population. Plant height exhibited the highest positive ($p<=0.05$) effect, followed by total dry matter and number of branches in the three years and when combined. Path coefficient analysis revealed that among the growth characters selected, plant height made the highest positive contribution of 34.77% to pod yield of groundnut, followed by total dry matter with a positive contribution of 17.46%, suggesting plant height was the most critical growth parameter for determining yield of groundnut under irrigation.

Rao *et al.* (2013) evaluated the association between yield and yield components under drought condition and reported that dry pod yield exhibited significant positive association with pods per plant, 100-kernel weight and SPAD chlorophyll meter reading (SCMR). The direct effect was high and positive for pods per plant, SPAD chlorophyll meter reading (SCMR) and 100-kernel weight.

Vange *et al*. (2014) evaluated nine improved varieties of groundnut and one locally cultivated variety for their breeding potentials in the Guinea Savannah Agro-ecological Zone. Correlation studies revealed that grain yield correlated positively with all except the phenological traits. The path analysis implicated biological yield, failed pegs per plant, number of leaves/plant, and basal stem diameter as having substantial influence on grain yield in groundnut. Thus, selection of breeding lines based on the biological yield, failed pegs, number of leaves per plant and basal stem diameter could give a better scope for maximum grain yield in groundnut.

3. MATERIALS AND METHODS

The experiment was carried out to explore the information on "Character Association and Path Analysis in Groundnut (*Arachis hypogaea* L.)" during *kharif,* 2015 at the Instructional Farm, College of Technology and Engineering (CTAE), Maharana Pratap University of Agriculture and Technology, Udaipur. Geographically, Udaipur is situated at an elevation of 582.17 meter above the mean sea level on latitude of 24º 34' North and longitude of 73º 42' East. The meteorological observations during crop period are given in Table 3.1.

Table 3.1: Weekly mean meteorological observations recorded during the crop season (July to September, 2015)

SMW*	Period		Temperature		R.H. %		Evaporation (mm)	Rainfall (mm)
	From	To	Max(^{o}C)	Min (^{o}C)	Mor.	Eve.		
28	09/07	15/07	34.5	26.2	69.7	44.4	9.2	0.0
29	16/07	22/07	32.7	24.9	79.3	61.1	5.2	45.2
30	23/07	30/07	34.5	23.0	92.1	88.1	2.8	217.8
31	31/07	05/08	28.5	23.3	80.3	69.7	4.1	29.2
32	06/08	12/08	31.6	24.3	84.0	68.6	4.3	43.4
33	13/08	19/08	29.8	23.6	89.1	73.9	2.9	62.0
34	20/08	26/08	30.3	23.8	79.4	61.3	4.7	0.0
35	27/08	02/09	31.6	22.8	82.9	57.0	4.9	0.0
36	03/09	09/09	32.0	20.6	76.3	48.6	5.0	0.0
37	10/09	16/09	34.8	22.5	70.1	41.9	5.4	0.0
38	17/09	23/09	30.5	23.5	86.1	72.1	3.5	41.6
39	24/09	30/09	31.9	19.3	77.6	41.3	4.9	0.0

* Standard meteorological week number

1. Experimental materials:

The experimental material comprised of 24 groundnut genotypes including three checks namely UG-5 (Pratap Raj Mungphali), PM-2, GG-7. Detail of selected germplasm lines are given in Table 3.1.

2. Experimental details:

A field experiment was carried out with 24 groundnut genotypes in a Randomized Block Design during *kharif*, 2015. The experimental material was planted in three replications. Each genotype was planted in three rows in each replication with row to row distance 30 cm and plant to plant distance 10 cm. Recommended agronomic practices were followed to raise a healthy crop.

Table 3.2: List of genotypes used in present study and their pedigree

Sr. No.	Name of genotypes	Pedigree
1.	UG-158	J 63 × TPG 41
2.	UG-160	GG 2 × B 95
3.	UG-161	GG 8 × TKG 19 A
4.	UG-162	GG 2× TPG 41
5.	UG-163	GG 20 × PBS 24030
6.	UG-164	ICGX 090018
7.	UG-165	GG 21 × R-2001-3
8.	UG-167	GG 2 × TG 26
9.	UG-168	GG 20 × TAG 24
10.	UG-169	GG 20 × ICGV 86325
11.	UG-170	GG-7 × R-2001-3
12.	UG-172	TG-37 A × GG 20
13.	UG-173	GG 2 × ICGV 91114-1
14.	UG-174	TG 40 × ICGV 86325
15.	UG-175	PBS 24030 × TG 37 A
16.	UG-177	J 11 × TPG 41
17.	UG-178	ICGV 76 × ICGV 86305
18.	UG-179	ICGV 86564 × TPG 41

Sr. No.	Name of genotypes	Pedigree
19.	UG-181	ICGV 86590 × PBS 24030
20.	UG-182	UG 20 × ALR-3
21.	UG-184	GG 5 × TPG 41
22.	Pratap Mungphali -2	ICGV- 86055 × ICG- (FDRS 10)
23.	UG-5	Selection from ICGV-98223
24.	GG-7	S 206 × FEFR 81-1-9-B-B

3. Characters studied:

Observations were recorded on five randomly selected competitive plants of each genotype in each replication for various characters except days to 50 % flowering, days to maturity and 100-kernel weight, which were recorded on plot basis. The methodology used for recording observations on different characters is described below:

(i) Days to 50% flowering:

Number of days were counted from the date of sowing to date when at least 50% of the plants having at least one flower.

(ii) Days to maturity:

The total number of days were calculated from the date of sowing to date when all the plants attained complete physiological maturity.

(iii) Plant height (cm):

Plant height was measured in centimeter from ground level to the tip of main axis at the time of maturity on each randomly selected five plants and averaged.

(iv) Pod yield per plant (g) :

The fully developed dry pods were weighed in grams from each randomly selected five plant at the time of maturity and average weight per plant was calculated.

(v) Kernel yield per plant (g) :

Kernel yield per plant was computed by multiplying the dry pod yield with shelling percentage and divided by hundred.

(vi) Sound mature kernel (%):

Fully matured kernels were counted from representative sample of 100 kernels obtained from each plot and was expressed as per cent sound mature kernels.

(vii) Shelling percentage (%):

The shelling percentage based on the weight of kernels recovered from the pods after shelling was calculated as under.

$$\text{Shelling percentage (\%)} \quad \frac{\text{Weight of kernels (g)}}{\text{Weight of pod sample (g)}} \times 100$$

(viii) 100-kernel weight (g):

Hundred kernels were counted from random sample from each plot and weighed in grams.

(ix) Number of matured pods per plant:

The number of fully developed mature pods were counted for each randomly selected five plants at the time of harvesting and averaged.

(x) Weight of single pod (g):

After harvesting, weight of single pod was taken in grams on electronic balance and averaged.

(xi) Number of kernels per pod:

From the bulk pods of a variety 5 pods were randomly drawn and number of kernels per pod were counted and averaged.

(xii) Oil content (%)

Two random samples of kernels were drawn from bulk harvest of five randomly selected plants under each replication and oil content of kernels was determined by the Soxhlet’s Method and average oil content in per cent was worked out. (Detailed procedure is given in Appendix II).

4. Statistical analysis:

The replication wise mean values of five randomly selected plants were used for the statistical analysis for 12 characters studied.

4.1 Analysis of variance for experimental design

The mean values for various characters were subjected to statistical analysis for various parameters *viz.*, variability, genotypic and phenotypic correlations as per details given below.

To test the variation among the genotypes, analysis of variance was carried out as per method suggested by Fisher (1918).The general structure of ANOVA is given in Table 3.2.

Table 3.2: Analysis of variance and expected mean squares

Source	**df**	**Mean sum of squares**	**Expected mean sum of squares**
Replications	(r-1)	M_r	$\sigma^2_e + g\sigma^2_r$
Genotypes	(g-1)	M_g	$\sigma^2_e + r\sigma^2_g$
Error	(r-1) (g-1)	M_e	σ^2_e
Total	(rg-1)		

Where,

r = Number of replications

g = Number of genotypes

M_r= Mean sum of squares due to replications

M_g= Mean sum of squares due to genotypes

M_e= Mean sum of squares due to error

Significance of mean sum of squares due to replications (M_r) and genotypes (M_g) were tested against error mean sum of squares (M_e).

The standard error of mean (S.Em.) was calculated using following formula:

$$\text{S.Em.} = \sqrt{M_e / r}$$

The critical difference (C.D.) to compare the mean of any two genotypes was calculated using following formula:

$$\text{C.D.} = \text{S.Em.} \times \sqrt{2} \times \text{'t'}$$

Where,

t' = Table value of 't' at 5 % level of significance at error degree of freedom.

The coefficient of variation (C.V.) was determined according to the following formula:

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

Where,

$\bar{X}$ = General mean of a character.

4.2 Estimation of variability parameters

Total variation was partitioned into phenotypic (σ_p^2), genotypic (σ_g^2) and environmental (σ_e^2) variance based on expected mean sum of square for respective source of variation described in ANOVA (Table 3.3).

$$\sigma^2_e = M_e$$

$$\sigma^2_g = \frac{Mg\text{-}Me}{r}$$

$$\sigma^2_p = \sigma_g + \sigma_e$$

Genotypic and phenotypic coefficients of variation were estimated as formula suggest by Burton (1952).

(a) Genotypic coefficient of variation (GCV):

$$GCV\ (\%) = \frac{\sqrt{\sigma^2 g}}{\bar{X}}\ X\ 100$$

(b) Phenotypic coefficient of variation (PCV):

$$PCV\ (\%) = \frac{\sqrt{\sigma^2 p}}{\bar{X}}\ X\ 100$$

(c) Heritability (h^2):

In broad sense, heritability is the ratio of genotypic variance to the phenotypic variance and was calculated according to formula suggested by Burton and De Vane (1953).

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

(d) Genetic gain (GG):

The genetic gain was calculated by using the following formula suggested by Johnson *et al.* (1955).

$$GG = \frac{Gs}{\overline{X}} \text{ x } 100$$

Where,

Gs = Expected genetic advance under selection

$\overline{X}$ = General mean of a character.

4.3 Correlation coefficients

Correlation coefficients measure the relationship between two or more series of variables. The genotypic correlation coefficient provides a measure of genotypic association between different characters, while phenotypic correlation includes both genotypic as well as environmental influences.

The phenotypic and genotypic correlation coefficients of all the characters were worked-out as per Al-Jibouri *et al.* (1958). The data were subjected to covariance analysis. Phenotypic and genotypic covariances for pair of characters were calculated in the similar fashion as variance for individual character in Table 3.3.

Table 3.3: Analysis of covariance between two characters

Source	df	Mean of sum sum of products	Expected mean of sum of products
Replication	(r-1)	Mr_1	—
Genotypes	(g-1)	Mg_1	$Cov_{exy} + Cov_{gxy}$
Error	(r-1) (g-1)	Me_1	Cov_{exy}

Where,

r = Number of replications

g = Number of genotypes

Cov = Covariance

1. Genotypic covariance ($Cov_{(xy)g}$)

The formula for calculating genotypic covariance is described as below:

$$Cov_{(xy)g} = (M_{g1} - M_{e1}) / r$$

Where,

M_{g1} = Mean sum of products due to genotypes between variables x and y

M_{e1} = Mean sum of products due to error between variables x and y

r = Number of replications

2. Phenotypic covariance ($Cov_{(xy)p}$)

The formula for calculating phenotypic covariance is explained as under:

$$Cov_{(xy)p} = Cov_{(xy)g} + M_{e1}/r$$

Where,

M_{e1} = Mean sum of products due to error between variables x and y

r = Number of replication

(a) Genotypic correlation coefficient (r_{gxy})

$$rgxy = \frac{Cov(xy)g}{\sqrt{\sigma^2 gx.\sigma^2 gy}}$$

Where,

Cov(xy)g = Genotypic covariance between two characters x and y.

σ^2_{gx} = Genotypic variance for character x

σ^2_{gy} = Genotypic variance for character y

(b) Phenotypic correlation coefficient (r_{pxy})

$$rpxy = \frac{Cov(xy)p}{\sqrt{\sigma^2 px.\sigma^2 py}}$$

Where,

Cov (xy)p = Phenotypic covariance between two characters x and y.

σ^2_{px} = Phenotypic variance for character x

σ^2_{py} = Phenotypic variance for character y

(c) Test of significance

The significance of the correlation coefficient values for (n-2) degrees of freedom was done by calculating the 't' value using following formula described by Panse and Sukhatme (1985).

$$t = \frac{r}{\sqrt{(1-r^2)}} X \sqrt{(n-2)}$$

Where,

't' = Calculated value of 't'

r = Correlation coefficient between two variables

n = Total number of observations

Cluster analysis carried out according to the formula suggested by Ward (1963).

4.4 Path coefficient analysis:

Path coefficient is a standardized partial regression coefficient and measures the direct and indirect influences of one variable upon another thereby permitting the separation of the correlation coefficient into the component of direct and indirect effects.

Path coefficient is the ratio of the standard deviation of the effect due to a given cause of the total standard deviation of the effects. The path coefficient analysis was carried out as per the method suggested by Dewey and Lu (1959).

Path coefficients were analyzed at genotypic level for dry pod yield per plant. The direct and indirect effects of 9 characters on dry pod yield per plant (Y) were obtained as per procedure given below:

$$\begin{bmatrix} r_{1Y} \\ r_{2Y} \\ ,, \\ ,, \\ ,, \\ ,, \\ R_{9Y} \end{bmatrix} = \begin{bmatrix} r_{11}\ r_{12}\ldots\ldots\ldots\ r_{1\,9} \\ r_{21}\ r_{22}\ldots\ldots\ldots\ r_{2\,9} \\ ,, \\ ,, \\ ,, \\ ,, \\ r_{9\,1}\ r_{9\,2}\ldots\ldots\ldots\ r_{9\,9} \end{bmatrix} \begin{bmatrix} P_{1Y} \\ P_{2Y} \\ ,, \\ ,, \\ ,, \\ ,, \\ P_{9Y} \end{bmatrix}$$

A B C

Where,

r_{1Y}, r_{2Y}, r_{3Y},…… r_{9Y} are the genotypic correlations of plant height (cm), number of branches per plant, number of mature pods per plant, kernel yield per plant, 100 kernel weight, sound mature kernels, shelling percentage, biological yield per plant and oil content (%) on dry pod yield per plant (Y), respectively.

P_{1Y}, P_{2Y}, P_{3Y},…………………..P_{9Y} are the direct effects of plant height (cm), number of branches per plant, number of mature pods per plant, kernel yield per plant or dry pod yield per plant, 100 kernel weight, sound mature kernels, shelling percentage, biological yield per plant and oil content (%) on dry pod yield per plant or kernel yield per plant (Y), respectively.

Or A = BC

Values of ‘C’ vector were obtained as:

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

Where,

A is the vector of direct correlations of nine characters with yield Y.

B^{-1} is the inverse of mutual correlation matrix of characters.

C is the vector of direct effects.

The inverse of this matrix was carried out by Pivotal Condensation Method (Singh and Chaudhary, 1979).

To obtain indirect effect, B matrix was multiplied with vector C as follows:

$$D = C \times B$$

Where,

D is the matrix of direct and indirect effect

B is the matrix of correlation among nine characters.

The residual effect was computed as follows:

$$R = \sqrt{1 - (r_{1Y}P_{1Y} + r_{2Y}P_{2Y} + r_{3Y}P_{3Y} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + r_{9Y}P_{9Y}}$$

Where, R is the residual effect.

4. RESULTS AND DISCUSSION

The present study entitled "Character Association and Path Analysis in Groundnut (*Arachis hypogaea* L.)" was carried out at the instructional Farm, CTAE, MPUAT, Udaipur.

The experimental material of present investigation was comprised of 24 genotypes of groundnut (*Arachis hypogaea* L.) including three checks namely UG-5 (Pratap Raj Mungphali), PM-2, GG-7. Twelve characters were studied for variability and correlation.

The results obtained for twelve characters of 24 genotypes are discussed under following heads:

4.1. Analysis of variance
4.2. Mean values and Range
4.3 Variability parameters
4.4. Correlation analysis
4.5. Path coefficient analysis

4.1 ANALYSIS OF VARIANCE

The observations recorded on twelve characters were subjected to statistical analysis. The mean sum of squares due to genotypes were significant for all the characters studied. All of the twelve characters exhibiting significant variation among the genotypes were used for analysis (Table 4.1).

4.2 MEAN VALUES AND RANGE

The mean performances of genotypes for different characters are presented in Appendix I. A perusal of the data revealed that the range was considerably high for most of the characters *viz*., days to 50% flowering (22 to 32 days), days to maturity (98 to 105 days), plant height (33.33 to 49.33 cm), number of mature pods per plant (11 to 26), dry pod yield per plant (5.83 to 9.36 g), kernel yield per plant (4.08 to 6.58 g) , 100-kernel weight (44.18 to 51.35 g), sound mature kernel (83 to 93.66 %), shelling percentage (66 to 74%), seed oil content (41.83 to 46.43%), weight of single pod (0.76 to 1.67g), number of kernels per pod (1.33 to 2.66) indicating an adequate variability for exercising selection and use in the breeding programmes.

Table 4.1: Mean square for various characters in Groundnut

S. No.	Characters	Replication	Genotype	Error
	d.f.	2	23	46
1	Days to 50% flowering	2.72	19.44**	1.54
2	Days to maturity	0.54	8.28**	1.57
3	Plant height (cm)	6.09	35.91**	2.31
4	Number of pods per plant	3.76	39.02**	2.73
5	Dry pod yield per plant	0.69	3.10**	0.88
6	Kernel yield per plant	0.53	1.72**	0.45
7	100-Kernel weight (g)	2.75	9.99**	0.89
8	Sound mature kernel (%)	7.05	29.52**	2.40
9	Shelling percentage (%)	6.05	15.46**	2.27
10	Oil content (%)	1.57	5.45**	0.70
11	Number of kernels per pod	0.38	0.24**	0.12
12	Weight of single pod (g)	0.04	0.19**	0.03

[] Figures in parenthesis are degrees of freedom

* Significant at 5% level of significance, respectively.

4.2.1 Days to 50 % flowering

Among 24 genotypes, mean days to 50% flowering ranged from 22.33 days (UG-160) to 32 days (UG-179). Genotype UG-160 (22.33 days) was the earliest to flower which was followed by UG-158 (23.33 days) and UG-167 (24 days). The overall mean recorded for the trait was 27.47 days.

4.2.2 Days to maturity

With respect to days to maturity, mean values ranged from 98.33 days (UG-170) to 105 days (UG-175). Genotype UG-170 was found earliest as it showed minimum 98.33 days to maturity followed by UG-162 (98.67 days). The overall mean recorded for the trait was 100.87 days.

4.2.3 Plant height (cm)

The mean plant height ranged from 33.33 cm (UG-161) to 49.33 cm (UG-169). The mean for plant height was 40.86 cm.

4.2.4 Number of mature pods per plant

Mean data for number of mature pods per plants revealed that among 24 genotype UG-158 (26.00 pods) possessed maximum number of mature pods per plant followed by UG-170 (23.33 pods) and UG-162 (21 pods). The numbers of mature pods per plant ranged from 11 pods (UG-164) to 26 pods (UG-158). The overall mean for this character was 16.76 mature pods per plant.

4.2.5 Dry pod yield per plant (g)

Maximum dry pod yield per plant was exhibited by genotype UG-162 (9.36 g), followed by UG-169 (9.16 g). The mean dry pod yield per plant ranged from 5.83 g (UG-164) to 9.36 g (UG-162) exhibiting wide range of variation. The overall mean for this character was 7.77 g dry pod yield per plant.

4.2.6 Kernel yield per plant (g)

Wide range of variation was also found for kernel yield per plant among the 24 genotypes, as the mean values ranged from 4.08g (UG-164) to 6.58g (UG- 162 and UG-169). The genotype UG-162 and UG-169 (6.58g) gave maximum kernel yield per plant. The overall mean for this character was 5.41g.

4.2.7 100-Kernel weight (g)

The mean 100-kernel weight was 47.44 g. The data for 100-kernel weight ranged from 44.18 g (UG-177) to 51.35 g (UG-165). Genotype UG-165 (51.35 g) had maximum100-kernel weight, whereas UG-177 (44.18 g) had lowest 100-kernel weight.

4.2.8 Sound mature kernel (%)

The sound mature kernel percentage ranged from 83% (UG-161) to 93.66% (UG-172 and UG-175). Maximum sound mature kernel percentage was exhibited by the genotype UG-172 and UG-175(93.66%) and mean was 90.44%.

4.2.9 Shelling percentage (%)

The means for shelling percentage ranged from 66% (UG-5) to 74% (UG-172) with a general mean of 69.65%. The genotype UG-172 (74%) showed maximum shelling percentage followed by UG-182 (72.33%).

4.2.10 Oil content (%)

With respect to oil content, genotype UG-172 (46.43%) had maximum oil content, followed by UG-174 (46.33%) whereas the genotype UG-184 (41.83%) had minimum oil content. The overall mean for oil content was 44.13%.

4.2.11 Number of kernels per pod

Mean values among 24 genotypes for number of kernels per pod ranged from 1.33 (UG-172) to 2.66 (UG-165 and UG-178). Genotype UG-165 and UG-178 (2.66) had highest number of kernels per pod. The overall mean recorded for the trait was 2.09.

4.2.12 Weight of single pod (g)

Among 24 genotypes, mean weight of single pod ranged from 0.76 g (UG-177) to 1.67 g (UG-158). Genotype UG-158 (1.67 g) exhibited maximum weight of single pod which was followed by UG-175 (1.47 g). The overall mean recorded for the trait was 1.17 g.

4.3 VARIABILITY PARAMETERS

Assessment of genetic variability in the base population is first step in any breeding programme as it provides scope for selection. Phenotypic coefficient of variation measures the amount of variation present for a particular character. However, it does not determine the proportion of heritable variation of the total variation present for particular character. Johanson *et al.* (1955) suggested that heritability and genetic gain together would be more useful in predicting the effect of selection. Therefore, in the present investigation, phenotypic (PCV) and genotypic (GCV) coefficients of variation, heritability and genetic gain were estimated and character wise results are presented in table 4.2 and discussed as follows.

Table 4.2: Variability parameters for various characters in Groundnut (*Arachis hypogaea* L.)

SN	Characters	GCV	PCV	ECV	h²	GG
1	Days to 50% flowering	8.89	9.97	4.52	79.40	16.32
2	Days to Maturity	1.48	1.93	1.24	58.80	2.34
3	Plant Height (cm)	8.19	8.99	3.72	82.90	15.35
4	Number of pods per plant	20.74	22.97	9.86	81.60	38.60
5	Dry pod yield per plant	11.08	16.39	12.08	45.70	15.43
6	Kernel yield per plant	11.99	17.29	12.45	48.10	17.14
7	100-Kernel weight (g)	3.67	4.17	1.99	77.20	6.64
8	Sound Mature Kernel (%)	3.32	3.74	1.71	79	6.08
9	Shelling percentage (%)	3.01	3.70	2.16	65.90	5.03
10	Oil yield (%)	2.85	3.42	1.90	69.20	4.88
11	Number of kernels per pod	9.44	19.50	17.06	23.50	9.52
12	Weight of single pod (g)	19.65	25.19	15.76	60.90	31.59

4.3.1 Days to 50% flowering

The values of GCV and PCV for days to 50% flowering revealed that the magnitudes of GCV (8.89%) and PCV (9.97%) were moderate for this trait. The moderate estimates of genotypic and phenotypic coefficients have been reported by Makhan Lal *et al*. (2003), Korat *et al.* (2009), Cholin *et al.* (2010) for days to 50% flowering.

The trait days to 50% flowering exhibited high heritability (79.40%) which suggested that larger portion of variation for this character in the material was due to additive gene action. Low genetic gain (16.32%) further suggested that prediction of performance for this character would not be easier. These findings are in accordance with Dashora and Nagda (2002), Patil *et al.* (2014).

4.3.2 Days to maturity

The estimates of genotypic (1.48%) and phenotypic (1.93%) coefficient of variation indicated that the parameters were low in days to maturity. The lower estimates of GCV and PCV have also been earlier reported by Makhan Lal *et al.* (2003).

The heritability in broad sense (58.80%) was high and genetic gain (2.34%) was low for this trait. If the heritability of a character is high, the phenotypic value provides a fairly close measure of the genotypic value and thus breeder can base his selection on the phenotypic performance. This was also reported by Dashora and Nagda (2002).

4.3.3 Plant height

Estimates of genetic parameters indicated that plant height exhibited moderate value of GCV (8.19%) and PCV (8.99%). The GCV and PCV values for plant height were more or less equal. The present findings are in accordance with the findings of Mothilal *et al.* (2004), as they also reported moderate GCV and PCV for plant height. While, Azad and Hamid (2000), Venkatramana (2001), Prasad *et al.* (2002), Makhan Lal *et al*. (2003) , Kumar and Rajamani (2004), Golakia *et al.* (2005) and John *et al.* (2006b) reported higher magnitude of phenotypic coefficient of variation than genotypic coefficient of variation to plant height.

The estimates of heritability (82.90%) were high, which suggested that larger portion of variation for this character in the material was due to additive gene action. Low estimates of genetic gain (15.35%) further suggested that prediction of performance for this character would not be easier.

4.3.4 Number of mature pods per plant

The magnitude of genotypic coefficient of variation (20.74%) and phenotypic coefficient of variation (22.97%) was found high for number of mature pods per plant. Azad and Hamid (2000), Prakash *et al.* (2000), Nath and Alam (2002), Mothilal *et al.* (2004), Wani *et al.* (2004), Golakia *et al.* (2005), Mahalaxmi *et al.* (2005), John *et al.* (2006b) and Kadam *et al.* (2007), Shinde *et al.* (2010), Nandini *et al.* (2011) and Yadlapalli (2014) also reported high magnitude of both GCV and PCV for number of mature pods per plant in groundnut.

On the other hand, heritability (81.60%) was high in magnitude, in conjunction with high estimates of genetic gain (38.60%). The high value of heritability as well as genetic gain indicated role of additive gene action. Selection may reward for such traits.

4.3.5 Dry pod yield per plant

The estimates of genotypic (11.08%) and phenotypic (16.39%) coefficient of variation indicated that both the parameters were moderate in magnitude for dry pod yield per plant. The higher estimates of GCV and PCV have been earlier reported by

Prasad *et. al.* (2002). While, Azad and Hamid (2000), Prakash *et al.* (2000), Nazar-Ali *et al.* (2000), Kumar and Rajamani (2004), Mothilal *et al.* (2004), Parameshwarappa *et al.* (2004), and Kadam *et al.* (2007), Korat *et al.* (2009), Shinde *et al.* (2010), Nandini *et al.* (2011) and Yadlapalli (2014) showed higher magnitude of GCV and PCV.

The heritability in broad sense (45.70%) was high and genetic gain (15.43%) was low for this trait. If the heritability of a character is high, the phenotypic value provides a fairly close measure of the genotypic value and thus breeder can base his selection on the phenotypic performance.

4.3.6 Kernel yield per plant

A perusal of the data for kernel yield per plant indicated that genotypic coefficient of variation (11.99%) and phenotypic coefficient of variation (17.29%) were high in magnitude for this character. These findings are in accordance with the results reported by Azad and Hamid (2000), Venkatramana (2001), Venkatramana *et al.* (2001), Parmeshwarapa *et al.* (2004), John *et al*. (2006b) and Kadam *et al.* (2007), Nandini *et al.* (2011).

The estimates of heritability for kernel yield were high (48.10%). Likewise, genetic gain was low (17.14%). This indicated that the trait was under the control of additive gene action.

4.3.7 100-kernel weight

The results pertaining to genetic variability for 100-kernel weight indicated that genotypic coefficient of variation (3.67%) and phenotypic coefficient of variation (4.17%) were low for this trait. The present findings are in accordance with the findings of Mothilal *et al.* (2004), Mahalaxmi *et al.* (2005).

The estimates of heritability (77.20%) were high, which suggested that larger portion of variation for this character in the material was due to additive gene action. Low estimates of genetic gain (6.64%) further suggested that prediction of performance for this character would not be easier.

4.3.8 Sound mature kernel percentage

Sound mature kernels showed low estimates of genotypic coefficient of variation (3.32%) and phenotypic coefficient of variation (3.74%). High amount of variation for sound mature kernels in groundnut was reported by Venkatramana (2001), Mothilal *et al.* (2004), John *et al.* (2006b), Shinde *et al.* (2010), Nandini *et al.* (2011).

The estimates of heritability (79%) were high, which suggested that larger portion of variation for this character in the material was due to additive gene action. Low estimates of genetic gain (6.08%) further suggested that prediction of performance for this character would not be easier. High heritability for sound mature kernel percentage also reported by Venkatramana (2001), Kumar and Rajamani (2004), Parmeshwarappa *et al.* (2004), John *et al.* (2006b), Shinde *et al.* (2010), Nandini *et al.* (2011).

4.3.9 Shelling percentage

Magnitude of genetic parameters for shelling percentage indicated that estimates of genotypic coefficient of variation (3.01%) and phenotypic coefficient of variation (3.70%) were low for this character, indicating narrow base of variability for shelling out-turn in the material studied. These results are in close agreement with the earlier reports of Nath and Alam (2002), Mothilal *et al.* (2004), Golakia *et al.* (2005) and Mahalaxmi *et al.* (2005).

The high heritability (65.9%), with low genetic gain (5.03%) was revealed for shelling percentage.

4.3.10 Oil content

Estimates of oil content revealed that genotypic coefficient of variation (2.85%) and phenotypic coefficient of variation (3.42%) were low in magnitude for this character. Findings for moderate amount of genetic variability for oil content in groundnut, was reported by Prakash *et al.* (2000) and Golakia *et al.* (2005).

The estimates of heritability (69.10%) and genetic gain (4.88%) for oil content were high and low, respectively. These findings are in accordance with Prakash *et al.* (2000), Venkatramana (2001), Venkatramana *et al.* (2001), Dashora and Nagda (2002). Lower heritability and higher genotypic coefficient of variation and phenotypic coefficient of variation for oil content were also reported by Mahalaxmi *et al*. (2005).

4.3.11 Number of kernels per pod

The genotypic coefficient of variation (9.44%) and phenotypic coefficient of variation (19.50%) for number of kernels per pod were high in magnitude. While high amount of genetic variability for number of kernels per pod in groundnut.

The estimates of heritability (23.50%) and genetic gain (9.42%) were low for this trait.

4.3.12 Weight of single pod

The estimates of genotypic (19.65%) and phenotypic (25.19%) coefficient of variation indicated that the parameters were high in magnitude for weight of single pod. The higher estimates of GCV and PCV have also been earlier reported by Shinde *et al.* (2010).

The heritability in broad sense (60.90%) was high and genetic gain (31.59%) was also high for this trait. The high value of heritability as well as genetic gain indicated role of additive gene action. Selection would be effective for this trait.

Thus, estimates of genotypic parameters revealed that differences between the estimates of GCV and PCV were found least for most of the characters. Higher estimates of GCV were observed for number of mature pods per plant (20.74%).

For days to maturity, 100-kernel weight, sound mature kernel, shelling percentage and oil yield both GCV and PCV estimates were found low.

The heritability was found maximum for plant height. While, maximum genetic gain was observed for number of pods per plant (38.60%) followed by weight of single pod (31.59%), indicated involvement of additive gene action and scope of improvement for these characters through selection.

4.4 Correlation Coefficients

Yield is a very complex character as it only depends upon the expression of a number of components known as yield components but also influenced by environment greatly. Correlation studies indicates a magnitude of association between any pair of characters. A knowledge of the association of the yield components with each other and with yield is helpful in the improvement of the complex character “yield” for which direct selection is not much effective.

The association studies are very important in case of groundnut, since pod develops below the ground level and hence genotypes for yield cannot be screened or evaluated prior to harvest. It is necessary to find out the correlation of some above ground morphological characters with yield which can be evaluated prior to harvest or used as a selection criteria.

The intensity and even the direction of character association may vary with material under study. The correlation observed in a collection of germplasm may not be found in its sub group differing in growth habits. Even these sub group may differ in correlation.

In the present study both genotypic and phenotypic correlation coefficients of various characters with dry pod yield and among themselves were calculated. The results indicated that the trends of genotypic and phenotypic correlation was almost similar for all the characters. The estimates of genotypic correlations were slightly higher than their respective phenotypic correlation. Higher values of genotypic correlation than their corresponding phenotypic correlation may be due to masking effect of environment in modifying the total expression of the genotype.

4.4.1 Correlation between dry pod yield and other characters

A perusal of Table 4.3 revealed that dry pod yield per plant was positively and significantly correlated at both genotypic and phenotypic level with kernel yield per plant (r_g =0.97**, r_p =0.97**), number of pods per plant (r_g =0.43**, r_p =0.29*) and plant height (r_g =0.35**, r_p =0.24*). These findings are in accordance with Chishti *et al.* (2000), Jayalakshmi *et al.* (2000), Kavani *et al.* (2004), Sumathi *et al.* (2007), John *et al.* (2009).

Likewise, characters; 100-kernel weight, sound mature kernels, shelling percent and number of kernels per pod were also exhibited positive correlation with dry pod yield per plant at both genotypic and phenotypic level. These findings are in accordance with Mathews *et al*. (2001), Venkatramana (2001), Kavani et al. (2004), Suneetha *et al.* (2004) and Shinde *et al.* (2010).

Table 4.3: Genotypic and phenotypic correlation coefficients between dry pod yield and other characters in groundnut

S. No.	Characters	Genotypic Correlation Coefficient (r_g)	Phenotypic Correlation Coefficient (r_p)
1.	Days to 50% flowering	-0.23*	-0.09
2.	Days to maturity	-0.25*	-0.11
3.	Plant height (cm)	0.35**	0.24*
4.	Number of pods per plant	0.43**	0.29*
5.	Kernel yield per plant	0.97**	0.97**
6.	100-kernel weight	0.20	0.12
7.	Sound mature kernel	0.22	0.13
8.	Shelling percentage	0.13	0.11
9.	Oil content (%)	-0.15	-0.06
10.	Number of kernels per pod	0.56**	0.22
11.	Weight of single pod (g)	-0.09	-0.06

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

4.4.3 Correlation among different characters

A perusal of table 4.4 and 4.5 revealed existence of positive correlation between dry pod yield per plant with kernel yield per plant (r_p =0.97**, r_g =0.97**), shelling percentage (r_p =0.11, r_g =0.13), 100-kernel weight (r_p =0.12, r_g =0.20), sound mature kernel (r_p =0.13, r_g =0.22), plant height (r_p =0.24*, r_g =0.35**), pods per plant (r_p =0.29*, r_g =0.43**) and kernels per pod (r_p =0.22 and r_g =0.56**) at both genotypic as well as phenotypic level. Similarly, kernel yield per plant also exhibited positive correlation with shelling percentage (r_p =0.32**, r_g =0.37**), 100-kernel weight (r_p =0.20 and r_g =0.36**), sound mature kernel (r_p =0.15 and r_g =0.25*), plant height (r_p =0.22 and r_g =0.31**), pods per plant (r_p =0.27* and r_g =0.42**) and kernels per pod (r_p =0.22 and r_g =0.53**) at both genotypic and phenotypic levels. Shelling percent also exhibited positive correlation with 100-kernel weight (r_p =0.40**, r_g =0.67**), sound mature kernel (r_p =0.14 and r_g =0.21), days to maturity (r_p =0.17 and r_g = 0.18), oil yield (r_p =0.20, r_g =0.24*) and pods per plant (r_p =0.03, r_g =0.10) at phenotypic and genotypic levels (Table 4.4 and 4.5). 100-kernel weight showed positive correlation with sound mature kernel (r_p =0.10 and r_g =0.17), days to 50% flowering (r_p =0.28* and r_g =0.33**), days to maturity (r_p =0.10 and r_g =0.24*), oil yield (r_p =0.18 and r_g =0.15) and kernel per pod (r_p =0.30** and r_g =0.73**).

The character sound mature kernel showed positive correlation with days to 50% flowering (r_p =0.20 and r_g =0.26*), days to maturity (r_p =0.16 and r_g =0.36**), oil yield (r_p =0.08 and r_g =0.15), plant height (r_p =0.29* and r_g =0.30**), pods per plant (r_p =0.18, r_g =0.25*), weight of single pod (r_p =0.04, r_g =0.04) and kernels per pod (r_p =0.30**, r_g =0.08). Days to 50% flowering exhibited positive correlation with the characters i.e., days to maturity (r_p =0.06 and r_g =0.11), plant height (r_p =0.27* and r_g =0.32**), kernels per pod (r_p =0.22 and r_g =0.53**). Oil content showed positive correlation with pods per plant (r_p =0.07 and r_g =0.11)and weight of single pod (r_p =0.11, r_g =0.16). Plant height exhibited positive correlation with only one character i.e. kernels per pod (r_p =0.19, r_g =0.50**). Weight of single pod exhibited positive correlation with kernels per pod (r_p =0.05, r_g =0.40**). Similar findings have already been reported by Chisti *et al.* (2000), Sumathi *et al*. (2000), Kavani *et al.* (2004), Khanpara *et al.* (2010), Shinde *et al.* (2010), Nandini *et al.* (2012).

Present experimental findings revealed that kernel yield per plant, dry pod yield per plant and shelling percent are important yield contributing traits because they showed high magnitude of positive correlation. Hence, these traits can be used for selection of both high dry pod yield as well as high kernel yield.

Table 4.4 Phenotypic correlation coefficients among different characters in Groundnut (*Arachis hypogaea* L.)

Character	Dry Pod Yield/ Plant(g)	Kernel Yield/ plant(g)	Shelling %	100-Kernel Wt. (g)	Sound Mature Kernel %	Days to 50 % Flowering	Days to Maturity	Oil content	Plant Height (cm)	Pods/ Plant	Weight of Single Pod(g)	Kernels/ Pod
Dry Pod Yield/ Plant(g)	1.0000	0.9771**	0.1149	0.1244	0.1341	-0.0928	-0.1194	-0.0605	0.2427*	0.2917*	-0.0656	0.2261
Kernel Yield/ plant(g)		1.0000	0.3213**	0.2051	0.1555	-0.1002	-0.0832	-0.0240	0.2286	0.2774*	-0.0710	0.2216
Shelling %			1.0000	0.4035	0.1446	-0.0749	0.1743	0.2017	-0.0553	0.0333	-0.0301	-0.0177
100-Kernel Wt. (g)				1.0000	0.1071	0.2897*	0.1030	0.1831	-0.0376	-0.1404	-0.0014	0.3020**
Sound Mature Kernel %					1.0000	0.2026	0.1670	0.0876	0.2967*	0.1870	0.0453	0.1030
Days to 50 % Flowering						1.0000	0.0668	-0.0274	0.2794*	-0.3558**	-0.0521	0.2208
Days to Maturity							1.0000	0.0081	0.0169	-0.2351*	-0.0218	-0.1082
Oil content								1.0000	-0.2013	0.0759	0.1116	-0.2607*
Plant Height (cm)									1.0000	-0.2571*	-0.1811	0.1992
Pods/ Plant										1.0000	0.2169	-0.0709
Weight of Single Pod(g)											1.0000	0.0588
Kernels/ Pod												1.0000

Table 4.5: Genotypic correlation coefficients among different characters in Groundnut (*Arachis hypogaea* L.)

Character	Dry Pod Yield/ Plnat(g)	Kernel Yield/ plant(g)	Shelling %	100-Kernel Wt. (g)	Sound Mature Kernel %	Days to 50 % Flowering	Days to Maturity	Oil content	Plant Height (cm)	Pods/ Plant	Weight of Single Pod(g)	Kernels/ Pod
Dry Pod Yield/ Plnat(g)	1.0000	0.9705**	0.1371	0.2062	0.2270	-0.2377*	-0.2538*	-0.1566	0.3590**	0.4376**	-0.0982	0.5614**
Kernel Yield/ plant(g)		1.0000	0.3709**	0.3620**	0.2594*	-0.2232	-0.2019	-0.0974	0.3162**	0.4257**	-0.0843	0.5366**
Shelling %			1.0000	0.6770**	0.2197	-0.0481	0.1825	0.2493*	-0.1262	0.1028	0.0620	-0.0073
100-Kernel Wt. (g)				1.0000	0.1724	0.3387**	0.2419*	0.1543	-0.0141	-0.1796	-0.0921	0.7333**
Sound Mature Kernel %					1.0000	0.2634*	0.3656**	0.1549	0.3088**	0.2547*	0.0405	0.0831
Days to 50 % Flowering						1.0000	0.1172	0.0393	0.3235**	-0.5252**	-0.1043	0.5391**
Days to Maturity							1.0000	-0.0188	0.1185	-0.3391**	-0.0524	0.0387
Oil content								1.0000	-0.2554*	0.1126	0.1623	-0.5894**
Plant Height (cm)									1.0000	-0.2614*	-0.2245	0.5055**
Pods/ Plant										1.0000	0.3828**	-0.1718
Weight of Single Pod(g)											1.0000	0.4055**
Kernels/ Pod												1.0000

4.5 Path Coefficient Analysis

Correlation studies alone can't provide a clear cut picture of cause and effect of relationship between yield attributes and their extent of association. Path analysis devised by Wright (1921) provides measure of direct and indirect effects of traits on yield, splitting the correlation coefficient into direct and indirect effects. In present study path coefficient analysis was carried out for dry pod yield at genotypic level.

4.5.1 Path coefficient analysis for dry pod yield per plant

Path coefficient analysis for dry pod yield per plant was carried out at phenotypic level using all characters. Out of these eleven characters only three i.e. kernel yield per plant, plant height and pods per plant exhibited positive significant association with dry pod yield per plant, hence only these characters were described for path analysis study. The description is as under.

(i) Kernel yield per plant

A perusal of Table-4.6 indicated that the highly significant positive correlation of kernel yield with dry pod yield per plant (0.97**) was mainly due to its high direct effect (1.05). These results are in accordance with the findings of Dhaliwal *et al.* (2010), Raut *et al.* (2010) and Sonone *et al.* (2010).

(ii) Plant height

Significant correlation of plant height with dry pod yield per plant (0.24*) was mainly due to its indirect effect via kernel yield per plant (0.24) and its direct effect (0.23). These findings were also reported by Babariya and Dobariya (2012) and Mukhtar *et al.* (2013).

(iii) Number of pods per plant

Significant correlation of number of pods per plant with dry pod yield (0.29*) was mainly due to its high indirect effect via kernel yield (0.29) as well as its direct effect (0.0017). Days to flowering (-0.0022) , days to maturity (-0.0015) and 100-kernel weight (-0.0009), plant height (-0.0016) had negative indirect effect. These findings are in accordance with Chishti *et al.* (2000), Kavani *et al.* (2004), Mane *et al.* (2008), John *et al.* (2009) and Awatade *et al.* (2010).

Residual effect

The value of residual effect of undefined factors (Table 4.6) was 0.028. This residual effect of path analysis indicated that 98 % variability for dry pod yield per plant could be attributed to variation in 8 independent characters considered in this study and 5 % variation in yield was attributable to some undefined factors.

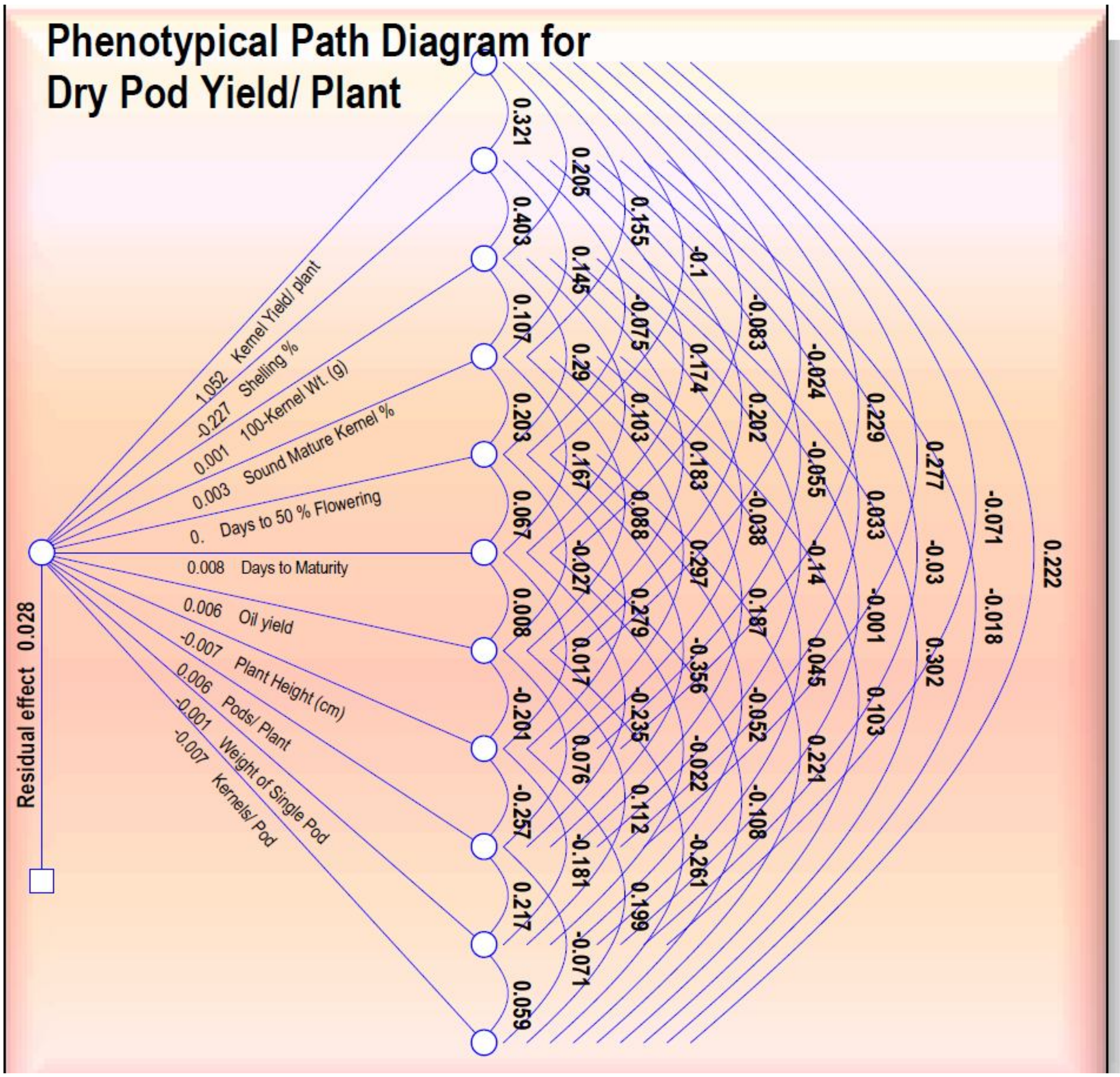
Highest positive direct effect on dry pod yield was exhibited by kernel yield per plant (0.97) followed by pods per plant (0.29).

However as revealed from the Table-4.6 the traits like kernel yield per plant, 100-kernel weight per plant, shelling percentage can be selected for further crop improvement in groundnut.

Table 4.6: Direct (diagonal) and indirect effects of different correlated characters towards dry pod yield per plant in Groundnut (*Arachis hypogaea* L.)

Character	Kernel Yield/ plant(g)	Shelling %	100-Kernel Wt. (g)	Sound Mature Kernel %	Days to 50 % Flowering	Days to Maturity	Oil content	Plant Height (cm)	Pods/ Plant	Weight of Single Pod(g)	Kernels/ Pod
Kernel Yield/ plant(g)	**1.0517**	0.3380	0.2157	0.1635	-0.1054	-0.0875	-0.0252	0.2405	0.2917	-0.0747	0.2330
Shelling %	-0.0730	**-0.2273**	-0.0917	-0.0329	0.0170	-0.0396	-0.0458	0.0126	-0.0076	0.0068	0.0040
100-Kernel Wt. (g)	0.0002	0.0003	**0.0009**	0.0001	0.0002	0.0001	0.0002	0.0000	-0.0001	0.0000	0.0003
Sound Mature Kernel %	0.0005	0.0005	0.0003	**0.0032**	0.0006	0.0005	0.0003	0.0009	0.0006	0.0001	0.0003
Days to 50 % Flowering	0.0000	0.0000	0.0000	0.0000	**0.0002**	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000
Days to Maturity	-0.0006	0.0014	0.0008	0.0013	0.0005	**0.0078**	0.0001	0.0001	-0.0018	-0.0002	-0.0008
Oil content	-0.0002	0.0013	0.0012	0.0006	-0.0002	0.0001	**0.0064**	-0.0013	0.0005	0.0007	-0.0017
Plant Height (cm)	-0.0017	0.0004	0.0003	-0.0021	-0.0020	-0.0001	0.0015	**-0.0072**	0.0019	0.0013	-0.0014
Pods/ Plant	0.0017	0.0002	-0.0009	0.0012	-0.0022	-0.0015	0.0005	-0.0016	**0.0063**	0.0014	-0.0004
Weight of Single Pod(g)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001	0.0001	-0.0001	**-0.0007**	0.0000
Kernels/ Pod	-0.0016	0.0001	-0.0022	-0.0007	-0.0016	0.0008	0.0019	-0.0014	0.0005	-0.0004	**-0.0071**
Dry Pod Yield/ Plant	**0.9771****	**0.1149**	**0.1244**	**0.1341**	**-0.0928**	**-0.1194**	**-0.0605**	**0.2427***	**0.2917***	**-0.0656**	**0.2261**
Partial R^2	1.0276	-0.0261	0.0001	0.0004	0.0000	-0.0009	-0.0004	-0.0018	0.0018	0.0000	-0.0016

Residual =0.028


Phenotypical Path Diagram for Dry Pod Yield/ Plant
1.052 Kernel Yield/ plant
-0.227 Shelling %
0.001 100-Kernel Wt. (g)
0.003 Sound Mature Kernel %
0. Days to 50 % Flowering
0.008 Days to Maturity
0.006 Oil yield
-0.007 Plant Height (cm)
0.006 Pods/ Plant
-0.001 Weight of Single Pod
-0.007 Kernels/ Pod
Residual effect 0.028
0.321 0.403 0.107 0.203 0.067 0.008 -0.201 -0.257 0.217 0.059
0.205 0.145 0.29 0.167 -0.027 0.017 0.076 -0.181 -0.071
0.155 -0.075 0.103 0.088 0.279 -0.235 0.112 0.199
-0.1 0.174 0.183 0.297 -0.356 -0.022 -0.261
-0.083 0.202 -0.038 0.187 -0.052 -0.108
-0.024 -0.055 -0.14 0.045 0.221
0.229 0.033 -0.001 0.103
0.277 -0.03 0.302
-0.071 -0.018
0.222

5. SUMMARY AND CONCLUSIONS

The present investigation entitled **"Character Association and Path Analysis in Groundnut (*Arachis hypogaea* L.)"** was carried out on 24 groundnut genotypes to elicit information on the genetic variability, correlation coefficients for yield and its contributing characters.

The groundnut genotypes were evaluated in randomized block design with 3 replications during *kharif*- 2015 at the Instructional farm, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur. Observations were recorded on five competitive plants for days to 50 per cent flowering, days to maturity, plant height, number of matured pods per plant, dry pod yield, kernel yield, 100-kernel weight, sound mature kernel, shelling out turn, number of kernels per pod. weight of single pod and oil content**.** The results are summarized and concluded as below:

- Mean squares due to genotypes for all the characters were significant as revealed from ANOVA indicating substantial amount of genetic variability among the genotypes under study. Genotypes exhibited wide range of variation for different characters *viz*., days to 50% flowering (22 to 32 days), days to maturity (98 to 105 days), plant height (33.33 to 49.33 cm), number of mature pods per plant (11 to 26), dry pod yield per plant (5.83 to 9.36 g), kernel yield per plant (4.08 to 6.58 g) , 100-kernel weight (44.18 to 51.35 g), sound mature kernel (83 to 93.66 %), shelling percentage (66 to 74%), seed oil content (41.83 to 46.43%), weight of single pod (0.76 to 1.67g), number of kernels per pod (1.33 to 2.66).
- The estimates of genotypic parameters revealed that the phenotypic coefficient of variation along with least difference from genotypic coefficient of variation observed for characters *viz*., days to maturity (GCV 1.48% and PCV 1.93%), plant Height (GCV 8.18% and PCV 8.99%), sound mature kernel (GCV 3.32% and PCV 3.74%) and shelling percentage (GCV 3.01% and PCV 3.70%), indicating that without much influence of environment, entire genetic determinants are translated into phenotype**.**
- Maximum heritability was observed for plant height followed by number of pods per plant, days to 50% flowering, sound mature kernel, 100-Kernel weight, oil yield, shelling percentage, weight of single pod, days to maturity, kernel yield per plant and dry pod yield per plant. While maximum genetic gain was observed for Number of pods per plant followed by weight of single pod. In general, moderate to high

heritability coupled with moderate to high genetic gain indicated the involvement of additive gene action and scope of improvement in these traits through selection.

- Association estimate revealed that dry pod yield was positively correlated at both genotypic and phenotypic levels with kernel yield per plant, number of pods per plant, plant height, 100-kernel weight, sound mature kernels, shelling percent and number of kernels per pod.
- Correlation for dry pod yield was divided into direct and indirect effects by different characters. Highest positive direct effect on dry pod yield was exhibited by kernel yield (0.97) followed by number of pods per plant (0.29) and plant height (0.24).

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