***Review Article***

**GENETIC VARIABILITY AND BREEDING POTENTIAL FOR YIELD AND QUALITY ENHANCEMENT IN GROUNDNUT (*Arachis hypogaea* L.)**

**Abstract**

Groundnut (*Arachis* *hypogaea* L.) displays notable genetic variability in morpho-physiological traits among its genotypes, with polygenic control influencing key characteristics such as kernel yield and dry matter production. Significant phenotypic and genotypic variations exist, with higher phenotypic coefficients suggesting environmental influences on traits like pod and kernel counts. This information is valuable for breeders aiming to mitigate environmental influences while enhancing genetic potential. High heritability for yield-related traits indicates additive gene action's role, crucial for breeding efforts. This is particularly encouraging for groundnut breeding, as it suggests that selection for improved yield traits can be effective in future breeding programs. In terms of seed quality, groundnut genotypes show variability in traits such as seed size, oil, and protein content. These traits, controlled by both maternal and nuclear genetics, exhibit correlations that offer potential for simultaneous improvement. The identification of superior genotypes, especially those with high oleic acid content, is promising for enhancing oil quality and crop improvement. The high oleic acid trait is highly desirable for oil quality and has the potential to meet the growing demand for healthier edible oils, thus offering promising prospects for crop improvement. Overall, understanding these traits is vital for developing groundnut varieties with improved yield and quality characteristics.

**Keywords:** Genetic variability, Morpho-physiological traits, Polygenic control, Heritability, Additive gene action, Seed quality, Oleic acid content and Oil quality.

**INTRODUCTION**

Groundnut is an important food and oil seed crop of *Fabaceae* family. Owing to its significant role in oil production, it is commonly known as "The King of oilseeds." It is cultivated in tropical and sub tropical regions of the world. Peanut kernel is rich in source of energy because of its high oil content (44-50%) and protein content (25-33%). It is also a good source of minerals (Calcium, Magnesium and Iron) and vitamins (B1, B2 and Niacin). It plays a pivotal role in supporting the oilseed economy of India (Javed et al., 2020). Consuming groundnuts has also been associated with additional health advantages. Osteoporosis and diabetes may be decreased and as it is a leguminous plant it increases soil fertility by fixing atmospheric nitrogen. Groundnut production in India is expected to reach 86.54 lakh tons with a productivity of 1953 kg ha-1 over an area of 44.31 lakh hectares (*www. Indiastat.com,* 2023-24). With a yield of 3.01 lakh tons and an average productivity of 984 kg ha-1, it is grown on 3.06 lakh hectares in Andhra Pradesh. High quality seed is essential and desirable to ensure good crop establishment. Though there are several varieties available in groundnut, much information is not available on morpho-physiological, coupled with seed quality and yield traits (Janila et al., 2016). Seed quality plays a vital role for successful crop production in groundnut as in other crops. Lack of timely availability of good quality seeds is a major constraint in groundnut production. For achieving genotype with desirable traits, it is necessary to investigate the inter-relationships between different characters (Dwivedi et al., 2016). The seed technological properties of new varieties have not been studied in detail. Development of high yielding varieties coupled with improved seed quality traits may help in meeting not only food but also nutritional demands.

**MORPHO-PHYSIOLOGICAL TRAITS**

Groundnut (Arachis hypogaea L.) exhibits significant genetic variability in morpho-physiological traits across different genotypes. Studies have shown that these traits are polygenically controlled and influenced by various component characters (Ali *et al*., 2019). Genotypes display significant differences in kernel yield, dry matter production, and partitioning to different plant parts at pre-anthesis and post-anthesis pod filling stages (Ali *et al*., 2019). Kumar *et al*. (2019) and Javed et al. (2020) evaluated 20 groundnut genotypes and revealed that days to 50% flowering, number of pods per plant, 100-pod weight and sound mature kernel had high heritability coupled with high genetic advance as per cent of mean and medium to high GCV, while the traits like primary branches per plant, pod yield and kernel yield had moderate GCV and heritability along with high genetic advance as per cent of mean indicating selection would be effective for these traits. Medium heritability along with low genetic advance as per cent of mean was observed for KL/KW ratio, protein content, oil content and sugar content indicating high influence of environment on expression of these traits. Interestingly, both phenotypic and genotypic variations have been observed in groundnut traits. The phenotypic coefficient of variance was found to be larger than the genotypic coefficient of variation in magnitude for various traits (Poojitha *et al*., 2024). However, quantitative features such as the number of pods and kernels per plant, days to bloom initiation, days to 50% flowering, days to maturity, test weight, shelling percent, and kernel yield per plant showed high heritability, indicating that the variation was caused by additive gene action ( Kumari *et al*., 2020; Poojitha *et al*., 2024). In conclusion, morpho-physiological traits in groundnut genotypes exhibit significant variability, which is crucial for breeding programs. High heritability and genetic advance have been observed for traits like kernel yield, pod yield, root weight, shoot weight, specific leaf area, and proline content, suggesting their potential usefulness in breeding and selection programs for improving groundnut yield (Kumari *et al*., 2020; Javed et al., 2020). Additionally, principal component analysis has revealed that traits such as days to first flowering, days to 50% flowering, number of pods per plant, and shelling percentage account for significant variation among genotypes (Yol *et al*., 2018). The investigation concluded that genotype ICG-8416, with the highest pod dry matter partitioning and lowest total dry matter at harvest, is a high-yielding option. Additionally, certain genotypes demonstrated high photosynthesis and transpiration rates, leading to better yields. ICG-0845, ICG-8316, and ICG-8525 recorded high protein and oil content, which may aid in crop improvement. Traits such as number of kernels per pod, photosynthetic rate, and leaf area at harvest positively correlated with dry pod yield, indicating they should be considered in future breeding programs for higher yields in groundnut (Borkar, V.H and Dharanguttikar, V.M. 2014). Lothe, G. R. and More, S. R. (2022) assessed the physiological indices for growth and yield of groundnut and revealed that, number of mature pods per plant, 100 kernels weight (g), showed maximum influence on dry pod yield (g/plant). The genotypes such as Phule Unnati, ICGV-15311 and ICGV-15303 showed higher yielding ability due to the most promising yield contributing characters like number of mature pods per plant, hundred kernels weight (g), dry pod yield per plant and HI (%).

**SEED YIELD ATTRIBUTING TRAITS**

Groundnut genotypes exhibit significant variability in yield-attributing traits, as demonstrated by several studies. Key yield components include the number of pods per plant, kernels per pod, test weight, shelling percentage, and pod yield (Nisani *et al*., 2023). High genotypic and phenotypic coefficients of variation have been observed for traits such as the number of pods per plant, 100 pod weight, 100 kernel weight, shelling percent, and number of mature kernels, indicating substantial variability for these characteristics (Vinithashri *et al*., 2019). Shrotri *et al.* (2021) and Javed et al., (2020) estimated genetic variability for pod yield and components in thirty groundnut genotypes. High heritability coupled with high genetic advance as per cent of mean was recorded by the kernel yield plant-1, pod yield plant-1, number of mature pods plant-1 and 100 kernel weight indicating that these characters are under additive genetic control. Raza et al. (2018) carried out variability studies in 40 groundnut accessions for 13 characters. The number of primary branches plant-1, 100 seed weight, pod yield plant-1 and kernel yield plant-1 recorded high PCV, GCV, heritability (broad sense) and genetic advance as percent of mean indicating that these characters were governed by additive gene action and simple selection could be used for their improvement. Days to 50% flowering, days to maturity, plant height, number of pods plant-1, number of seeds pod-1, shelling %, harvest index, protein per cent and oil per cent exhibited moderate to low GCV, PCV, high heritability and moderate to low genetic advance. Gali et al. (2021) studied the genetic variability on 21 characters with 66 genotypes of peanut. They revealed that the mean sums of squares owing to genotypes for all the traits were significant. Results of genetic parameters showed that traits viz., number of mature pods per plant, number of immature pods per plant, weight of pods per plant, kernel weight per plant, 100 seed weight showed high genetic variability (GCV and PCV), high heritability (Hbs) coupled with high genetic advance as per cent of mean (GAM), indicating the predominance of additive gene action in these traits. Direct selections for higher phenotypic values of these traits will be effective in improvement of these characters among the genotypes. Interestingly, some studies have found contradictions in the genetic control of yield-related traits. While Vinithashri *et al*. (2019) and Javed et al. (2020) suggest that high heritability and genetic advance as percent of mean (GAM) for most traits indicate the presence of additive gene action, Boraiah *et al*. (2015) reports that the variance due to specific combining ability (SCA) was greater than the variance due to general combining ability (GCA) for most characters, implying a predominance of non-additive gene action. In conclusion, yield-attributing traits in groundnut genotypes are influenced by both genetic and environmental factors. Principal component analysis has shown that days to flowering, number of pods per plant, and shelling percentage are major contributors to variation among genotypes (Danalakoti *et al*., 2024; Yol *et al*., 2018). The identification of genotypes with superior yield-attributing traits, such as Girnar 5 and Girnar 4 (Nisani *et al*., 2023), and the use of genetic transformation techniques (Gantait & Mondal, 2018) offer promising avenues for groundnut improvement programs aimed at enhancing yield potential and stress tolerance. Genotype ICG 14466 was identified as the best genotype for 100 seed weight, pod yield, kernel yield, pod length and kernel length.

**SEED QUALITY TRAITS**

Groundnut (Arachis hypogaea L.) exhibits significant genetic variability in seed quality traits across different genotypes. Several studies have explored various aspects of seed quality in groundnut, including seed size, oil content, protein content, and other nutritional components. Seed size traits, such as seed weight, length, width, and length:width ratio, are controlled by both maternal and nuclear gene effects, with additive genetic effects playing a significant role (Venuprasad *et al.,* 2011). These traits are highly correlated, suggesting the possibility of simultaneous improvement. Oil content, an essential quality trait, shows moderate to high coheritability with other important traits like seed yield, indicating the potential for concurrent improvement (Yusuf *et al*., 2021). Additionally, oil content, linoleic acid, stearic acid, and palmitic acid exhibit significant positive correlations, while oil and protein content show a negative correlation (Viswanatha *et al*., 2020). Interestingly, some studies have found contradictory results regarding the relationship between seed mass and oil or protein content. Dwivedi *et al*. (1990) reports no significant association between seed mass and percent oil or protein contents among 64 genotypes. However, within genotypes, oil content showed a significant linear increase as seed mass increased in graded samples, while no such relationship was observed for protein content. Oleic acid is a crucial seed quality trait in groundnut (Arachis hypogaea L.) breeding programs, with significant implications for nutritional value, shelf life, and marketability. Research has shown that high oleic acid content (>74%) and low linoleic acid content (<10%) are desirable characteristics in groundnut oil (Barkley et al., 2009). In conclusion, groundnut genotypes display considerable variation in seed quality traits, offering opportunities for crop improvement. The complex interplay between different traits, such as the negative correlation between oil and protein content, presents challenges for breeders. However, the identification of superior genotypes for various quality traits (Viswanatha *et al*., 2020) and the potential for simultaneous improvement of multiple traits (Yusuf *et al*., 2021) provide promising avenues for developing improved groundnut varieties with enhanced seed quality characteristics**.** Sharma, S *et al.* (2019) and Javed et al. (2020) analyzed seed quality traits in 58 groundnut germplasm accessions and observed that some of the lines had oleic acid above 80% which also contributes to high oleic to linoleic acid ratio (O/L ratio) that imparts longer shelf life to the oil. These genotypes may further be used for studying genetics of quality traits in groundnut breeding programmes.

**CONCLUSION**

In conclusion, groundnut (Arachis hypogaea L.) shows significant genetic variability in morpho-physiological traits, seed yield components, and seed quality, which are crucial for breeding programs. Traits such as kernel yield, pod yield, and photosynthetic rate exhibit high heritability, indicating their potential for improvement through selective breeding. Seed quality traits like oil content and protein content also show genetic variation, offering opportunities for concurrent improvement. While some contradictory results exist regarding genetic control, genotypes with superior traits, such as ICG-8416 for high yield and ICG-14466 for seed quality, provide promising candidates for developing high-yielding and nutritious groundnut varieties. These findings highlight the importance of genetic diversity in advancing groundnut breeding for better yield, quality, and stress tolerance. The variability in seed quality traits, such as oil content and protein levels, offers the potential for simultaneous improvement in both yield and quality, particularly with the identification of genotypes with high oleic acid content. This could significantly enhance the oil quality and meet the growing demand for healthier edible oils.

**Future Prospects:** Given the promising genetic potential for improving yield and quality traits in groundnuts, breeding programs should focus on selecting genotypes with desirable traits such as higher kernel yield, increased dry matter production, and superior seed quality, including high oleic acid content. Research efforts should further explore the genetic basis of these traits, leveraging the heritable nature of yield-related characteristics for efficient selection. Additionally, integrating molecular breeding techniques could accelerate the identification of superior genotypes and facilitate the development of groundnut varieties that are more resilient to environmental stresses, while also meeting the increasing demand for nutritious and healthier edible oils. The overall goal should be to enhance both productivity and quality, contributing to improved food security and crop sustainability.

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