EVALUATION OF SOME MEDIUM MATURING SOYBEAN (*Glycine max* (L.) Merill) VARIETIES FOR GROWTH AND YIELD RESPONSE IN KEFFI, NASARAWA STATE

***Adeshina D.A., Adeboye S.E., Ogunremi O.C., Okoye C.I., Inegbedion, E. and Osisami, O.**

Department of Agricultural Biotechnology, National Biotechnology Development Agency, (NABDA) Umaru Musa Yar'dua Expressway, Lugbe - Abuja, Nigeria

Corresponding Author: dollyadeshina@yahoo.com

Abstract
Soybean, scientifically known as *Glycine max* (L.) Merrill is commonly known as a "miracle crop" because of its crucial role in maintaining nutritious diets for both humans and animals (Rajni *et al*., 2020). The research took place at the Department of Biological Sciences Unit farm, Botanical Garden at Nasarawa State University, Keffi, during the rainy season of 2015. An RCBD (randomized complete block design) was used to set up the experiment with three replications. The growth and yield response of five varieties of medium-maturing Soybeans were evaluated, observing their genotypic and phenotypic characteristics. Data regarding different growth and yield factors was gathered, encompassing data such as the time taken for emergence (no), duration until 50% flowering (no), the height of the plants (cm), leaf count (no), stem thickness (cm), grain yield per hectare (Kg/Ha), the weight of 100 seeds (Kg), and the volume of oil content (ml). ANOVA and Pearson's correlation were utilized for statistical analysis. The results revealed significant variations ($P<0.05$) among different varieties for all the traits examined. A strong and significant positive correlation was found between grain yield (kg/ha) and total seed weight per plot (kg) (0.5102**), the number of pods per plot (no) (0.3362**), and oil content (0.1874**). Based on these findings, it is recommended that farmers in the Keffi area consider cultivating the TGX 1989 – 45F variety, which demonstrated the highest yield averaging 3733 Kg/Ha in the study.

Keywords: Correlation, medium maturing, oil content, soybean, yield

Introduction

Soybean, scientifically known as *Glycine max* (L.) Merrill is globally acknowledged as a highly valuable crop due to its extensive applications and the exceptional value of its seeds (Jarecki *et al*., 2020). This crop holds great economic significance as its seeds possess a high oil content of 18%, abundant protein content of 40%, and contribute positively to soil fertility, productivity, and profitability. Consequently, it has earned the reputation of being a "miracle crop" (Rajni *et al*., 2020). In Nigeria, soybean cultivation has expanded due to its nutritional and economic importance, serving various domestic purposes. Additionally, it primarily plays a significant role as a vegetable source in the global market (Dashiel, 1993).

Each year, a substantial amount of soybean production worldwide is transformed into various nutritious forms of soybean meal and oil which are essential for human consumption and valuable for animal feeds in the market (Popovic *et al*., 2013). It serves as an excellent source of plant protein which is vital in promoting child and adult health, as it serves as a substitute for animal protein sources which are often insufficient and expensive for low-income households (Seyi, 2014). Soybean cultivation in various states of Nigeria can be achieved effectively with minimal agricultural inputs. Ashraf *et al*. (2012), in their research, had a goal to boost seed production and oil content; they conducted experiments in different geographical regions, and they confirmed that specific plant characteristics should be prioritized when choosing soybean genotypes.

Soybean breeders have a hypothesis that there is a negative correlation between oil content and yield (Babka *et al*., 2003). To effectively identify appropriate selection criteria, it is crucial to understand the association between different characteristics and seed yield. Correlation studies observe the interrelationships among morphological traits and how they individually contribute to yield components (Amsalu *et al*., 2014). Often, these traits exhibit correlations, meaning that selecting one trait may positively or negatively affect other traits (Morakinyo, 1996). Understanding these traits' correlation and heritability is crucial (Morakinyo, 1996). Selecting the most suitable varieties for optimal oil, grain yields, or both poses a challenge for breeders and farmers making it important to study and predict responses to the correlation and heritability of desired traits. This research, motivated by this problem, seeks to evaluate the response between soybean growth and seed yield parameters to achieve maximum outputs in the Keffi community.

Materials and Methods

Study Area

The experimental trial took place at the Nasarawa State University, Keffi's Botanical Garden Unit farm. Nasarawa State lies in Nigeria's Guinea Savannah Zone with geographical coordinates approximately around 8°32′N and 8°18′E. The area experiences yearly rainfall that ranges from 1100 mm to roughly 1600 mm.

Sample Collection
The study utilized five medium-maturing varieties

obtained from the International Institute of Tropical Agriculture (IITA), Ibadan. These varieties, namely TGX 1990 - 106FM, TGX 1990 - 106FM, TGX 1989 – 45F, TGX 1989 – 42F, and TGX 1990 – 78F had maturity dates ranging from 115 to 130 days.

Experimental Design
A Randomised Complete Block Design (RCBD) was used for designing the experiment (Gerald, 2012). The five varieties were arranged randomly across the three replicates ensuring each treatment was represented on each block with a different arrangement to avoid bias (Gerald, 2012).

Site Preparation
Manual tillage was carried out in preparing the soil, and NPK 15:15:15 fertilizer was administered. The plot size measured 2.5m x 1.5m, with a spacing of 50cm between rows and 10cm between individual plants. Two weeks after planting, the field was thinned to have one plant per hill. To control insects during the flowering stage, Cypermethrin + Dimethoate 10EC was applied twice at a rate of 100ml per 15 litres of water. Weeding of the field was carried out manually every two weeks.

Data collection
The data collection methodology used to obtain the growth, oil content, yield, and yield components aligned with the approach Dashiel (1993) and Dashiel and Osho (1998) described. The following were the characters collated:

1. **Days to 50% emergence:** The duration between the time of seeding and when half of each plot's seedlings appeared was recorded.
2. **Days to 50% flowering:** The number of days between sowing and the point at which 50% of the plants reached the flowering stage was documented for the samples analyzed.
3. **Plant height (cm):** The mean height (cm) of three plants was collated per plot weekly until the plants reached 50% flowering.
4. **The number of leaves (no):** The leaves of three plants in the net plot were manually counted and collated weekly until the plants attained 50% flowering.
5. **Stem diameter (cm):** This process was repeated weekly until the plants reached 50% flowering. The thickness of the stem in cm was measured using tape for three plants in each plot then the mean diameter was documented.
6. **Yield (Kg/Ha):** The total weight of mature pods in each plot in Kg was determined using a weighing balance and calculated in Kg/Ha.
7. **Seed weight (Kg**): The total number of seeds in each plot was measured in kilograms.
8. **Number of Flowers (no)**: Three plants were randomly selected from each plot; the flowers were counted and the average was collated.
9. **Leaf Area (cm^2)**: The procedure to measure leaf area is listed below:

The leaf area of each leaf was calculated using the formula:

λ1 = (length x breadth for the leaf) / Area of drawn leaf on a graph sheet
In this equation, λ1 represents the calculated Area for leaf 1.
The mean obtained for all areas was used to calculate the leaf area index, which is then used as a constant to multiply the length and breadth of leaves in all the calculations.

The formula used is as follows: Leaf length (cm) x Leaf breath (cm) x Leaf area index = Leaf area (cm2)

Calculating and measuring Oil content (ml)
The amount of oil per 100 grams of the seeds was calculated. Petroleum ether was used to remove the fat (oil). Following the steps given by Kettle (2013), after the distillation of the resultant solution, the ether extract which was generated and separated was quantified in milliliters.

Statistical analysis
The collected data were statistically analyzed using SAS software version 9.3 (July, 2011), adopting the general linear model. Descriptive statistics and analysis of variance were employed at a significance level of p = 0.05. Pearson correlation was used to analyze the correlation coefficients (r). The General Linear Model (GLM) technique and Analysis of Variance were applied for both pre-harvest and post-harvest characteristics. Duncan's multiple range test (DMRT) separated the means when significant variations were found. The standard linear model for a randomized complete block design (RCBD) can be expressed as follows:

$$Yij = \mu + Ti + Bj + \varepsilon ij$$

Where: Yij represents an observation in treatment I and block j, μ is the overall mean, Ti is the effect of treatment I, Bj is the effect of block j, εij is the random error with a mean of 0 and a variance of σ^2, t represents the number of treatments, and b represents the number of blocks.

To determine the level of association between various traits and yield, as well as among different yield components, correlation coefficients (r) were computed using the statistical analysis system (SAS) program. The estimation of these correlation coefficients followed the Pearson correlation coefficient formula, as outlined by Singh and Chaudhary (1985) and Bozokalfa *et al.* (2010).

$$r_{xy} = \frac{\mathrm{cov}(xy)}{\sqrt{\mathrm{var}(y)}\,\mathrm{var}(x)}$$

In the formula provided:
Cov (x, y) represents the covariance between trait x and y, Var(y) represents the variance of y, and Var(x) represents the variance of x.

Results and Discussion

Analysis of variance for five medium-maturing soybean genotypes
The collected data on yield traits for the five medium-maturing soybean varieties were analyzed using Analysis of Variance (ANOVA). Traits such as 100 seed weight (kg), Grain yield (Kg/ha), number of pods (no), and oil content (ml), among others, were recorded, and the results are presented in Table 1.

The results obtained over the course of eight weeks indicated significant differences ($P < 0.05$) among the ten yield and growth parameters studied, with eight of the characters showing statistically significant differences,

thus indicating some degree of genetic diversity among the studied soybean varieties. However, despite the observed variations, the two characters did not exhibit statistically significant differences (Table 1), The parameters that displayed highly significant differences included stem diameter (cm), number of seeds per pod (NSP), 100 seed weight per plot (HSW) (kg), total seed weight per plot (TSW) (kg), grain yield (Kg/Ha), and oil content (ml), as well as the number of pods (Table 1). In terms of leaf area (cm^2), there were significant differences ($P < 0.05$), while no significant differences were observed for the number of leaves (no) and plant

height (cm) (Table 1). These results are consistent with those presented by Ali *et al*. (2006) and Khanghah and Sohani (1999), after studying several soybean genotypes and obtaining significant differences in all the yield and growth parameters investigated.

The Correlation between yield traits and oil content among five medium-maturing soybean genotypes.

A Pearson correlation was conducted at ($P < 0.05$) to examine the association between the Oil content (ml) and some yield parameters (100 seed weight (HSW) (Kg), total seed weight per plot (TSW) (Kg), Number of pods per plot (NP) (no), Number of seeds per pod (NSP) (no), and Grain yield (Kg/Ha) for five Soybean varieties. The results obtained are shown in (Table 2). There was a positive and highly significant correlation between Grain yield (kg/ha) and total seed weight per plot (kg) (0.5102**), number of pods per plot (no) (0.3362**), and oil content (0.1874**); also, positive and significant correlation coefficients were obtained between Grain yield (Kg/Ha) and Number of seeds per pod (no) (NSP) (0.8432*) and 100 seed weight (HSW) (Kg) (0.6291*). The degree (strength) and kind (direction) of a link between characters is measured by the correlation coefficient (r) (Moradi and Salimi, 2012).

Table 1: An analysis of variance showing the five medium-maturing soybean genotypes

Source	DF	No of leaves	Stem diameter	Leaf area	Plant height	No of pods	100 seed weight per plot	Total seed weight per plot	No of seeds per pod	Grain yield	Oil Content
Genotype	4	3355.758^{ns}	2612.614**	45.663*	574.760^{ns}	12866.133**	14.844**	0.439**	5.333**	100344.88**	488.020**
Replicate	2	5756.275^{ns}	7052.730^{ns}	36.545^{ns}	17046.110^{ns}	330.533^{ns}	5.239^{ns}	0.035^{ns}	0.533^{ns}	450.643^{ns}	0.078^{ns}

Means were separated using LSD, ns- not significant, *0.05 significant difference, **0.01 highly significant difference, No of leaves (no), Stem diameter (cm), leaf area (cm^2), Plant height (cm), No of pods (no), 100 seed weight per plot (kg), Total seed weight per plot (kg), No of seeds per pod (no), grain yield (kg/ha), Oil content (ml)

Table 2: Correlation between Grain yield and some yield parameters in medium maturing varieties

	Oil Content	No of seeds per pod (NSP)	100 seed Weight (HSW)	Total seed weight per plot (TSW)	No of pods per plot (NP)	Grain yield
Oil Content	1					
NSP	0.59481**	1				
HSW	0.64714**	0.42603^{ns}	1			
TSW	0.02175^{ns}	0.56993^{ns}	0.19294^{ns}	1		
NP	0.26273^{ns}	0.61495^{ns}	0.42603*	0.56993**	1	
Grain yield	0.1874**	0.8432*	0.6291*	0.5102**	0.3362**	1

ns- not significant, *0.05 Significant difference, ** 0.01 highly significant difference, Oil content (ml), No of seeds per pod (no), 100 seed weight (kg), Total Seed weight(kg), No of pods per plot (no), Grain yield (kg/ha)

The positive and significant correlation between the analysed parameters demonstrates that the improvement in one trait will equally increase the other trait it is associated with if the necessary conditions for healthy growth and environment are met, this was buttressed by Salimi (2012) in his results he observed that increasing the number of seeds per pod will result in higher grain output and oil content. Furthermore, Moradi and Salimi (2012) also supported this as they reported a significant correlation between yield parameters and Oil content when the varieties' studies are under the same biological and environmental elements and are subjected to similar ecological and environmental issues despite their varying genetic constituents.

This finding is further supported by Ashraf *et al*. (2012), who discovered a significant and positive association between yield, leaf area, pods generated per plant, and oil content, indicating a beneficial relationship between these factors. Like other crops, soybeans have a complicated nature and a variety of factors that affect seed production. Therefore, it is essential to understand the yield-contributing traits and how they relate to one another to yield to establish effective selections for high yields.

In a previous study on multiple Soybean varieties by Ali *et al*. (2003), interactions between yield and its parameters were observed. The researchers discovered a significant positive correlation between seed yield per plant and all the examined parameters, consistent with the current study's findings. The authors emphasized that the number of pods per plant (no), number of seeds per pod (no), and 100-seed weight in kilograms were the key components influencing yield (Kg/Ha). Among these factors, the number of pods per plant, number of seeds per pod (no), and 100-seed weight (Kg) positively impacted yield per plant. In line with the present study, Jagdish *et al*. (2000) highlighted the importance of focusing on the number of pods per plant (no), 100 seed weight (Kg), and seed quality for soybean grain improvement.

Similar to the outcomes of this study, Ashraf *et al*. (2012) also stated that the number of pods per plant had the highest genotypic association with seed output in soybeans. They stated that it is critical to observe the contributions of traits to yield to guide optimal varietal selection for crop improvement studies. They buttressed

their study points out that varieties with a higher seed output tend to have higher oil content.

Conclusion

In this study, positive correlations were observed between the number of pods (no), the 100 seed weight (Kg), and the total seed weight per plot (Kg). However, a correlation was not observed between the number of seeds per pod (no), the total weight of seeds per plot (Kg), and oil content (ml). Correlation analysis plays a crucial role in understanding the relationship between yield and its components, aiding in the selection of suitable varieties for specific geographical locations (Moradi and Salimi, 2012). A significant positive association between two desirable traits, such as oil content and yield, is advantageous as it indicates the simultaneous improvement of these traits in the medium-maturing soybean varieties studied. Conversely, a negative correlation would hinder the simultaneous expression of both traits. This finding aligns with the research conducted by Rajanna *et al*. (2000), who reported a significant and positive correlation between the number of pods per plant (no) and grain yield (Kg/Ha), as well as with Chamundeswori and Aher (2000) findings that grain yield exhibited a positive correlation with the number of pods per plant.

Recommendation

The study revealed that the five medium-maturing soybean varieties varied significantly in their oil content and seed yield. This made it evident that selecting a variety appropriate for the location will boost seed output. Farmers interested in grain yield and oil content are advised to adopt varieties TG 1989 - 45F and TG 1989 - 42F, which achieved the maximum grain yield and oil content, respectively.

Declaration of interest

The authors have no relevant financial or non-financial interests to disclose.

Acknowledgement

We deeply appreciate Prof. Abdullahi Mustapha, the Director General of the National Biotechnology Development Agency (NABDA), for founding the NJBR - NABDA Journal of Research, and Dr. (Mrs.) Rose Gidado, the director of the agricultural biotechnology department, for her mentorship and guidance. The International Institute of Tropical Agriculture (IITA), Ibadan, provided the enhanced seeds for our study, and we are grateful for their assistance.

References

1. Ali, N., Arshad, M. and Ghafoor, A. (2006). Character correlation and path coefficient in Soybean *Glycine max* (L.) Merrill. *Pakistan Journal of Botany 38(1):121-130*.

2. Amsalu, A., Geremew, A. and Mekbib, F. (2014). Correlation and Path Coefficient Analysis Study among Seed Yield and Oil Content in Ethiopian Coriander (*Coriandrumsativum* L.) Genotypes. *International Journal of Plant Breeding and Genetics, 8: 224-240*.

3. Ashraf, M., Meseka, S. and Ngalamu, T. (2012). Performance of Soybean (*Glycine max* L Merill) genotypes under different planting dates in Sennar State of the Sudan. *Journal of Applied Biosciences 49: 3363 - 3370*.

4. Babka, H.L., Chung, J., Cregan, P.B., Graef, L., Lee, D.J., Shoemaker, R.C. and Specht, J.E. (2003). The seed protein, oil and yield QTL on Soybean linkage group I. *Crop Sci. Journal 2003 Vol 43 (1053-1067)*

5. Bozokalfa, K. M., Esiyokhulya, D. I. and Kaygisiz, T. A. (2010). Estimates of genetic variability and association studies in quantitative plant traits of Eruca spp. Landraces. *Genetika*, *Vol.42, No.3, 501-512.* DOI: 10.2298/GENSR1003501B

6. Chamundeswori, N. and Aher, R.P. (2003). Character association and component analysis in Soybean (*Glycine max* L. Merril). *Annals Biol. 19 (2)* :199-203.

7. Dashiell, K.E. (1993). Soybean production and utilization in Nigeria. Paper presented at the National workshop on small-scale and industrial level processing of Soybeans, held at IITA, Ibadan, 27th-29th July.

8. Dashiell, K.E. and Osho, O. (1998). Expanding Soybean production, processing and utilization in Nigeria. In R.S.B. Ferris(ed). Post-harvest Technology and Commodity Marketing. Proceedings of a post-harvest Conference, 29 Nov.1 Dec.1995, Accra, Ghana. (IITA Ibadan, Nigeria), pp: 151-156.

9. Gerald, E.D. (2012). *Randomized complete block designs*. Jean Mayer USDA Human Nutrition Research Center on Aging, Tufts University,711 Washington Street, Boston, MA 02111.

10. Jagdish, S., Parmar, R.P., Singh, J. and Yadav, H.S. (2000). Assessment of genetic variability and selection parameters in the early generation of soybeans. *Advance Plant Science.* 13:227-232.

11. Jarecki, W., Buczek, J. and Janczak-Pieniazek, M. (2020). Soybean (*Glycine max* (L.) Merr.) response to commercial inoculation with *Bradyrhizobiym*

Japonicum. Applied Ecology and Environmental Research 18(5): 6713 - 6724.

12. Kettle, A. (2013). *Extraction of oil content from oilseeds by accelerated solvent extraction.* Thermo Fisher Scientific, Sunnyvale, CA, USA

13. Khanghah. H.Z. and Sohani, A.R. (1999). Genetic evaluation of some important agronomic traits related to seed yield by multivariate of soybean analysis methods. *Iranian Journal Agricultural Science.* 30:807-816.

14. Moradi, S. and Salimi, S. (2012). Effect the correlation, regression and path analysis in Soybean genotypes *Glycine max. (L.)* Under moisture and normal conditions. *International Journal of Agronomy and Plant Production.* 3(10):447-454.

15. Morakinyo, J.A. (1996). Heritabilities Correlation and expected responses to a selection of some yield components in grain Sorghums (*Sorghum bicolor* (L.) Moench). *Nigerian Journal of Genetics.11:48-54.*

16. Popović, V., Miladinović, J., Tatić, M., Đekić, V., Dozet, G., Đukić, V. and Grahovac, N. (2013). Stability of soybean yield and quality components. *African Journal of Agricultural Research*, *8*(45), 5651-5658.

17. Rajanna, M.P., Viswanatha, S.R., Kulkarni, R.S.

and Ramesh, S. (2000). Correlation and path analysis in Soybean (Glycine max (L.) Merril). *Crop Res Hisar. 20(2): 244-247.*

18. Rajni, M., Beenu, T., Ankit, G. and Vikas, K. (2020). Soybean (*Glycine max*). Oil seeds: Health Attributes and Food Applications Springer Publishers, Singapore *10.1007/978-981-15-4194-0_1.*

19. Rezai, A. and Siahsar, B. (1999). Correlation and path coefficient analysis of morphological and phonological traits associated with yield in soybean Glycine max (L.) Merrill. *Iranian Journal Agricultural Science* 30:685-696.

20. Seyi, T. (2014). Soyabeans Supply Business Posted in Grain Market Report, Local Marketing report.www.royalfarmproduce.com.www.agron.iastate.edu/courses/agron212/readings/Soyhistory.htm

21. Singh, R. K. and Chaudhary, B. D. (1985). *Biometrical methods in quantitative genetic analysis*. New Delhi, India: Kalyani Publisher, New Delhi, India, pages: 318.