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MULTI-LOCATIONAL ASSESSMENT OF SOYBEAN MORPHO-AGRONOMIC PERFORMANCE AND SEED YIELD

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Abstract
Commonly referred to as the miracle crop of the 21st century, soybean [Glycine max (L. Merrill)] is valuable for human food and animal feed, due to its high protein content. However, its cultivation in Nigeria is normally characterized by low yield and poor nutrient content, emanating from wrong choice of genotypes grown and inappropriate management practices by local farmers. Study was conducted at the Teaching and Research Farms of Ladoke Akintola University of Technology, Ogbomoso, Oyo State and the Federal University Wukari, Taraba State during the 2015 and 2016 cropping seasons to assess adaptability and agronomic trait performance of 37 soybean genotypes on the field while the harvested seeds were evaluated for yield traits. Data collected on the morphometric traits (days to flowering, pod maturity, harvest), seed yield traits (pods per plant, branching pattern, seeds per pod, 100 seed weight and yield/ha) and proximate nutritional content (crude protein, crude fiber, carbohydrate, moisture, ash and oil) were subjected to Analysis of Variance with mean separated using Duncan Multiple Range Test (DMRT), at 5% probability level. Results of the study revealed that TGM954 exhibited yield superiority (992.05kg/ha) over other genotypes, while TGM136 attained maturity earlier at 75days and TGX1904-6F produced the largest seed size, with the highest 100 seed weight (14.50g). It is concluded that, for earliness, high yield and large seed size, TGM136, TGM954 and TGX1904-6F respectively should be considered for cultivation.

Keywords: genotypes, seed yield, nutritional content, traits, maturity.

INTRODUCTION

Soybean is tolerant to a wide range of soil conditions but does better on warm, moist, and well drained fertile loamy soils, that provide adequate nutrients and good contact between the seed and soil for rapid germination and growth (Hans *et al.*, 1997). According to Ngeze (1993), soybean does well in fertile sandy soils with pH between 5.5 and 7.0 and can tolerate acidic soils than other legumes but does not grow well in water logged soils. However, high yield is also possible in loamy textured soil (Ferguson *et al.*, 2006). Seed development in soybean normally requires much water and nutrient supplies from the plant (IITA, 2009). Also, at this stage, redistribution of nutrients take place, when the soybean plant itself supplies about 50% of the nitrogen (N), phosphorus (P) and potassium (K) from its vegetative parts and the remaining half from the nitrogen fixation and nutrient uptake by the roots.

According to Rienke and Joke (2005), typically, soybean is a short day plant, physiologically adapted to temperate climatic conditions, although some have been adapted to the hot, humid, tropical climate. In the tropics, the growth duration of adapted genotypes is commonly 90-110 days (Osafo, 1997). The relatively short growth duration is primarily due to sensitivity to the day length. This affects the extent of vegetative growth, flower induction, production of viable pollen, length of flowering, pod filling and maturity characteristics (Norman *et al.*, 1995).

Soybean is grown primarily for the production of seed, because it has numerous uses in the food and industrial sectors, representing one of the major sources of edible vegetable oil and of proteins for livestock feed use. It commonly used in various food products, including tofu, soya sauce, simulated milk and meat products. Soybean meal is used as a supplement in feed rations for livestock. Soybean seed coat pigmentation could be yellow, green, black, mottled and/or several shades of brown, but most commercial cultivars are yellow. Number of pods and seeds per pod are the most important yield components of soybean.

It was first introduced to Africa in the early 19th century, through Southern Africa (Ngeze, 1993) and is now widespread across the continent (Tukamuhawba *et al.*, 2002). However, serious attempts to establish the production of the crop in Ghana started in the early 1970s (Shurtleff and Aoyagi, 2007), as a result of collaborative breeding efforts of Ghana's Ministry of Food and Agriculture (MoFA) and the International Institute of Tropical Agriculture (IITA) (Tweneboah, 2000). Nigeria is the largest producer of soybeans for food in West and Central Africa (Sandar, 2012).

Assessment of extent of genetic relatedness/diversity in germplasm can be achieved through morphological characterization and the characterized material would help plant breeders to select the genotypes to be utilized in hybridization program (Ghafoor *et al.*, 2002). Phenotypic evaluation of soybean germplasm is a fundamentally important step in the management of collections and assessment of genetic diversity. The knowledge of the genetic variation within genotypes from germplasm collections is essential to the choice of strategy to incorporate useful diversity into the program, to understand the evolutionary relations among accessions, to better sample germplasm diversity and to increase conservation efficiency (Fu, 2003).

The research is aimed at identifying soybean genotypes that are well adapted to the agro-ecologies under study through morpho-agronomic assessment and yield performance.

MATERIALS AND METHODS

Experimental site

The study was conducted during the 2015 and 2016 planting seasons, at the Teaching and Research Farms of the Ladoke Akintola University of Technology, Ogbomoso and the Federal University Wukari, Wukari, Nigeria. The Teaching and Research Farm of the Ladoke Akintola University of Technology (at the longitude 4^0 10'E and latitude 8^0 10'N), is located in the Guinea Savannah Zone of Southwest Nigeria (Aremu *et al.* 1997). The temperature ranges from 28^0C to 33^0C, with a relative humidity of about 74% (all year round), except in January when dry wind blows. Rainfall distribution is bimodal and extends from about eight to nine months of the year. The soil of the experimental site is moderately drained, characterized by a sandy-loam texture (Ogungbile *et al.*, 1999). Wukari is situated on latitude 7^0 52'17.00^{0}N and longitude 9^0 46'40.30^{0}E. It falls within the guinea savannah of North-eastern Nigeria with the annual rainfall of 1058mm-1300mm and the relative humidity dropping to about 15%, alongside with the annual temperature of 28^0C and 30^0C. Its characteristic alfisol soil is clay enriched, with subsoil that has relatively high native fertility is suitable for the cultivation of many crops such as yam, soybean, sorghum, maize, rice and other assorted fruit and vegetables (Franke and Rufino, 2010).

Collection of genotypes

The collection comprised of 37 varieties; four soybean varieties were obtained from the College of Agricultural Resaerch, Yandev, Benue state. Additional five varieties were obtained from the Institute for Agricultural Research, Samaru, Kaduna state, while twenty nine (of diverse origins and place of cultivation) were obtained from the International Institute for Tropical Agriculture, Ibadan, Oyo state.

Experimental design

The experimental fields were laid out in Randomized Complete Block Design (RCBD), with three replications for each of the 37 soybean varieties. Beds of dimensions 2×5m were horizontally aligned, with 50cm distance between beds, 1m demarcation between replications and 2m border row across the length and breadth of the experimental field. At the experimental site, planting distance of 50cm intra-row and 75cm inter-row spacing was used, thus there were 35 soybean plant stands per bed. Thus, the dimension of each of the experimental fields was 96m×26m (2,496m^2) and the total number of soybean

plant stands per field was 5,180. Soybean seeds were sown directly into the raised bed, using the drilling planting method, by placing seeds inside the shallow dug holes of about 2cm depth and covered with soil.

Field management

Plants were raised following the standard agronomic and cultural practices recommended for soybean cultivation, as contained in the IITA handbook of Soybean production.

Data collection

A minimum of five plants (exempting the border plants), were randomly selected and tagged from each variety and each of the replications for the purpose of data collection. Observations were made on the morphological as well yield performance characteristics of the soybean seeds and plants using the parameters such as Seed coat and hilum colour; Seed coat texture and luster; 100 seed weight; Seedling shoot length; Seedling root length; Full seedling length; Plant growth habit; Plant height; Plant pubescence; Total number of primary branches per plant; Total number of secondary branches per plant; Days to flowering; Pubescence on pod; Pod shattering attribute; Number of pods per plant; Pod length; Number of seeds per pod; Days to physiological maturity of pods; Days to harvest; Seed yield (kg/ha).

Statistical Analysis

Analysis of variance (ANOVA) conducted through the SPSS (23rd edition) statistical package at 5% probability level and the mean separated using the Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Morpho-agronomic and Yield Traits across Locations

The mean yield and yield-related traits for 37 soybean varieties grown during the 2015 and 2016 planting seasons, in the two locations of Ogbomoso and Wukari were computed and presented in Table 1. The average number of days oberved for soybean seed to emerge for the two locations under study was 5.88. However, TGM111 (Wukari) emerged in just 5.00 days. Plant height ranged from 24.25cm for TGM555 to 95.00cm for TGM577 in Wukari. TGX1904-6F (Ogbomoso) had the largest 100 seed weight (30.20g), while the least value (8.40g) was recorded for TGM577 with the mean value of 15.45g. Number of pods per plant was highest (342.00) for TGM111 (Wukari), yet TGM555 (Wukari) recorded the least number of pods, with the average number of pods borne by the soybean varieties in the two locations under study was 101.87.

Number of primary branches per plant ranged from 2.0 for TGM574 to 14.0 for TGM577 but, the two variations recorded an average of 6.12. Average number of days to flowering was 39.03, although 44.00 days was obtained for TGM555, while the lowest value (28.00) was recorded for TGM954. TGM577 recorded the highest number of seeds per pod (4.00), while the least number of seeds per pod (2.00) was observed in TGM584 and the average number of seeds per pod for both locations was 2.72. TGM553 matured in 81 days while it took TGX1904-6F 108 days to attain maturity. The average number of days taken by pods to attain maturity however was 89.97. TGM111 recorded the highest seed yield (1455.30kg/ha), while the yield was 120.09kg/ha for TGM574. However, the average seed yield for the two locations was 523.97kg/ha.

Table 1: Yield and Yield-Related Traits across Two Locations (Ogbomoso and Wukari)

SN	TRAIT	MEAN	MINIMUM	MAXIMUM
1	Days to emergence	$5.88_{\pm 0.0490}$	5.00 (T111W16)	7.75 (T1904-6FW16)
2	Plant height at maturity (cm)	$57.21_{\pm 1.3959}$	24.25 (T555W16)	95.00 (T577W16)
3	100 seed weight (g)	$15.45_{\pm 0.6253}$	8.40 (T577W16)	30.20 (T1904-6FO16)
4	Pods per plant	$101.88_{\pm 5.3643}$	20.30 (T555W16)	342.00 (T111W16)
5	Primary branches	$6.12_{\pm 0.2089}$	2.00 (T577W16)	14.00 (T574W16)
6	Days to flowering	$39.03_{\pm 0.2901}$	28.00 (T954O15)	44.00 (T555W;O16)
7	Seeds per pod	$2.72_{\pm 0.0339}$	2.00 (T584W16)	4.00 (T577O16)
8	Days to pod maturity	$89.97_{\pm 0.2850}$	81.00 (T553W15)	93.80 (T584W16)
9	Days to harvesting	$102.6176_{\pm 0.3485}$	92.00 (T954W15)	108.00(T1904-6FW;O16)
10	Yield (kg/ha)	$523.9683_{\pm 20.6447}$	120.09 (T574W15)	1455.30 (T111W16)

O15 = Ogbomoso, 2015; W15 = Wukari, 2015; O16 = Ogbomoso, 2016; W16 = Wukari, 2016

Mean, Mean Square, Coefficient of Variation, Maximum and Minimum Values of Metric Traits

There exist wide variations in the yield-related traits measured among the twenty five varieties of soybean grown during 2016 planting season (Table 2). Ranging from hundred seed weight (g) to total seed yield (kg/ha), the soybean varieties exhibited significant difference in almost all measured values, except for the number of days to emergence and their tolerance to pest disease incidence. The highest values for Coefficient of variation were recorded for seed yield (53.40%), number of seeds per plant (50.41%), number of pods per plant (48.94%), and number of secondary branches (32.26%), while number of days to harvesting had the least value (5.01%). Except for the number of secondary branches, there existed significant difference in the values of all characters measured. The number of days to emergence varied significantly between the soybean varieties, with an average of 6.17 days. While TGM584 and TGM94 emerged in 5.00 days, TGX1904-6F took 7.75 days to emerge, Difference in weight of 100 seeds for the soybean varieties was highly significant, where TGM116 has the least (7.00g), TGX1904-6F recorded the highest value (14.50g), with a mean of 10.53g. Significant variation was recorded for plant height at maturity, with an average value of 56.34cm. However, the highest value (95.00cm) was recorded for TGM577, while the least (27.67cm) was observed in TGX1448-2E. The number of pods per plant varied significantly, with TGM547 recording the highest value (288.15) and TGM574 having the least number (30.50) of pods per plant. On the average, however, the number of pods per plant stood at110.63.

Variations in the number of primary and secondary branches borne by the soybean plants varied significantly. While TGX1448-2E recorded the highest values for both number of primary and secondary branches, at 7.00 and 11.00 respectively, the least value for both were recorded for TGM136 and TGM94, at 2.00. However, the mean values for number of primary and secondary branches across the entire varieties grown were 3.05 and 5.38 respectively. There was a significant difference in number of seeds per pod, with the highest being 3.30, for TGM94 and the least value (2.0) recorded for TGM95, TGM14, TGM112, TGM584, TGX1904-6F and TGM574, thus putting the average number of seeds per pod at 2.48. Number of days taken by pods to attain physiological maturity and the corresponding number of days to harvesting were significantly different among the soybean varieties. TGM136 recorded the least values (74.60 days and 89.00 days) for number of days to pod maturity and number of days to harvesting. Highest value for number of days to pod maturity (93.80) was recorded for TGM584. Also, TGM584 and TGX1904-6F were due for harvest 108.00 days, being the highest value. In terms of seed yield (kg/ha), which reflects a relatively high

significant variation, the highest value (992.05kg/ha) was recorded for TGM954, while the least yield (120.09kh/ha) was observed in TGM574 and the average yield for the soybean population was 368.65kg/ha.

Table 2: Mean, Mean Square, Co-efficient of Variation Maximum and Minimum Values of Metric Traits

SN	TRAIT	MEAN	M.SQUARE	COV (%)	MAX.	MIN.
1	Days to emergence	$6.17_{\pm 0.0464}$	0.43*	7.51	7.75	5.00
2	100 seed weight (g)	$10.53_{\pm 0.1418}$	5.54*	13.47	14.50	7.00
3	Seedling shoot length (cm)	$13.29_{\pm 0.1779}$	8.10*	13.39	18.00	9.00
4	Seedling root length (cm)	$6.94_{\pm 0.1552}$	6.04*	22.37	12.40	4.00
5	Plant height at maturity (cm)	$53.34_{\pm 1.2505}$	514.41*	23.45	95.00	27.67
6	Number of pods per plant	$110.63_{\pm 5.4139}$	8890.63*	48.94	288.15	30.50
7	Pod shattering	$0.21_{\pm 0.0409}$	0.66*	23.48	1.00	0.00
8	Number of primary branches	$3.05_{\pm 0.0894}$	2.32*	29.29	7.00	2.00
9	Number of secondary branches	$5.38_{\pm .01735}$	3.98*	32.26	11.00	2.00
10	Pod length (cm)	$3.41_{\pm 0.0436}$	0.53*	11.99	4.20	2.05
11	Days to flowering	$36.40_{\pm 0.4120}$	55.58*	11.32	44.00	28.00
12	Pest-Disease incidence	$0.27_{\pm 0.4460}$	0.79*	16.52	1.00	0.00
13	Number of seeds per pod	$2.45_{\pm 0.0308}$	0.25*	12.57	3.30	2.00
14	Number of seeds per plant	$232.58_{\pm 11.7244}$	41372.04*	50.41	575.00	64.05
15	Days to pod maturity	$87.51_{\pm 0.4986}$	92.08*	5.70	93.80	74.60
16	Number of days to harvesting	$100.77_{\pm 0.5047}$	88.90*	5.01	108.00	89.00
17	Seed length (cm)	$0.05_{\pm 0.0130}$	6.67*	19.65	0.90	0.50
18	Seed width (cm)	$0.40_{\pm 0.0074}$	0.01*	17.90	0.60	0.20
19	Inter-node distance (cm)	$3.42_{\pm 0.8900}$	1.76*	25.51	5.10	2.00
20	Seed yield (kg/ha)	$368.65_{\pm 19.6826}$	111336.89*	53.40	992.05	120.09

* = Significant at $P \leq 0.05$

Correlation of Yield and Yield-related Traits

The correlation study revealed that there was a positive relationship between the seed yield (kg/ha) and number of days to emergence, 100 seed weight (g), number of pods per plant (cm), number of primary and secondary branches, pod length, number of days to flowering, number of seeds per pod, seeds per plant, days to pod maturity and inter-node distance (cm).It further showed a negative association with plant height at maturity (cm), seed length (cm) and seed width (cm). However, 100 seed weight, number of pods per plant, number of secondary branches, pod length, number of seeds per plant and number of days to pod maturity exerted highly significant effect, but seed length was significantly negative (Table 3). The result also revealed a positive association between number of seeds per plant and other yield parameters measured, except seed length that showed a negative relationship. 100 seed weight expressed a positive and significant correlation with pod length and seed width, while it is negatively correlated with plant height at maturity and seed length.

CONCLUSION

Traits that contributed majorly and exhibited significant effect on seed yield (kg/ha) were 100 seed weight, number of pods per plant, secondary branches on which the pods were usually borne and the total number of seeds per plant. Others are number of days taken by the plant to attain pod maturity. Conversely, seed length associates negatively with seed yield, indicating that the longer the seed length, the fewer the number of seeds contained in the pod, thus reducing the number of seeds produced by the plant and the corresponding yield. The observed significant differences in yield and other morphological characters among the genotypes was in consonance with the earlier finding of Ugur *et al.* (2005), that reported that morphological traits such as number of branches, number of pods and days to physiological maturity are dependent on the genetic constituent of such genotypes.

Table 3: Correlation of Yield and Yield-Related Traits in Soybean

	DTE	100 Seed Weight (g)	PHAM (cm)	NOP/P	PB	SB	PL (cm)	DTF	S/Pod	S/Plant	DTPM	SL (cm)	SW (cm)	Internode (cm)
100 Seed Weight (g)	.01													
PHAMM (cm)	.05	-.26**												
NOP/P	.17	.03	-.05											
PB	-.01	-.05	-.12	.57**										
SB	.11	.08	.24*	.50**	.51**									
PL (cm)	.15	.22*	-.28**	.20*	.18	-.03								
DTF	.30**	.20	.34**	.09	.15	.28**	.20*							
S/Pod	-.27**	.04	-.02	-.03	-.04	.01	.31**	-.13						
S/Plant	.21*	.05	.03	.75**	.09	.30**	.25*	.05	.14					
DTPM	.18	.04	.19	.15	-.01	.16	.22*	.39**	.03	.30**				
SL (cm)	-.03	-.25*	-.02	-.14	.04	-.07	-.09	-.27**	-.15	-.19	-.19			
SW (cm)	.09	.20*	.03	-.22*	-.05	-.04	-.02	.25*	-.06	-.22*	-.20*	.01		
Internode (cm)	.10	-.05	-.09	.17	.21*	-.06	.25*	.03	.02	.23*	.28**	.07	-.17	
S. yield (kg/ha)	.18	.29**	-.03	.72**	.08	.31**	.30**	.09	.15	.97**	.31**	-.22*	-.15	.18

* Significant at 0.05 probability level, ** Significant at 0.01 probability level

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