PERFORMANCE ASSESSMENT OF SOME EARLY MATURING SOYBEAN LINES ACROSS THREE AGRO ECOLOGIES OF NIGERIA

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ABSTRACT

Twelve early maturing soybean lines were evaluated across three agro ecological zones in Nigeria [Northern Guinea Savannah (Igabi), Southern Guinea Savannah (Minna), and Sudan Savannah (Gwarzo)], in 2015 to determine their productivity especially in seed yield. In each of the locations, the experiment was laid out in randomized complete block design with three replications. Data were collected on growth and yield parameters and subjected to Analysis of Variance (ANOVA) using Statistical Analysis System (SAS) Version 9.1.3. Seven lines (TGX 1989-40F, TGX 1989-48FN, TGX 1989-49FN, TGX 1990-57F, TGX 1990-46F, TGX 1990-55F, and TGX 1987-10F) were identified to be high yielding in both Northern and Southern Guinea Savannah, while only two (TGX 1989-40F and TGX 1990-57F) were high yielding in Sudan Savannah. This suggests that environmental differences could be responsible for soybean productivity, from one agro ecology to another. Therefore, soybean lines could be recommended for cultivation according to their performances in a given location.

Keywords: Soybean, performance, agro ecology, Nigeria

INTRODUCTON

Soybean (*Glycine max* [L.] Merril), a member of Fabaceae family is a very important food crop in human nutrition. According to Kolapo (2011), soybean is often referred to as the miracle golden bean, the Cinderella crop of the century, the pearl of the orient, the meat that grows on vines, the protein hope of the future, and the salvation crop. These attributes are mainly as a result of the relatively high protein content of about 40 % contained in soybean seeds. In addition, soybean also contains approximately 20 % fat. Therefore, the well – known and most widely used soybean products are soybean oil and soybean meal according to United States Soybean Export Council (USSEC, 2015). Soybean oil is utilized throughout the world for human consumption as margarine, cooking oil, salad and shortening (Kolapo, 2011). Soybean meals such as soymilk, soy cheese, and Tom Brown, an infant weaning food, are major sources of vegetable protein. Nutritionally, soybeans are superior among vegetable proteins due to their good content of essential amino acids, though they are slightly deficient in some sulphur-containing amino acids like cysteine and methionine. Soybean also supplies adequate amount of carbohydrate, minerals, vitamins, digestible fibres among others.

Soybean cultivars are affected by climatic factors such as rainfall, temperature, photoperiod and humidity. Although soybean is of temperate origin, it has a wide range of adaptability and grows well in tropical and sub-tropical climates (Viana *et al.*, 2013).

Water availability is an important factor for soybean productivity in every agro-ecology. The first critical period is during germination and seedling development (Viana *et al.*, 2013). In order to ensure good germination, soybean seeds need to absorb enough moisture to achieve 50 % moisture content. An annual rainfall of 700-1200 mm that is well distributed during the soybean production cycle will meet the crops water needs (Mondine *et al.*, 2001).

Temperature has great influence on the rate at which all the metabolic and physiological processes take place during soybean development. This directly influences growth rate and yield. Also, temperature has significant impact on the duration of the different development stages that make up the crops cycle (Viana *et al.*, 2013). Average temperatures essential for the best soybean development are between 20 and 35 °C. As reported by Viana *et al.* (2013), temperatures outside this range (20-35 °C) can lead to physiological disorders with flowering and Rhizobialinoculation, as well as poor growth. Soybean planting should not be done when the soil temperature is below 20 °C in order to ensure good germination and seedling emergence. Photoperiod simply means the length of time that organism receive sunlight (Podolsky, 2015). Soybean flowering is induced and/or accelerated by short days. Thus, it is considered short day plant. This is crucial for soybean adaptation in northern growing region where photoperiod increases with latitude which potentially delays maturity (Podolsky, 2015). Photoperiod influence many development processes such as seed germination, growth of stem and leaves, flowering, storage organs formation and assimilate partitioning (Taiz and Zeiger, 2004).

Soybean production in Nigeria is mostly in the middle belt or the savannah zone (Okpara and Ibiam, 2000). However, its production has extended beyond this traditional areas to cover other Northern and Southern regions of the country that were otherwise regarded unsuitable or marginal for soybean production (Asiegbu and Okpara, 2002). As reported by Agricultural Media Resources and Extension Centre (AMREC, 2007), the major soybean producing states in Nigeria are Benue, Kaduna, Taraba, Plateau, and Niger. Other producing areas are Nasarawa, Kwara, Oyo, Kebbi, Jigawa, Borno, Bauchi, Sokoto, Lagos, Zamfara, and Abuja.

MATERIALS AND METHODS

The research was conducted in three locations across three different agro ecologies of Nigeria (Table 1). Twelve (12) early maturing lines of soybean (TGX 1989-40F, TGX 1990-52F, TGX 1989-48FN, TGX 1990-40F, TGX 1989-49FN, TGX 1990-57F, TGX 1989-68FN, TGX 1990-46F, TGX 1990-55F, TGX 1987-10F, TGX 1835-10E, and TGX 1485-1D) were laid out in a Randomized Complete Block Design (RCBD) with three (3) replications in each location. The twelve (12) early maturing lines of the soybean were obtained from International Institute of Tropical Agriculture (IITA), Ibadan. The gross plot size was 3.75 m × 2 m = 7.5 m^2; with 5 ridges of 2 m long each. The net plot size was 2.25 m × 2 m = 4.5 m^2; with 3 ridges of 2 m long each. Gross plots were separated by a distance of 0.5 m, while a distance of 1 m separated one replication from the other. The total experimental area was 30 m × 13.25 m = 397.5 m^2. The duration of the field experiment in the individual environment is presented in Table 2.

Table 1 Three selected locations and their agro ecologies

Location	State	Ecology
Minna	Niger	Southern Guinea Savannah
Igabi	Kaduna	Northern Guinea Savannah
Gwarzo	Kano	Sudan Savannah

Table 2 Field experiment duration in the individual environments

Location	Date planted	Date harvested
Minna	28th July, 2015	7th November, 2015
Igabi	18th July, 2015	31st October, 2015
Gwarzo	25th July, 2015	24th October, 2015

Seeds were inoculated with *Rhizobium* inoculants (Legumefix). Three (3) soybean seeds were sown per hill and later thinned down to one plant per stand. The planting distance used was 75cm × 20cm between and within rows, respectively. This gave a plant population of 66,667 plants ha^{-1}. Single super phosphate (SSP) was applied at the rate of 40kg/ha at 2 weeks after planting. Weed and insects were intensively controlled in each location.

Growth and yield parameters such as Days to 50 % flowering, Days to maturity, Plant height, Branches per plant, Pods per plant, Above ground biomass, Seed yield, 100 seed weight and Harvest indexwere taken during the field experiment and data collected were subjected to Analysis of Variance (ANOVA) using General Linear Model (GLM) procedure of SAS (SAS, 1997). Levels of significance were determined at 5%. Means were separated using Duncan Multiple Range Test at $p = 0.05$. Weather parameters (temperature and rainfall) were also taken in each of the locations.

RESULTS AND DISCUSSIONS

Weather

The two weather parameters (temperature and rainfall) taken across the three locations, for the year 2015 are presented in Figures 1 and 2, respectively. The temperatures within each duration fall in the best range of temperature for soybean development (20-35 °C), as recommended by Viana *et al.* (2013).

The peak of rainfall in each environment for the year was within the production period and was fairly distributed during the developmental stages of the crop. However, there was an abrupt decline in Gwarzo (Sudan savannah), in the month of September (Figure 2). This coincided with the seed filling stage of the genotypes in this environment. The total annual rainfall for the year 2015 in the three locations is presented in Figure 3.

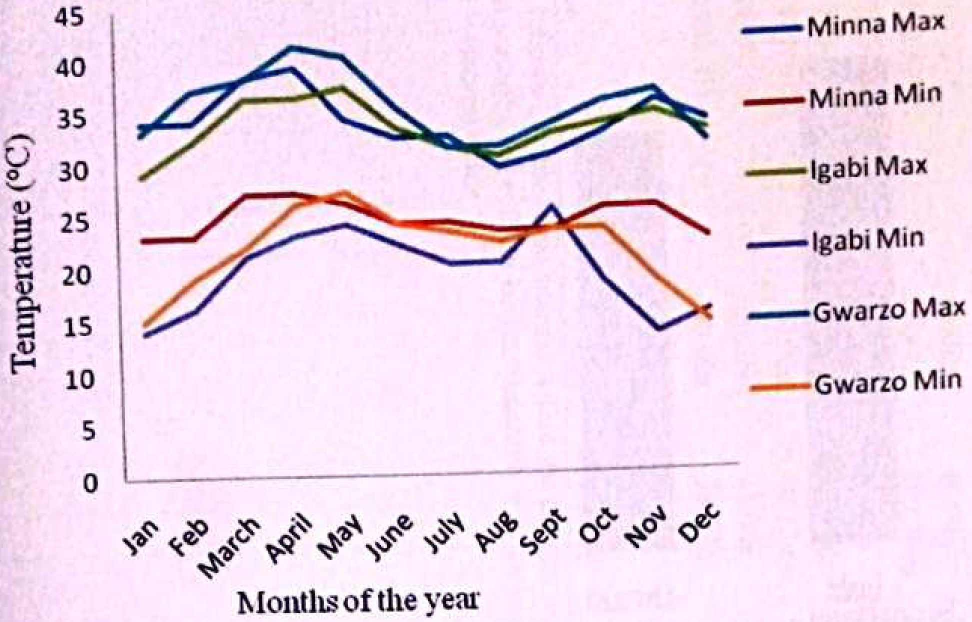

Figure 1 Monthly average temperatures for Minna, Igabi and Gwarzo in 2015

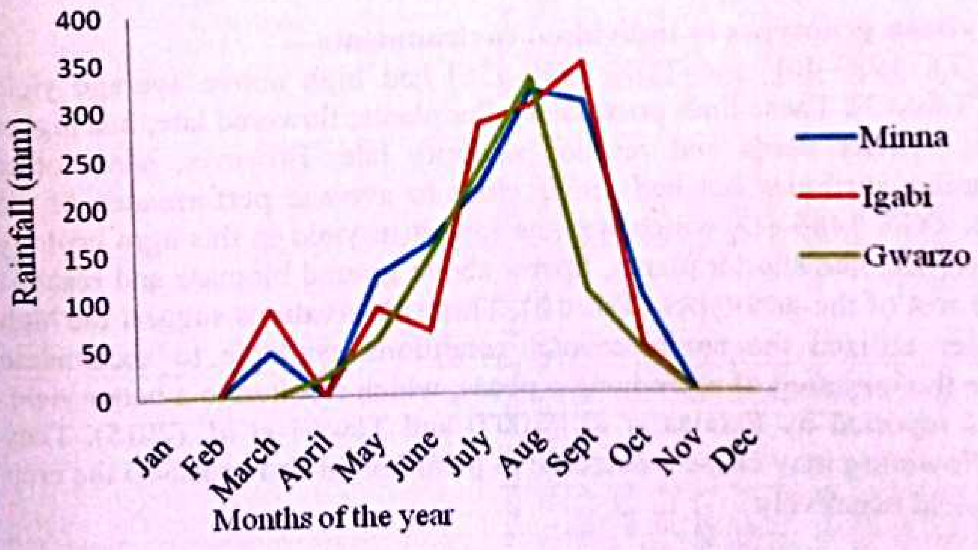

Figure 2 Monthly rainfall in Minna, Igabi and Gwarzo in 2015

Sources: Institute for Agricultural Research, Samaru, Zaria, Kaduna State (Igabi and Gwarzo) (2015) and Upper Niger River Basin Development Authority, Minna, Niger State (Minna) (2015).

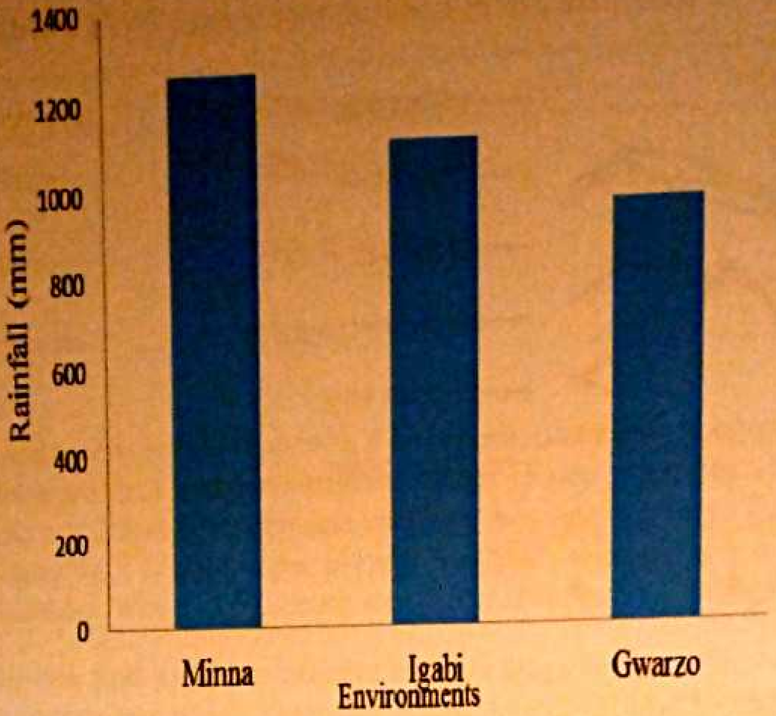

Figure 3 Total annual rainfall for three environments in 2015

Sources: Institute for Agricultural Research, Samaru, Zaria, Kaduna State (Igabi and Gwarzo) (2015) and Upper Niger River Basin Development Authority, Minna, Niger State (Minna) (2015).

Performance of the soybean genotypes in individual environments

Two soybean lines (TGX 1989-40F and TGX 1990-55F) had high above average yield performance in Minna (Table 3). These lines possessed taller plants; flowered late; had higher above ground biomass; heavier seeds and reached maturity late. However, some other genotypes exhibited similar attributes but had yields close to average performance of the genotypes (1.78 ton/ha). TGX 1485-1D, which was the lowest in yield in this agro ecology (1.37 ton/ha) flowered earlier, had shorter plants, lowest above ground biomass and reached maturity earlier than the rest of the genotypes (Table 3). These observations suggest the high yielding genotypes better utilized the environmental conditions available to accumulate adequate biomass before the initiation of reproductive phase, which resulted to a better yield. Similar observation was reported by Faraias *et al.* (2007) and Tewari *et al.* (2015). They observed that too early flowering may cause a decrease in plant height and speed-up the crop maturity, which affects yield negatively.

In Igabi, TGX 1989-40F and TGX 1989-48FN had good above ground biomass and high above average seed yield performance (Table 4). This high yield could be a reflection of a good branching pattern, number of pods per plant, number of seed per pod and seed weight, which they possessed. The genotypes that yielded above average (TGX 1989-40F, TGX 1990-57F and TGX 1987-10F) in Gwarzo (Table 5) could be as a result of their better seed per pod, above ground biomass and seed weight. However, the mean seed yield of the genotypes in this agro ecology is low. This low yield could be because of the too early initiation of the reproductive phase by the lines, which led to quick maturation. This in turn could be linked to the decline in the amount of rainfall in the month of September in this environment (Figure 2), which coincided with the seed filling stage of the crop. This is in accordance with the work of Viana *et al.* (2013), which reported that the seed filling stage is a critical period when addressing moisture stress.

Table 3 Mean performance of the twelve soybean genotypes in Minna for the measured traits in 2015

Genotype	Emergence (%)	D50%F	DM	PH (cm)	Brnch/Plt	Pod/Plt	Seed/pod	AGB (ton/ha)	SY (ton/ha)	100sw (g)	HI
TGX 1989-40F	74.00a	40.00abc	100.67ab	28.73bcd	6.00ab	94.67ab	3.00a	6.70a	2.70a	14.20a	0.41b
TGX 1990-52F	76.33a	40.00abc	100.67ab	34.00b	5.67ab	60.67cde	2.00b	3.97bcd	1.67bcd	13.30ab	0.42b
TGX 1989-48FN	72.33a	40.33abc	101.67a	24.40d	5.33abc	62.00cde	2.00b	3.70cd	1.67bcd	12.90ab	0.46ab
TGX 1990-40F	63.67ab	40.00abc	99.33bc	32.33b	5.67ab	72.67bcde	2.00b	4.70bc	1.90bc	13.27ab	0.41b
TGX 1989-49FN	73.00a	39.33cd	100.33ab	31.40bc	7.00a	69.67bcde	2.00b	4.00bc	1.67bcd	13.23ab	0.42b
TGX 1990-57F	68.00a	40.00abc	100.67ab	33.00b	4.67bc	75.00bcd	2.00b	3.87bcd	1.77bcd	14.23a	0.46ab
TGX 1989-68FN	66.67a	39.67bcd	101.00a	25.80cd	4.33bc	58.67cde	2.00b	3.90bcd	1.67bcd	13.97a	0.43b
TGX 1990-46F	75.67a	41.00a	99.33bc	33.80cd	5.67ab	104.33a	2.00b	3.93bcd	1.70bcd	11.37c	0.43b
TGX 1990-55F	65.67a	40.67ab	101.67a	39.47a	5.00bc	82.00abc	2.00b	5.03b	2.03b	14.07a	0.40b
TGX 1987-10F	70.00a	40.33abc	98.00c	33.07b	3.67c	48.67e	3.00a	3.6cd	1.80bcd	13.23ab	0.50a
TGX 1835-10E	50.33b	41.00a	95.33d	30.00bcd	4.67bc	53.67de	3.00a	3.17d	1.47cd	11.23c	0.46ab
TGX 1485-1D	80.00a	38.67d	94.67d	26.33cd	5.67ab	49.33de	2.00b	3.00d	1.37d	12.37bc	0.46ab
Mean	69.64	40.08	99.44	31.03	5.28	69.28	2.25	4.13	1.78	13.12	0.44
±SE	4.91	0.36	0.44	1.74	0.53	7.73	0	0.37	0.13	0.42	0.02
p-value	0.0331	0.0063	<.0001	0.0002	0.0205	0.0005	<.0001	<.0001	0.0001	0.0002	0.0209

Means followed by the same letter(s) within the column are not significantly different ($p = 0.05$) by Duncan Multiple Range Test.D50%F = Days to 50 % flowering, DM = Days to maturity, PH = Plant height, Brnch/Plt = Branches per plant, Pod/plt = Pods per plant, AGB = Above ground biomass, SY = Seed yield, 100sw = 100 seed weight and HI = Harvest index.

Table 4 Mean performance of the twelve soybean genotypes in Igabi for the measured traits in 2015

Genotype	Emergence (%)	D50%F	DM	PH (cm)	Brnch/Plt	Pod/Plt	Seed/pod	AGB (ton/ha)	SY (ton/ha)	100sw (g)	HI
TGX 1989-40F	78.67	45.67g	96.00d	30.03def	5.33ab	96.67abc	3.00a	5.87a	2.53a	12.87ab	0.43cd
TGX 1990-52F	87.33	48.00e	100.67b	34.67bcd	5.33ab	74.33bc	2.00c	3.20d	1.33e	11.40c	0.41d
TGX 1989-48FN	77.67	51.00bc	103.67a	25.90f	6.00a	122.00a	2.67b	4.67bc	2.13ab	13.00a	0.46b
TGX 1990-40F	75.67	50.33cd	98.00c	34.53bcd	5.33ab	105.67ab	2.00c	4.00cd	1.57cde	11.03c	0.39e
TGX 1989-49FN	81.33	46.67fg	96.33d	33.47cde	5.33ab	94.67abc	2.00c	3.90cd	1.73bcde	12.97a	0.45bc
TGX 1990-57F	71	51.67ab	98.00c	35.83bc	6.00a	124.00a	3.00a	4.30cd	1.83bcde	10.93c	0.43cd
TGX 1989-68FN	82.67	52.33a	100.33b	28.93ef	4.33b	76.67bc	2.00c	3.73cd	1.40cde	12.07abc	0.37e
TGX 1990-46F	76.67	50.33cd	98.00c	39.30b	5.33ab	120.67a	2.00c	3.53cd	1.87bcde	11.47bc	0.53a
TGX 1990-55F	73.33	47.33ef	100.67b	45.57a	5.00ab	124.00a	2.00c	5.73ab	1.90bcd	11.47bc	0.33f
TGX 1987-10F	76.67	50.00cd	93.33e	38.43b	5.33ab	84.33bc	3.00a	3.67cd	1.93bc	11.67abc	0.53a
TGX 1835-10E	83.33	52.67a	94.00e	28.37f	6.00a	64.33c	3.00a	4.10cd	1.90bcd	11.67abc	0.46b
TGX 1485-1D	71.33	49.33d	93.00e	26.10f	5.00ab	87.33bc	2.00c	3.10d	1.37de	10.97c	0.44bc
Mean	77.97	49.61	97.67	33.43	5.33	97.89	2.25	4.15	1.79	11.79	0.44
±SE	6.72	0.41	0.42	1.5	0.32	9.81	0.1	0.38	0.16	0.43	0.01
p-value	0.848	<.0001	<.0001	<.0001	0.0455	0.001	<.0001	0.0004	0.0011	0.0098	<.0001

Means followed by the same letter(s) within the column are not significantly different ($p = 0.05$) by Duncan Multiple Range Test.

D50%F = Days to 50 % flowering, DM = Days to maturity, PH = Plant height, Brnch/Plt = Branches per plant, Pod/plt = Pods per plant, AGB = Above ground biomass, SY = Seed yield, 100sw = 100 seed weight and HI = Harvest index.

Table 5 Mean performance of the twelve soybean genotypes in Gwarzo for the measured traits in 2015

Genotype	Emergence (%)	D50%F	DM	PH (cm)	Brnch/Plt	Pod/Plt	Seed/pod	AGB (ton/ha)	SY (ton/ha)	100sw (g)	HI
TGX 1989-40F	56.00dc	36.00c	88.33cde	23.43bcde	2.00bc	46.67	3.00a	3.63ab	1.73b	11.20b	0.48bc
TGX 1990-52F	86.00ab	37.67ab	89.00bcd	24.27abcd	1.66bc	44	2.00b	1.93f	1.07ef	10.80bc	0.56a
TGX 1989-48FN	88.00ab	38.00ab	90.33ab	20.43e	2.33b	43	2.00b	2.23def	1.03f	10.67bc	0.47bc
TGX 1990-40F	78.33ab	38.00ab	87.33cde	22.67cde	2.33b	44	2.00b	2.57cdef	1.07ef	10.33bc	0.42cd
TGX 1989-49FN	73.67abc	35.00c	86.67e	22.30cde	1.66bc	48.33	2.00b	2.63cde	1.27de	11.20b	0.48bc
TGX 1990-57F	45.67d	37.67ab	88.33cde	22.80cde	2.00bc	49.67	3.00a	3.77a	2.07a	12.97a	0.55a
TGX 1989-68FN	91.67a	37.33b	89.00bcd	20.80de	2.00bc	42.3	2.00b	2.07ef	1.03f	10.87bc	0.50ab
TGX 1990-46F	68.33bc	38.33ab	86.33e	26.87ab	1.33c	46	2.00b	2.50cdef	1.13def	10.47bc	0.46bc
TGX 1990-55F	81.67ab	38.67ab	89.33abc	27.10a	2.00bc	51.33	2.00b	2.87cd	1.03f	8.77d	0.36d
TGX 1987-10F	84.67ab	37.33b	87.00de	24.13abcd	2.00bc	49	3.00a	3.17abc	1.50c	11.17b	0.47bc
TGX 1835-10E	73.67abc	38.67ab	87.33cde	24.17abcd	1.66bc	45	3.00a	3.07bc	1.30d	9.63cd	0.43c
TGX 1485-1D	91.33ab	39.00a	91.00a	24.47abc	3.67a	50.33	2.00b	2.90c	1.23de	10.90bc	0.42cd
Mean	76.58	37.64	88.33	23.62	2.06	46.64	2.33	2.78	1.29	10.75	0.47
±SE	6.85	0.43	0.61	1.05	0.26	2.18	0	0.2	0.07	0.43	0.02
p-value	0.0032	<.0001	0.0002	0.0039	0.0006	0.1318	<.0001	<.0001	<.0001	0.0004	<.0001

Means followed by the same letter(s) within the column are not significantly different ($p = 0.05$) by Duncan Multiple Range Test.D50%F = Days to 50 % flowering, DM = Days to maturity, PH = Plant height, Brnch/Plt = Branches per plant, Pod/plt = Pods per plant, AGB = Above ground biomass, SY = Seed yield, 100sw = 100 seed weight and HI = Harvest index.

Performance of the lines across the environments for seed yield

The yield variation expressed by the various locations showed that the agro ecologies were diverse. Although temperature distribution is relatively uniform and favourable across the three environments during the production period, rainfall pattern varied (Figures 1 and 2), this could be the major cause of yield variation across the agro ecologies. The similar high mean performance of the lines in Minna (Niger State) and Igabi (Kaduna State) (Table 6) could be traced to the favourable rainfall pattern exhibited by the two locations. On the other hand, the lower yield experienced in Gwarzo (Kano State) may be attributed to the decline in rainfall during the seed filling stage of the lines (September). This caused seed maturation to occur too early, which lowered their weight and resulted in yield reduction. This result could be part of the reasons Kaduna and Niger states (Kano not included) were classified among the major soybean producing states in Nigeria by Agricultural Media Resources and Extension Centre (AMREC, 2007).

Table 6 Mean seed yield of soybean lines across the three locations (ton/ha) in 2015

Genotype	Minna	Igabi	Gwarzo	Mean
TGX 1989-40F	2.70	2.53	1.73	2.32
TGX 1990-52F	1.67	1.33	1.07	1.36
TGX 1989-48FN	1.67	2.13	1.03	1.61
TGX 1990-40F	1.90	1.57	1.07	1.51
TGX 1989-49FN	1.67	1.73	1.27	1.56
TGX 1990-57F	1.77	1.83	2.07	1.89
TGX 1989-68FN	1.67	1.40	1.03	1.37
TGX 1990-46F	1.70	1.87	1.13	1.57
TGX 1990-55F	2.03	1.90	1.03	1.65
TGX 1987-10F	1.80	1.93	1.50	1.74
TGX 1835-10E	1.47	1.90	1.30	1.56
TGX 1485-1D	1.37	1.37	1.23	1.32
Mean	1.78	1.79	1.29	1.62
± SE	0.13	0.16	0.07	0.12
p-value	0.0001	0.0011	<.0001	0.0006

CONCLUSION AND RECOMMENDATIONS

The soybean lines had different performances across the three agro ecologies, as influenced by climate especially rainfall distribution. However, seven lines (TGX 1989-40F, TGX 1989-48FN, TGX 1989-49FN, TGX 1990-57F, TGX 1990-46F, TGX 1990-55F, and TGX 1987-10F) had similar high yield performance in Minna (Southern Guinea Savannah) and Igabi (Northern Guinea Savannah). These lines are therefore recommended for cultivation in both Northern and Southern Savannah. The lines with outstanding performance in Gwarzo (Sudan Savannah) were TGX 1989-40F and TGX 1990-57F and could be selected for cultivation in Sudan Savannah agro ecology of Nigeria.

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