

Variation in Grain Yield and Other Agronomic Traits in Soybean Evaluated at Makurdi (Southern Guinea Savanna Ecology), Nigeria.

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Abstract
Twenty five varieties of soybean were evaluated in Makurdi (southern Guinea Savanna ecology), Nigeria, with the objective of identifying high yielding genotypes that could replace the popularly grown variety (TGX 1448 – 2E). Highly significant genotypic differences were observed for all the characters (days to flowering, days to podding, days to maturity, plant height, height of lowest pod, number of pods/plant, 100 seed weight, haulm yield and grain yield) studied. Seven varieties, namely TGX1990-98F, TGX1991-10F, TGX1990-86F, UG5, TGX1485-1D, TGX1990-48F and TGX1990-80F yielded higher than TGX 1448 – 2E and were identified as possible candidates for the replacement of TGX 1448 – 2E in Makurdi. Further studies on the evaluation of these seven varieties across more locations within the southern Guinea Savanna ecology of Nigeria are required prior to location specific selection and recommendation.
Keywords: southern Guinea Savanna, genotype, variety, yield, soybean.

1.0 INTRODUCTION

Soybean is one of the most important World crops with higher protein content than any other pulse crop and currently the world's most important source of vegetable oil that is a rich source of vitamin E in human nutrition (Giller and Dashiell, 2007). It therefore serves as a cheap source of protein in meeting human dietary requirement in poor countries of the World, such as Nigeria. The crop is also very important in animal nutrition and virtually every part of the plant is fed to livestock. Apart from its direct use by man and livestock, soybean is used in the manufacture of various products in the confectionery, pharmaceutical and printing industries.

Soybean is widely cultivated in the tropical, subtropical and temperate regions of the world (Giller and Dashiell, 2007) with a steady worldwide annual increase in production (Liu, 1997) aimed at reducing the demand-supply deficit. Despite this global effort, Nigeria has a very low annual production of 439,000t/ha, accounting for only 0.25% of the world annual output of 173 million tons between 1999 and 2003 (FAO, 2005). This low annual production output of soybean grains in Nigeria could be attributed to small area of land devoted to the cultivation of the crop and low yield of 0.946t/ha (Tefera, 2011). While the problem of small area of land devoted to the crop could be solved by simply increasing the hectarage, the problem of low yield could only be resolved through concerted breeding effort.

The International Institute for Tropical Agriculture (IITA) has a global mandate to improve soybeans productivity and use (Dashiell et al., 1991; Tefera et al., 2009) and has recently developed some varieties of soybean that need to be evaluated. The identification of high yielding varieties from such breeding effort will obviate the problem of low yield and enhance the income of soybean farmers. The bulk soybean produced in Nigeria is from the southern Guinea Savanna ecology of the country (Okpara and Ibiam, 2000; Chiezey et al., 2001) where commercial production is concentrated (Ojo and Ayuba, 2012). Encouraging results from previous evaluation of IITA developed varieties (Akande et al., 2007; Aduloju et al., 2009), indicate the suitability of southern Guinea Savanna ecology of Nigeria for the production of soybean and have identified some higher yielding genotypes (Akande et al., 2007) compared to the popularly grown TGX 1448 – 2E (Ojo and Bello, 2010). This indicates that the recently developed varieties are likely to perform better than the previously developed versions.

The objective of this research work was to evaluate some recently developed varieties of soybean towards identifying high yielding varieties that could replace TGX 1448 – 2E in the southern Guinea Savanna ecology of Nigeria.

2.0 MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out during the 2011 and 2012 cropping seasons between the months of June and November at the Teaching and Research Farm of the University of Agriculture Makurdi (lat. 7^0 $41^'$N, long. 8^0 $28^'$E, 97m asl.) .The location falls within the southern Guinea Savanna agro-ecological zone of Nigeria.

2.2 Soybean Genotypes

Twenty five (25) varieties (21 recently developed and 4 previously developed varieties) were evaluated in the course of the research. The previously developed varieties include TGX 1835 – 10E, TGX 1448-2E (late maturing and moderately resistant to rust), TGX 1485-1D (early maturing and highly susceptible to rust) (Twizeyimana et al., 2011) and UG 5 (a highly rust resistant accession (Kawuki et al., 2003) with unknown pedigree (Twizeyimana et al., 2011)). The variety TGX 1448-2E is the most popular variety currently in production in the southern Guinea Savanna of Nigeria (Ojo and Bello, 2010).

2.3 Experimental Layout

Twenty five varieties of soybean were planted out in a randomized complete block design with four replications on 30th June 2011 and 2nd July, 2012 respectively. The size of each plot was $12m^2$. Each plot consisted of 4 ridges of 4m length, spaced 0.75m apart. Seeds were drilled into the crest of the ridges at a depth of 2cm and later thinned down to 26 plants per meter after emergence. The field was manually weeded at two (2WAP) and five weeks after planting (5 WAP). Only single superphosphate fertilizer (SSP) was applied at the rate of 36kg P_2O_5/ha immediately after the first weeding at 2 WAP. Harvesting was carried out in November of each year.

2.4 Data Recording and Analysis

The following observations were recorded during the conduct of the experiment:

(i) Days to flowering, recorded at flowering of 50% of plants within a plot
(ii) Days to 50% podding, recorded at podding of 50% of plants within a plot
(iii) Days to maturity: recorded at the time 50% of the plants within a plot senesced and turned brown
(iv) Height of lowest pod, from the mean of ten randomly selected plants in each plot
(v) Plant height at maturity, from the mean of ten randomly selected plants in each plot
(vi) Number of pods per plant, determined from the mean of five randomly selected plants in each plot.
(vii) 100-seed weight, determined from the mean of duplicate 100 seed-weights taken from seed lot of each plot
(viii) Haulm yield in tons/ha, estimated from haulm yield/plot
(ix) Grain yield in tons/ha, estimated from grain yield per plot
(x) Rust incidence
(xi) Rust severity using a five – point scale of 1 = No visible symptom; 3 = Lesion on < 20% leaf area or total plants infected; 5 = Lesion on 21 – 40% leaf area or total plants infected; 7 = Lesion on 41 – 70% leaf area or total plants infected; 9 = Lesion on over 71% leaf area or total plants infected.

Data were subjected to Analysis of Variance procedures using the General Linear Model of SAS (2007) while SPSS version 7 was used to correlate genotypic means of phenotypic traits.

3.0 RESULTS

Data analysis precluded rust rating for incidence and severity because no natural development of symptom for rust infection was observed in the course of evaluation. Significant ($P \leq 0.05$) and highly significant ($P \leq 0.01$) differences in years were observed for days to flowering, days to podding, days to maturity, height of lowest pod and plant height at maturity (Table 1). The data were however combined for analysis due to non significance of genotype X year interaction. Highly significant difference in genotypes was observed for all the traits measured (days to flowering, days to podding, days to maturity, height at lowest pod, plant height at maturity, number of pods/plant, haulm yield, 100 seed weight and grain yield).

Days to flowering ranged from 46.5 days for UG5 to 50.0 days for TGX1990-78F with an overall mean of 47.8 days and coefficient of variation (CV) of 1.4% (Table 2). The variety UG5 was also the earliest in days to podding (53.0 days) and days to maturity (89.5 days) while TGX 1990-100F recorded the longest number of days to podding (66.5 days) and maturity (112 days). A CV of 2.1% and 3.2% were observed for days to podding and maturity respectively.

Height of the lowest pod ranged from 5.25cm for TGX 1990-77F to 14.65cm for TGX 1991-5F with an overall mean of 8.42cm and a CV of 7.4%. The variety TGX1991-5F was tallest with a height of 58.95cm while TGX1990-72F was the shortest with a height of 38.73cm. Grand mean for plant height was 50.43cm with a CV of 3.4%.

Number of pods per plant was highest in TGX 1990-80F (147.1pods/plant) while TGX1990-86F recorded the least number of 42.7pods/plant. The grand mean for pods/plant was 82.4 with a CV of 5.0%. Haulm yield was highest in the variety TGX1990-98F (4.42t/ha) and lowest in TGX1990-100F (1.18t/ha). Mean haulm yield was 2.4t/ha with the highest CV of 23.3%. The 100 seed weight ranged from 12.35g for TGX1991-1F to 18.35g for UG5 with a grand mean of 15.32g and a CV of 12.9% respectively. The variety TGX1990-98F recorded the highest grain yield of 3.99t/ha, while TGX1990-79F recorded the lowest yield of 2.10t/ha. The grand mean for grain yield was 3.099t/ha with a CV of 16.7%.

A positive and highly significant correlation was observed among the three maturity group traits of days to flowering, days to podding and days to maturity (Table 3). No significant correlation was observed between any of these maturity group trait and other traits. Similarly, no significant correlation was observed between the height traits (plant height and height of the lowest pod) and any other trait. The grain yield was however highly significantly correlated with number of pods/plant (0.816) and haulm yield (0.629) while a significant correlation (0.487) was observed between number of pods/plant and haulm yield.

4.0 DISCUSSION

The highly significant difference in variety observed for grain yield and all the other traits is an indication that the studied population is genetically diverse for all the traits studied. This observation is consistent with the findings of Aduloju *et al* (2009) for the southern Guinea savanna and Ojo *et al* (2010) for the rain forest ecologies of Nigeria. Thus the varieties evaluated lend themselves to possible selection for production within the southern Guinea Savanna ecology of Nigeria.

The plant height observed in the current work is consistent with the range previously reported by aduloju et al. (2009) for the southern Guinea Savanna ecology. It however exceeded the range reported by Akande et al. (2007) and Ojo et al. (2010) for the southern Guinea Savanna and the rain forest ecologies respectively. The number of pods/plant and the grain yield observed in the current work, far exceeded the upper limit reported in the previous studies (Akande et al., 2007; Aduloju et al., 2009; Ojo et al., 2010). These inconsistencies could be attributed to both genetic and environmental factors. Most of the genotypes used in the current work are recently developed varieties and are therefore expected to be superior in performance compared to previously developed varieties in earlier evaluations (Akande et al., 2007; Aduloju et al., 2009; Ojo et al., 2010). Environmental factors arising from location specific differences in terms of disease prevalence, amount of rainfall and distribution, solar radiation and soil type could have favoured a better performance of soybean in Makurdi, compared to other locations in the southern Guinea Savanna and the humid rain forest ecologies of Nigeria. For example, while mild symptoms of rust disease was observed in previous studies (Akande et al., 2007), no incidence of rust was observed in the current work. Moreover, the low grain yield observed in the previous (Akande et al., 2007) compared to the present could be due to non application of fertilizer in the previous work.

The highest CV of 12.9%, 23.3% and 16.7% observed for number of pods/plant, haulm yield and grain yield respectively, is an indication that a faster progress in selection will be achieved by concentrating on these three traits. The highest (highly significant) correlation observed between grain yield and the two yield components of number of pods/plant and haulm yield is an indication that they contributed most to grain yield. It is also an indication that these two traits (number of pods/plant and haulm yield) could be simultaneously improved with grain yield in a selection programme.

Seven (7) varieties namely TGX1990-98F, TGX1991-10F, TGX1990-86F, UG5, TGX1485-1D, TGX1990-48F and TGX1990-80F yielded higher than the popularly grown variety (TGX1448-2E). These varieties are therefore possible candidates for replacement of the TGX1448-2E in the Makurdi environment. Further studies on the evaluation of these seven varieties across more locations within the southern Guinea Savanna ecology of Nigeria are required prior to location specific selection and recommendation within the ecology.

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Table 1: Mean squares for grain yield and other agronomic traits in soybean

Source of variation	df	Days to flowering	Days to podding	Days to maturity	Height of lowest pod	Plant height at harvest	Number of pods/plant	Haulm yield(t/ha)	100 seed weight(g)	Grain yield(t/ha)
Years	1	32.4000**	50.4870**	78.9926**	2.1243**	18.4414*	260.1142	0.4454	2.5467	0.6110
Reps(years)	6	0.5103	1.5549	4.9738	0.7123	4.6452	41.8624	0.1644	1.0492	0.0755
Genotypes	24	36.2592**	225.1970**	540.338**	1.6954**	31.6450**	940.3661**	1.1121**	8.6618**	1.3456**
Genotypes X Years	24	0.0676	3.4261	5.6811	0.0214	4.8164	23.3110	0.4110	0.6218	0.2551
Error	144	0.4562	1.5832	11.1146	0.3922	2.8780	17.2986	0.3124	3.9164	0.2683

Table 2: Character means and coefficient of variability for grain yield and other agronomic traits in soybean

S/No	Varieties	Days to flowering	Days to podding	Days to maturity	Height of lowest pods	Plant height at harvest (cm)	Number of pods/plant	Haulm yield (t/ha)	100 seed weight (g)	Grain yield (t/ha)
1	TGX1991 -10F	48.25	61.25	107.25	8.45	58.28	125.50	2.50	15.15	3.90
2	TGX1990 -102F	47.50	60.75	108.25	6.75	54.03	69.20	1.92	13.90	2.48
3	TGX1990 -75F	48.25	61.25	105.25	7.88	41.06	58.80	1.92	15.17	2.34
4	TGX1991 -1F	47.75	60.75	105.25	7.09	42.23	83.00	1.94	12.35	3.16
5	TGX1990 -99F	48.25	61.25	108.75	7.73	51.06	68.30	2.02	17.00	2.64
6	TGX1990 -48F	47.75	62.25	109.75	6.75	51.75	89.10	3.24	14.12	3.71
7	TGX1991 -8F	47.25	58.75	100.75	9.13	52.65	69.10	2.96	15.57	2.69
8	TGX1448 -2E[a]	47.50	63.25	110.50	8.35	56.05	125.30	1.78	15.46	3.57
9	TGX1990 -76F	46.50	58.75	105.45	8.73	44.43	56.60	1.82	15.22	2.52
10	TGX1991 -5F	46.25	59.25	103.25	14.65	58.95	66.30	1.70	15.94	2.57
11	TGX1485 -1D[a]	46.75	55.25	99.75	6.93	51.38	97.60	3.48	13.78	3.62
12	TGX1990 -73F	47.75	60.50	109.75	9.03	51.33	83.10	2.86	15.44	3.46
13	TGX1990 -72F	46.75	59.25	102.50	9.18	38.73	75.60	3.08	14.84	3.49
14	TGX1990 -44F	49.00	60.75	107.60	6.95	51.28	50.90	1.64	13.27	2.22
15	TGX1990 -79F	47.75	60.50	106.00	10.08	53.18	42.70	1.38	16.57	2.10
16	TGX1990 -86F	49.00	59.00	100.50	11.75	49.93	89.30	2.50	15.62	3.80
17	TGX1990 -101F	48.50	61.25	107.75	5.65	50.48	73.70	1.50	14.55	2.97
18	TGX1835 -10E[a]	47.00	58.25	91.25	8.63	48.78	84.00	2.54	13.28	3.56
19	TGX1990 -80F	48.00	60.00	98.00	8.88	53.18	95.50	1.94	16.01	3.60
20	TGX1990 -100F	49.25	66.50	112.25	7.53	47.35	83.20	1.18	16.39	2.54
21	TGX1990 -74F	47.25	59.50	105.25	11.68	52.73	68.50	3.58	17.37	2.75
22	TGX1990 -77F	48.00	60.75	107.25	5.25	53.00	106.60	2.60	15.19	3.30
23	TGX1990 -78F	50.00	61.25	110.50	9.43	53.01	71.20	2.14	16.28	2.85
24	UG5[a]	46.50	53.00	89.50	7.03	48.02	85.80	3.44	18.35	3.80
25	TGX1990 -98F	49.00	65.50	109.50	7.01	48.02	147.10	4.42	16.12	3.99
GRAND MEAN		47.830±0.51	60.27±0.76	104.85±2.64	8.42±0.92	50.43±1.82	82.4±16.76	2.40±0.33	15.32±1.38	3.10±0.40
$LSD_{.05}$		0.94	1.74	4.62	0.87	2.35	5.76	0.77	2.74	0.72
C.V. (%)		1.4	2.1	3.2	7.4	3.4	5.0	23.3	12.9	16.7

[a]previously released varieties

Table 3: Phenotypic correlation of genotypic means for grain yield and other agronomic traits in soybean

Trait	Days to podding	Days to maturity	Height of lowest pods	Plant height at harvest (cm)	Number of pods/plant	Haulm yield (t/ha)	100 seed weight (g)	Grain yield (t/ha)
Days to flowering	0.638**	0.536**	- 0.231	0.110	0.144	- 0.207	0.030	- 0.063
Days to podding		0.806**	- 0.157	0.060	0.273	- 0.268	- 0.058	- 0.144
Days to maturity			-0.159	0.149	0.067	-0.272	-0.060	-0.307
Height of lowest pod				0.187	-0.261	-0.064	0.341	-0.155
Plant height at harvest					0.177	-0.134	0.178	-0.023
Number of pods/plant						0.487*	0.007	0.816**
Haulm yield							0.157	0.629**
100 seed weight								-0.030
Grain yield								