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Evaluation of the growth and yield response of some promiscuous soybean varieties in the derived savanna zone of the southeastern agro-ecology of Nigeria

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Abstract

Promiscuous soybean (naturally nodule forming varieties), bred by International Institute of Tropical Agriculture essentially for the Guinea savanna belt of Nigeria were evaluated in 2007 and 2008 for their growth and yield responses in a derived Savanna part of Southeastern Nigeria with no history of soybean cultivation. The soil is shallow with unconsolidated parent materials (shale residuum) within 1m of the soil surface, described as *Eutric leptosol*. The twelve varieties evaluated showed high adaptable features with high significant growth and yield parameters, high germination rates (80-100%), producing grain yield of up to 5-7 tons ha^{-1}; seed weight of 21-33 g $plant^{-1}$; nodule number of 17-37per plant and the varieties had a vigorous growth with a height of up to 69 cm and a girth size of 1.5cm. The significant differences observed were good indices that soybean can be integrated in the farming cultures of the resource-constrained smallholder farmers of this area as a veritable resource in soil fertility rehabilitation, food and feed needs of the farmers in this zone.

Keywords: Promiscuous soybean; Eutric leptosol; Derived savanna; Natural nodule forming

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1. Introduction

The soybean (U.S.) or soya bean (U.K.), *Glycine max* (L.) Merrill is a species of edible legume (pulses) grown essentially for its seed grains but classed as an oilseed rather than a pulse by FAO (2008). The plant is described variously as a "golden bean", a "miracle bean", "crop of the planet", "God´s sent golden bean", "greater bean," etc., and belongs to the plant order Fabales, family Fabaceae and subfamily Faboideae (Wikipedia, 2011) with chromosome number 2n=40 (Singh, Rachie, and Dashiell, 1987; Hymowitz and Newell, 1981), a native of East Asia. The earliest written record of the culture of soybean (perhaps the oldest cultivated temperate legume) dates back to 3000 BC in China where it is a long established cultivated plant (Onwueme and Sinha, 1991, Rehm and Espig, 1991). Soybean has become the dominant commercial world oil crop and the most important producer and supplier of high quality edible vegetable oil (20%), superior protein (40%), carbohydrate/soluble sugars (35%) and ash (5%), found to be suitable as human food as well as feed for animals (Singh, Rachie, and Dashiell, 1987; Thompson 1981). The seed of soybean comprises approximately 8% seed coat or hull, 90% cotyledons and 2% hypocotyls or germ.

From the USDA Nutrient Database, the nutritional value per 100g of mature seeds are as follow; energy -1866 kJ (446 kcal), carbohydrates -30.16g, (sugars -7.33g, dietary fibre -9.3g), fat -19.94g, (saturated -2.884g, monounsaturated -4.404g, polyunsaturated -11.255g), protein -36.49g, (tryptophan -0.591g, threonine -1.766g, isoleucine -1.971g, leucine -3.309g, lysine -2.706g, methionine -0.547g, cystine -0.655g, phenylalanine -2.122g, tyrosine -1.539g, valine -2.029g, arginine 3.153g, histidine -1.097g, alanine -1.915g, aspartic acid -5.112g, glutamic acid -7.874g, glycine -1.880g, proline 2.379g, serine -2.357g), water -8.54g, vitamin A equiv -1µg (0%), vitamin B_6 -0.377mg (29%), vitamin B_{12} 0µg, choline -115.9mg (24%), vitamin C -6.0mg (7%), vitamin K -47µg (45%), calcium -277mg (28%), iron -15.70mg (121%), magnesium -280mg (79%), phosphorus -704mg (101%), potassium -1797mg (38%), sodium -2mg (0%), and zinc -4.89mg (51%). The crop has been proved to be an excellent source of food for man and very ideal as infant foods as it has minimal oligosaccharides which cause flatulence in other grain legumes. Its oil content belongs to the linolenic unsaturated fatty acid group without cholesterol (Rehm and Espig, 1991).

The largest producers in 2008 were the USA 80.5 million metric tonnes, Brazil 59:9, Argentina 46.2, China 15.5, and India 9.0, representing more than 90% of global soybean production, others Paraguay 6.8, Canada 3.3, Bolivia 1.6, and European Union 0.6, to arrive at a world total of 230.9 million tones, (Wikipedia, 2011). In the 2010-2011 production year the U.S. figure is expected to be over 90 million tonnes. The production of soybean in the tropics is deterred primarily by biological constraints on the crop and lack of markets and inadequate knowledge of cultivation and utilization practices (Singh, Rachie, and Dashiell, 1987). Studies have shown that Nigeria is the largest producer of in Africa and its production is mainly in the southern Guinea savanna zone which comprises Benue, Kaduna, Oyo, Ondo, Adamawa Taraba and Plateau, while Benue is found to be the highest (Smith, Woodworth and Dashiell, 1995; Olufajo and Adu, 1992, Roots, Oyekan and Dashiell, 1987).

In literature, it is reported that the United Soybean Board (USB) of America has pronounced soybean a versatile crop due to its many applications and the board is committed to increasing soybean demand through advancements in soy-based research and technology such as adhesives, coatings and printing inks,

lubricants, plastics, biodiesel and specialty products (Gibson and Benson, 2005). New soy-based products are quickly gaining popularity as many benefits of soybeans are updated and alternative industrial products have seen heightened demand as manufacturers are replacing petrochemicals with the renewable product (soy plastics and foams, soy methyl esters and soy ink). Approximately 85% of the world's soybean seeds are processed into soybean meal and vegetable oil. Early uses in Asia was the processing of seeds into variety of fresh, fermented and dried food products while the U.S. used it as forage. Presently, the oil extracted from the seeds is made into shortening, margarine, cooking oil, and salad dressings. Soy oil is also used in industrial paints, vanishes, caulking compounds, linoleum, printing inks, and other products. Recently development efforts have resulted in several soy oil-based lubricant and fuel products that replace non-renewable petroleum products. Lecithin from soy oil is a natural emulsifier and lubricant used in many foods, commercial, and industrial applications. As an emulsifier, it can make fats and water compatible with each other, e.g. it helps keep the chocolate and cocoa butter in a candy bar from separating. It is also used in pharmaceuticals and protective coatings (Gibson and Benson, 2005).

The high protein meal remaining after oil extraction can be processed into soybean flour for human food or incorporated into animal feed, and helps balance the amino acid deficiencies of grains like corn and wheat which are low in important amino acids, lysine and tryptophan. Soy proteins are also used in baby formula, weight-loss drinks, sport drinks, and as a low-fat substitute for hamburger. Soy flour and grits from grinding whole seeds are used in the commercial bakery industry to aid in dough conditioning and bleaching. They possess excellent moisture-holding qualities that help retard staling in bakery products. A 60-pound bushel (27.24kg) of soybeans yields about 11pounds (5kg) of oil and about 48pounds (21.79kg) of meal (Gibson and Benson, 2005).

Cultivars are grouped into three: Early maturing- 125-130 days; Medium maturing- 140-150 days and Late maturing - 150-160 days cultivars though, the maturity length do increase with increased latitude, increased day light and cool conditions. Soybean is considered suitable for integration into the traditional intercropping systems (na Lampang, 1981) due to its outstanding features; its short growth duration (100 + 20 days), adaptability to short spells of moisture deficiency, high yield potentials, soil improving capacity as a benchmark nitrogen fixing legume second only to stem-nodule forming legumes (Ludwig, 1989), and its highly desirable nutritional profile. The major and specific objective of this study was therefore to evaluate the growth and yield responses of some twelve IITA bred promiscuous soybean varieties in the derived savanna zone of the southeastern agro-ecology of Nigeria.

2. Materials and methods

2.1. Site description

The location of the experimental site is indicated using the digital global positioning system pocket model, while Anikwe, Okonkwo and Aniekwe (1999) described the soil and weather characteristics of the research farm, Faculty of Agriculture and Natural Resources Management (FARM), Ebonyi State University, Abakaliki,

in Southeastern Nigeria, lying on latitude 06^0 19′ 407′′ N and longitude 08^o 7′ 831′′ E at an altitude of about 447 m above sea level with a mean annual rainfall of about 1700 mm to 2060 mm spread between April and October. The maximum mean daily temperature is between 27^oC to 31^oC with abundant sunshine and a high humidity all through the year. The soil is shallow with unconsolidated parent materials (shale residuum) within 1m of the soil surface, described as *Eutric Leptosol.* The average soil properties of the research farm are: bulk density- 1.57gcm^{-3}; total porosity- 41%; pH in water- 5.18; total N- 0.14%; available P- 19.5 ppm, organic carbon- 1.53%; organic matter- 2.64% (obtained by multiplying the organic carbon with a constant 1.724 (Odu, Babalola, Udo, Ogunkunle, Bakare and Adeoye, 1986), extractible Na- 0.06, K- 0.33, Mg- 1.30 and Ca- 2.13 mol kg^{-1} (National Root Crop Research Institute (NRCRI), Umudike, Nigeria analytical laboratory).

2.2. Land preparation and plot maintenance

The field was cleared and flat beds cultivated in May, 2007, while in June, 2008, the field was cleared and flat beds cultivated manually with large-blade Indian dwarf hoe common among the smallholder farmers in the state in each year. Seeds were manually sown on the flat beds at a depth of about 2cm held between the thumb and the forefinger in May, 2007, while sowing was in June, 2008 immediately after land preparation in each year. Three weeding periods were manually done on the plots as the need arose with small blade Indian dwarf hoe. No external soil amendments were added to augment the soil fertility status to assess soybean performance in the area without history of soybean cultivation.

2.3. Treatment application

Twelve promiscuous soybean varieties bred by International Institute of Tropical Agriculture (IITA) were planted out in a Randomized Complete Block Design (RCBD) in four replications. Plot size was 2m x 1m separated by 0.5m, which gave 36 plant stands per plot at a spacing of 30cm x 15cm, at 1seed per stand. Each replicate was separated by a 1m space giving a total area of 11m x 18.5m or 203.5m^2. Field establishment was done as soon as the rains stabilized in each year (May in 2007 and June in 2008). Data collection on the soybean varieties were on emergence count at 6 days after planting (DAP), number of pods per plant at maturity/ harvest, number of seeds per plant after shelling, number of branches per plant at harvest, number of leaves per plant at flowering, leaf area (cm^2) per plant at flowering, plant height (cm) at harvest, girth size (cm), nodule number/ plant at flowering (the plots were watered to soften the soil before uprooting the plants for nodule observation and counting, except it rained the previous day), pod weight (g) per plant and 1000 seed weight (g).

2.4. Statistical analysis

All data collected were subjected to analysis of variance (ANOVA) according to (Steel and Torrie, 1980), using a statistical tool, the GenStat model, version 2 (Release 7.22 DE 3). Treatment means were separated using Fisher's Least Significant Difference (F-LSD = LSD) as described by (Carmer and Swanson, 1971) and illustrated by (Obi, 1986) to identify significant treatment effects in the experiments.

3. Results

Table 1 displays the mean growth and yield performances of the twelve promiscuous soybean varieties as influenced by the Abakaliki, Southeastern Nigeria environment. The mean seed weight yield of twelve soybean varieties was significantly ($p<0.05$) favoured in year one (2007) planting (Table 1) and in the years combined (Table 3), than in year two (2008, Table 2). TGx1844-18E had the highest grain seed weight with 50.0g, followed by TGx1904-2F with 45.6g and TGx1903-7F with 43.2g, while the lowest was recorded against TGx1485-1D with 26.7g plant^{-1} in 2007, while the highest in 2008 was 23.8g produced by TGx1903-7F, followed by TGx1485-1D with 22.5g plant^{-1} while the highest was 33.5g from TGx1903-7F and 31.2g plant^{-1} from TGx1844-18E in the years combined. Generally, the twelve soybean varieties performed better in year one than in year two and in the years combined.

In the same vein, the mean number of seeds per plant performances of twelve soybean varieties were significantly ($p<0.05$) influenced in year one (2007) planting and in the years combined, but was lowered in year two (2008). The highest number of seeds per plant (438.6) was recorded in 2007 from TGx1844-18E, but 311.0 seeds were produced by TGx1903-7F in 2008 while 345.4 and 345.2 were recorded from TGx1903-7F and TGx1844-18E respectively in the combined years. Generally also, the twelve varieties performed better in terms of number of seeds in year one than in year two and years combined.

The mean girth size (cm) of the twelve (12) soybean varieties evaluated in the two year plantings was significantly ($p<0.05$) supported by this environment better in year one (2007) planting and in the years combined than in year two (2008). TGx1876-4E however, had the largest girth size of 1.93 cm in 2008, followed by TGx1844-4E with 1.45 cm, which had the largest girth size of 1.55 cm in 2007, followed by TGx1740-2F with 1.45 cm per plant. Although variations were observed in the girth sizes of the varieties, the width of differences was insignificantly small as the girth sizes revolved around one and a fraction of centimeters and at most approximately 2.00cm.

The mean number of seedling emergence in the twelve soybean varieties in Tables 1, 2 and 3 was significantly different ($p<0.05$) among the varieties in 2007, 2008 and in the years combined. TGx1904-2F had the least seedling emergence (12.25 out of 36 seeds sown) in 2007 and in years combined (15.00), while TGx1903-7F was the least in 2008 (17.00). The pattern of seedling emergence among the varieties did not follow any definite direction as the variety with the highest or the lowest in 2007 was not the highest or the lowest in 2008 or in the average of the two year plantings. Good germination percentage is a good feature that ensures a plants ability to continue its existence in a location. Number of branches per soybean plant is considered a significant factor for yield among soybean varieties. TGx1740-2F produced the highest number of branches in 2007 (6.00), in 2008 (5.50) and in the mean of the two years (5.8), followed by TGx1844-4E with 5.22 (2007), 4.75 (2008) and 5.00 (combined years) of the experiments. TGx1909-3F and TGx1904-6F had the lowest number of branches observed (2.00-2.25) among the twelve varieties of soybean in the experiment.

The mean1000 seed weight (g) of the twelve soybean varieties was significantly ($p<0.05$) different among the varieties studied in the two year plantings. However, TGx1903-5F appeared to have the heaviest 1000 seed weight (g) per variety among the varieties in 2007(133.75 g) and in the years combined (126.9 g), but in

2008 it had the third heaviest 1000 seed weight with 120.08 g after TGx1904-2F with 120.88g and TGx1904-4F with 120.48g. The mean number of pods in 2007 was not significantly ($p>0.05$) different among the varieties but was significantly ($p<0.05$) higher in 2008 and in the year mean among the varieties studied, although not all the varieties maintained high numbers in 2008 as in 2007. The percentage variation in the mean number of pods in 2008 was wider among the varieties than in 2007 in the range of 48.64 % in the widest number to 3.70 % in the closest number.

There were significant ($p<0.05$) differences in the plant height among the varieties in 2007, 2008 and in the year mean and the tallest plants in 2007 maintained their tallness all through except TGx1904-2F that was slightly taller in 2007 than in 2008 and in the year mean. However, TGx1740-2F was the tallest of all (74.38, 64.25 and 69.31 cm, across the years) followed by TGx1844-4E with 54.50 cm in 2007 and TGx1903-5F with 54.38 in 2007. The number of nodules per plant of the twelve soybean varieties was significantly ($p<0.05$) different in the first and second years as well as the mean of the years. However, there was no significant ($p>0.05$) differences in the number of nodules produced by a variety from year to year, yet almost all the varieties that had high number of nodules in the first were high in the second year as well as the mean of the years.

Table 1. Mean Growth and Yield Parameters of twelve (12) Soybean Varieties in Abakaliki in 2007

	Parameters										
Variety	Emergence Count (no)	Plant Ht (cm)	Girth size (cm)	Branch (no)	Nodule (no)	Pod (no)	Pod wt (g plt^{-1})	Seed (no)	Seed wt (g plt^{-1})	1000 seed Wt (g)	Grain yield (t ha^{-1})
TGx1904-6F	27.38	36.38	1.33	2.25	28.50	153.0	45.8	309.0	35.2	116.75	7.83
TGx1485-1D	21.00	34.25	1.40	3.00	38.75	121.5	38.6	245.0	26.7	124.13	6.22
TGx1844-18E	29.75	43.12	1.15	2.75	34.75	220.8	52.0	438.6	50.0	119.63	11.35
TGx1903-7F	16.50	41.62	1.30	5.00	33.00	190.2	54.0	379.8	43.2	123.13	9.75
TGx1844-4E	27.25	54.50	1.55	5.22	18.50	126.0	33.5	246.8	28.4	129.38	6.50
TGx1740-2F	23.50	74.38	1.45	6.00	18.75	133.8	44.7	249.6	29.5	132.00	6.85
TGx1903-5F	18.50	54.38	1.40	4.25	31.50	176.0	49.4	319.8	38.5	133.75	9.03
TGx1876-4E	30.75	53.50	1.00	2.50	21.00	137.7	42.0	246.0	28.5	107.50	7.07
TGx1908-8F	33.75	34.25	1.13	3.25	21.75	152.7	52.3	275.5	31.4	114.13	7.88
TGx1904-2F	12.25	32.50	1.33	3.00	33.25	217.2	66.0	382.9	45.6	129.75	11.18
TGx1909-3F	34.75	29.12	1.18	2.25	22.25	147.0	69.1	264.9	31.7	122.00	7.57
TGx1904-4F	15.00	38.00	1.23	3.75	22.25	165.5	44.4	296.5	35.7	112.25	8.50
F-LSD(P=0.05)	6.82	1.37	0.28	0.84	10.13	67.24	29.68	133.9	15.38	3.86	3.46

In 2007 (year one), TGx1844-18E attained a yield size of 11.35 t ha^{-1}) and TGx1904-2F (11.18 t ha^{-1}), which were the highest grain yield per hectare among the varieties compared to grain yields in 2008 and in the mean of years. Generally, the varieties performed better in 2007 and in the mean of years than in 2008 but the grain yield per hectare per variety was significantly ($p<0.05$) different in 2008.

There were significant ($p<0.05$) differences in the weight of pods among the varieties in 2008 only but improvement on the mean weight of pods per plant in year one and in the mean of years did not come to significance ($p>0.05$) though better. The varieties also produced higher weight of pods in 2007 with TGx1904-2F and TGx1909-3F having 66 and 69.1 g $plant^{-1}$ each, while others had lower weight of pods per plant.

Table 2. Mean Growth and Yield Parameters of twelve (12) Soybean Varieties in Abakaliki in 2008

	Parameters										
Variety	Emergence Count (no)	Plant Ht (cm)	Girth size (cm)	Branch (no)	Nodule (no)	Pod (no)	Pod wt (g plt^{-1})	Seed (no)	Seed wt (g plt^{-1})	1000 seed Wt (g)	Grain yield (t ha^{-1})
TGx1904-6F	36.00	31.25	1.13	2.25	19.75	102.5	30.8	193.5	16.6	112.50	3.67
TGx1485-1D	21.50	32.25	1.28	2.75	35.50	117.0	37.1	244.9	22.5	109.23	5.03
TGx1844-18E	32.00	36.25	1.03	2.50	24.00	123.0	26.3	257.7	12.3	114.05	2.77
TGx1903-7F	17.00	41.00	1.20	4.00	31.25	140.2	39.8	311.0	23.8	114.00	5.30
TGx1844-4E	29.75	45.25	1.45	4.75	16.25	98.0	26.1	198.2	14.1	116.10	3.12
TGx1740-2F	25.50	64.25	1.25	5.50	20.50	109.7	36.7	231.7	23.3	117.53	5.17
TGx1903-5F	18.50	42.75	1.40	3.25	31.00	116.0	32.6	246.9	19.7	120.08	4.38
TGx1876-4E	32.75	47.00	1.93	2.25	22.75	86.2	26.8	135.4	17.5	111.78	3.87
TGx1908-8F	34.00	31.25	1.13	3.25	20.00	104.0	35.6	145.6	20.3	114.53	4.52
TGx1904-2F	17.75	29.00	1.20	3.00	30.75	125.2	38.0	213.3	15.8	120.88	3.52
TGx1909-3F	31.75	29.25	1.40	2.00	12.00	75.5	22.3	151.3	14.4	117.53	3.23
TGx1904-4F	18.00	36.00	1.13	3.25	17.98	107.2	28.7	182.2	15.8	120.48	3.52
F-LSD(P=0.05)	5.16	3.80	0.18	0.74	6.92	24.01	7.24	48.1	4.30	8.05	0.95

4. Discussion

Abakaliki is located in the zone not known as a soybean growing area (Okonkwo and Nnoke, 1993), yet the twelve soybean varieties bred by International Institution for Tropical Agricultural (IITA) for the savanna

and guinea savanna zones evaluated in this study showed significant adaptable growth and yield features desired for a crop to be integrated into the farming system of the derived savanna zone.

Table 3. Mean Growth and Yield Parameters of twelve (12) Soybean Varieties in Abakaliki, 2007 and 2008 Combined

	Parameters										
Variety	Emergence Count (no)	Plant Ht (cm)	Girth size (cm)	Branch (no)	Nodule (no)	Pod (no)	Pod wt (g plt^{-1})	Seed (no)	Seed wt (g plt^{-1})	1000 seed Wt (g)	Grain yield (t ha^{-1})
TGx1904-6F	32.2	33.8	1.2	2.3	24.1	127.7	38.3	251.3	25.9	114.6	5.8
TGx1485-1D	21.3	33.3	1.5	2.9	37.1	119.2	37.9	245.0	24.6	116.7	5.6
TGx1844-18E	30.9	39.7	1.4	2.6	29.4	171.9	39.2	345.2	31.2	116.8	7.1
TGx1903-7F	16.8	41.3	1.4	4.5	32.1	165.2	46.9	345.4	33.5	118.6	7.5
TGx1844-4E	28.5	49.9	1.0	5.0	17.4	112.0	29.8	222.5	21.2	122.7	4.8
TGx1740-2F	24.5	69.3	1.1	5.8	19.6	121.7	40.7	240.6	26.4	124.8	6.0
TGx1903-5F	18.5	48.6	1.3	3.8	31.3	146.0	41.0	283.3	62.8	126.9	6.7
TGx1876-4E	31.8	50.3	1.3	2.4	21.9	112.0	34.4	190.7	23.0	109.6	5.5
TGx1908-8F	33.9	32.8	1.2	3.3	20.9	128.4	44.0	210.5	25.8	114.3	6.2
TGx1904-2F	15.0	30.8	1.3	3.0	32.0	171.2	52.0	298.1	30.7	125.3	7.4
TGx1909-3F	33.3	29.2	1.1	2.1	17.1	111.2	45.7	208.1	23.1	119.8	5.4
TGx1904-4F	16.5	37.0	1.3	3.5	20.1	136.4	36.5	239.4	25.8	116.4	6.0
F-LSD(P<0.05)	5.9	2.0	0.16	0.55	5.91	34.74	15.05	69.02	27.79	4.3	1.75

4.1. Vegetative growth

The growth parameters shown in Tables 1, 2 and 3 showed no feature depicting unsuitability in this area indicating that the observation of (Okonkwo and Nnoke, 1993) could not have been that of unsuitability, but paucity of literature on soybean cultivation in this zone. At any rate, soybean cultivation is relatively new among the farming families who are dominantly yam, sweet potato, cassava, cocoyam, rice, maize and vegetable cowpea farmers. However, because information on its utilization is scanty, soybean is a strange crop until IITA popularized its breeding, production and utilization in Sub-Saharan Africa in general and Nigeria in particular through its crop improvement programmes (IITA, 1992). In the past, seeds easily lose viability and lose the creamy golden colour arising from moisture absorption in the field before it is harvested due to the rainfall pattern in this zone. These factors and more may have contributed to unpopularity of this wonderful legume.

The girth size (cm) of the 12 varieties was similarly equal to 1cm. However, the girth sizes of TGx1844-4E and TGx1876-4E only could approximate to 2cm, but in both years, their mean girth sizes were similar 1.30cm and they maintained a vigourous growth generally, which further proved that soybean cultivation can be developed and commercialized in this zone. Number of seedling emergence of the varieties was significantly high and characteristically similar in both years and across the years. Wien and Kueneman (1981) reported that several lines from Indonesia were still viable after 8 months of storage under ambient conditions, a feat that was difficult if harvest is delayed which is a common occurrence among the smallholder farmers. However, only one variety (TGx1904-6F) reached the 100% seedling emergence having all the 36 seeds planted per plot (18 seeds per plot at two seeds per hole) turned into seedlings. Even though oil seeds like soybean, loss their viability easily, these ones had very high viability index attested to by this high record to the credit of International Institute of Tropical Agriculture, Ibadan, Nigeria (IITA, 1992).

Most of the varieties exhibited high branching potentials with non having less than 2 branches while TGx1740-2F had up to 6 branches, followed by TGx1903-7F and TGx1844-4E with 5 branches each in 2007, indicating favourable growing conditions for soybean cultivation. Ability to form branches should be a way to compensate for its non-prostrate growth form which also enhances grain yield of the plant. TGx1740-2F could grow to a height of 74.38cm in 2007 and 69.3cm in the years combined which compares well with the observation of (Ndaeyo, Oguzor, Utuk and Dan, 2000) who reported plant heights of 70.9-72.4cm under the influence of cow dung and NPK fertilizer treatments 80 days after sowing. However, others were still as short as 39.12cm in both years to the extent that the branches heavy with pods are prone to touching the soil which disposes the seeds to decay and spoilage. At any rate, some of the varieties grew taller in 2007 than in 2008.

It is the ability of soybean to fix atmospheric nitrogen through nodule formation and its popularity as a quality food protein source that marks it out from other legumes. The promiscuous IITA varieties breed true to type as all were able to form effective nodules although there were very few of them. This means that the soil environment in Abakaliki can support soybean production adequately. In 2007, 27.02 nodules were recorded and 23.48 in 2008. TGx1485-1D produced up to 37.12 nodules while TGx1904-2F produced 32 nodules.

4.2. Yield parameters

The yield parameters are documented in Tables 1, 2 and 3for 2007, 2008 and years combined data. Weight of seeds and number of seeds per plant were significantly high among the varieties, as seed weight was heavier in year one (2007), 41.0 g than in 2008 (18.0 g), but only three varieties produced up to 30 and more grammes of seeds per plant. TGx1903-7F produced 33.5 g, TGx1844-18E (31.2 g) and TGx1904-2F (30.7 g). The soil environment tended to be very conducive for the plants that they were able to express their yield potentials fully. Abakaliki soil is naturally fertile and has in the recent past started to show signs of decline as cropping intensity increased with increase in human populations. In this respect, there is high prospect for the smallholder farmers to be convinced to integrate soybean crop in their cropping systems as a sustainable rich source of food, fodder and fertilizer. Also, number of seeds correlating highly with seed weight is a good

yield index, as much of the varieties could produce such number of seeds as 345.2 per plant, there is high prospect of its adoption and acceptance by the smallholder farmers in this zones, number of seeds in 2007 was higher per plant (304.5) than in 2008 (208.8). 1000 seed weight (g) was not significantly different among the varieties but there were minor differences but could not mark out one from the other.

The high pod number, grain yield t ha^{-1} and the gramme per plant pod weight are good yield indices which IITA studied and improved among the varieties are great landmark spring boards for launching the revitalization of the rural livelihood in the nearest future. TGx1844-18E and TGx1903-7F produced the highest pod number (171.9 and 165.2) each, TGx1844-18E, TGx1903-7F and TGx1904-2F had the largest grain yield per ton, while TGx1904-2F had the highest pod weight than others (52.0 g), These varieties have high prospects as a crop for the future in this zone since it could be cultivated profitably with the native fertility without endangering the future of farming of the poor in the zone (Singh, Rachie and Dashiell, 1987; Parsley and Lantin, 2000).

5. Conclusion

Twelve promiscuous soybean varieties which can naturally form nodules bred by IITA (International Institute of Tropical Agriculture) Ibadan, Nigeria, were evaluated between 2007 and 2008, for their growth and yield responses to an area without history of soybean cultivation. The assessed twelve IITA promiscuous soybean varieties (TGx1740-2F, TGx1904-2F, TGx1904-4F, TGx1903-5F, TGx1909-3F, TGx1844-4E, TGx1876-4E, TGx1903-7F, TGx1485-1D, TGx1844-4E, TGx1904-6F and TGx1908-8F), performed well in the derived savanna belt of Southeastern Nigeria in all the parameters evaluated. They all showed high adaptable potentials by exhibiting significant good growth and high yield components. Varieties like TGx1740-2F, TGx1485-1D, TGx1904-6F, TGx1908-8F, TGx1903-5F, TGx1844-18E, TGx1904-2F and TGx1903-7F produced seed grain of up to 6.0-7.5 tons/ha, seed weight between 29.1-33.5 g/plant, nodule number between 20.9-37.1 and a vigorous growth to a height of up to 30.8-69.3 cm with girth size of 1.2-1.5cm. These qualities observed were good evidence that soybean can be successfully cultivated in Abakaliki climatic conditions and that soybean can be a veritable resource among the resource-constrained smallholder farmers for food and for their soil fertility improvement without the costly external fertilizer inputs.

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