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EDITORIAL

The Editorial Board is happy to release Volume 10(1) of our reputable Journal. This volume is coming under a new Editorial Board and with some new features and framework which will improve the aesthetics of the Journal. The cover has been slightly beautified, including changing the University logo to the new design. This Volume comes with a lot of challenges: first the attention of the Editorial Board was diverted to the hosting of the *First International Conference of Agriculture and Agricultural Technology* (ICAAT), second, the incessant strike action of the *Academic Staff Union of Universities* (ASUU) has always disrupted the smooth operation of the Editorial Board. However, the Editorial Board is putting measures on ground that would ensure that this type of disruptions have minimal effect on the Journal. That is the reason why this volume is being released even during a major industrial action by ASUU.

The Editorial Board is also making frantic efforts to register the Journal with Journal Databases and cataloguing institutions in order to promote the readership of the Journal. Part of the reasons why it has not materialized is our inability to maintain constancy and currency. These are the key requirements of most databases. In that regard, I want to appealed to our contributing Authors to continue to send their papers at any time. The journal production is a circular and continuous process. As from Volume 11, as we prepare to join international institutions, the date of first submission, date of review and date of acceptance of each paper would be part of the metrics of the journal. We may also publish the names of reviewers along with the paper as a form of transparency and promoting integrity in research and publications.

Let me express our profound appreciation to our numerous reviews for sparing their valuable time and scarce resources to review papers for this Volume in a timely manner in spite of their tight schedules. We appeal that they will oblige us this same privilege whenever we approach them for the same favour. I will however appeal to our reviewers to be more critical with the papers since we are dealing with a global audience.

We are very thankful for the support of the Dean of the School, Prof. A. J. Odofin, the Board of the School and the elders of the School for their fatherly roles for all the support. We also express our profound appreciation to our Editorial advisers for their sense of commitment and dedication. We are also appreciative of the role the Vice Chancellor and other Principal Officers in providing the enabling environment in the University for quality Journal publishing.

Editor-in-Chief

Prof. Job N Nmadu

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PERFORMANCE OF SOYBEAN GENOTYPES UNDER RHIZOBIA INOCULATION ACROSS THREE AGRO-ECOLOGICAL ZONES OF NIGERIA

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ABSTRACT
There is need to improve soybean yield productivity per unit area in the tropics, at least to the world average productivity level. To achieve this, attention has to be paid to the selection of high yielding and stable genotypes through plant breeding improvement programmes. Twenty four soybean genotypes were investigated across three agro-ecological zones (Southern Guinea savanna, Northern Guinea savanna and Sudan savanna) in Nigeria to determine their productivity. In each zone, the experiments were laid out in split-plot design with three replications. Data were collected on growth and yield parameters. Results indicated that, genotypes TGx 1987-10F, TGx 1990-55F, TGx 1990-46F, TGx 1990-57F, TGx 1989-49FN, TGx 1989-48FN, TGx 1989-40Fand TGx 1989-40F were high yielding across the three agro-ecological zones. This indicates that environmental differences could be responsible for soybean productivity from one agro ecology to another. Therefore, soybean genotypes should be recommended for cultivation across the environments. Appropriate soybean inoculation with LegumeFix and or NoduMax should be adopted in order to enhance soybean yield and productivity.

KEYWORDS: Soybean, Agro-ecology, Performance, Interaction

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is a legume native to East Asia perhaps in North and Central China (Laswai *et al*., 2005) and belongs to the family Leguminosea. Soybean has been recognized as one of the premier agricultural crops today, thus it is the best source of plant protein and oil. It has now been recognized as a potential supplementary source of nutritious food (Wilcox and Shibles, 2001). It has been found to substitute other sources of good quality protein such as milk, meat and fish. Therefore, it has become very suitable compared to other protein sources that are scarce or too expensive to afford (Asrat *et al*., 2009).

Soybean contains a good quality protein of 42 % and 19.5 % oil (Wilcox and Shibles, 2001). Soybean protein is considered complete, because it supplies sufficient amounts of the types of amino acids that are required by the body for building and repair of tissues (Jinze, 2010). Essential amino acids found in soybean are methionine, isoleucine, lysine, cystine, phenylalanine, tyrosine, theonine, tryphophan as well as valine (Bellaloui *et al*., 2009). Amino acids are used in the formation of protoplasm, the site for cell division and therefore facilitate plant growth and development. Soybean has been found to have different uses; for example in food industry, soybean is used for flour, oil, cookies, candy, milk, vegetable cheese, leathin and many other products (Coskan and Dogan, 2011).

Improving soybean yield productivity per unit area is needed, at least, to the world average productivity level in the tropics. To achieve this, attention has to be paid to the selection of high yielding and stable genotypes through plant breeding/improvement programmes. In plant improvement programmes, knowledge of the genetic variability and the adequate eva1uation of breeding materials under several environments are of paramount importance. With the identification of high-yielding and well-adapted soybean genotypes, breeders can make recommendations to farmers, for soybean production in specific environments and across environments, which is expected to address the yield gap presently experienced in Nigerian agro ecologies. Therefore the objectives of the study were to evaluate the performance of soybean genotypes across environments, evaluate yield stability of the genotypes across the three environments and select superior advance genotypes in the test environments under rhizobia inoculation for yield evaluation.

METHODOLOGY

The study area: The experiment was conducted during the 2015 and 2016 rainy seasons at three experimental sites across three different agro-ecologies of Nigeria. The experimental sites were; Abuja located between latitude 9°16'N and longitude 7°20'E, in the Southern Guinea savanna, Igabi located between latitude 112°12'N and longitude 7°20'E in the Northern Guinea savanna, Gwarzo located between latitude 11°19'N and longitude 8°51'E in the Sudan savanna.

Treatments and experimental design: The experimental treatment of 24 soybean genotypes (TGx 1989-11F, TGx 1990-110FN, TGx 1989-42F, TGx 1990-95F, TGx 1989-45F, TGx 1990-114FN, TGx 1989-53FN, TGx 1993-4FN, TGx 1989-75FN, TGx 1990-78F, TGx 1987-62F(Check), TGx 1448-2E(Check), 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(Check), TGx 1835-10E(Check), TGx 1485-1D(Check) (Checks are already released genotypes)) and three inoculation types (Without Inoculation, LegumeFix and NoduMax) fitted into a Split-plot design with three replications. The main plots consisted of the soybean genotypes and the sub-plots were the inoculation types. Gross plot size was 3 m × 4 m (12 m^2) containing five ridges (3 m long) each. Net plot size was 3 m × 2.5 m (7.5 m^2). An alley of 1 m was used to separate the blocks, and 0.5 m for the treatment plots.

Agronomic practices: The experimental field in each location was ploughed, harrowed and ridged with tractor. Then followed by field layout in which 216 sub-plots were marked out according to the treatments. Single super phosphate (SSP) was applied at the rate of 40 kg P_2O_5 ha^{-1} at 2 weeks after sowing as basal fertilizer using side placement method of fertilizer application. Cypermethrin (Best) at the rate of 0.14 kg a.i ha^{-1} (Afolayan and Braimoh, 1991) was applied at 3 weeks after sowing on the seedlings with knapsack sprayer to control insect pests infestation. In each of the location and year of research, seed yield was taken in which seeds were separated from the husk and kept in labelled bags representing respective plots and then converted to kilogram per hectare.

Analysis: Data collected on growth parameters and seed yield were subjected to Analysis of Variance (ANOVA) using General Linear Model (GLM) procedure of SAS (SAS, 2003). Treatment of significance was determined at 5 %. Means were separated using Duncan Multiple Range Test at p = 0.05. Combined data was used for correlation. To determine genotypic sensitivity and stability, linear regression and correlation model was used (Eberhart and Russell, 1966). Additive Main Effect and Multiplicative Interaction (AMMI) were used to determine the stability pattern of the genotypes across the locations (Adie and Krisnawati (2015). The AMMI model is $Y_{ij.} = \mu + g_i + e_j + \sum \lambda_k \alpha_{ik} \gamma_{jk} + \varepsilon_{ij.}$

Where Y_{ij} is the mean of the ith line in the jth environment, μ is the grand mean, g_i is the genotype effect, e_j is the site effect, λ_k is the singular value for principal components k, α_{ik} is the eigenvector score for genotype i and component k, γ_{jk} is the eigenvector score for environment j and component k, and $\varepsilon_{ij.}$ is the error for genotype i and environment j.

RESULTS AND DISCUSSION

Mean seed yield of soybean as affected by genotypes and inoculation during the 2015 and 2016 cropping seasons across the environments is presented in Table 1. Seed yield was significant among the genotypes and the inoculation applications at both cropping seasons and their combined (the average of 2015 and 2016 cropping season data for each treatment) data. TGx 1990-110FN, TGx 1990-46F, TGx 1989-45F, TGx 1989-49FN and TGx 1990-55F recorded significantly higher seed yield during the 2015 cropping season while TGx 1990-95F was significantly lower in yield during the same cropping season. In 2016 cropping season, TGx 1990-46F produced the highest yield but not significantly different from TGx 1835-10E(Check), TGx 1485-1D(Check), TGx 1989-49FN, TGx 1989-45F and TGx 1990-110FN. Also, the combined data revealed that, TGx 1990-46F and TGx 1984-49FN had significantly higher seed yield than the other genotypes. Plants without inoculation produced significantly lower seed yield in both cropping seasons. Furthermore, the interaction between genotypes and inoculation was not significant except during the 2016 cropping season. Seed yield were generally higher in plants inoculated with either NoduMax or LegumeFix compared to those plants without inoculation (Table 2). Among the inoculated plants, irrespective of the inoculants, TGx 1990-110FN, TGx 1989-49FN and TGx 1990-46F produced significantly higher yield, similar to those produced by NoduMax-inoculated TGx 1989-48FN, TGx 1990-40F and the LegumeFix-inoculated TGx 1989-42FN, TGx 1989-68FN and TGx 1990-55F plants. These were similar in yield as the checks TGx 1835-10E, TGx 1835-10E, TGx 1967-62F and TGx 1987-10F (Table 2). In the combined data, all the growth and yield attributes measured correlated positively and significantly with the seed yield (Table 3). The strongest relationship in the combined data, was that between 100-seed weight and seed yield (r = 0.889*). This was in turn also the strongest relationship between any two growth parameters recorded. Table 4 shows the sensitivity and stability coefficients for seed yield of soybean genotypes across environments during the 2015 and 2016 cropping seasons. TGx 1989-19F recorded mean seed yield (1577 kg ha^{-1}) greater than average mean 1570 kg ha^{-1} and showed average genotypic sensitivity (b = 1) hence averagely stable. Also, five genotypes TGx 1990-40F, TGx 1989-11F, TGx 1990-52F, TGx 1448-2E(Check) and TGx 1990-55F recorded more than mean performance and above average sensitivity, thus less stable. Furthermore, four genotypes, TGx 1989-45F, TGx 1989-75FN, TGx 1990-110FN and TGx 1990-95F had more than mean performance and below average sensitivity (b < 1) making it more stable.

The genotype and environment interaction clearly plays a significant role in breeding adaptable genotypes to the wide environment. These results agree to the findings of Gebeyehu and Assefa (2003) who reported that selections based on the highest yielding genotypes appeared less stable than the average of all genotypes. Furthermore, Gebeyehu and Assefa (2003) stated that selection solely for seed yield could result in rejection of several stable genotypes. TGx 1989-45F and TGx 1990-110FN out yielded others because of its yield components such as plant height, number of leaves, number of pods per plant and some other growth traits that have contributed to the high yield. The mean performance (Table 1) revealed that high yielding genotypes across the environments over the two years were TGx 1989-45F, TGX 1990-110FN and TGx 1989-53FN. Thus, the outstanding performance by TGx 1989-45F in terms of yield made it the best performer across the three environments over two years. These conform to Egli (1998) explanation for soybean performance that yield variation across environments and years was associated with changes in number of seeds per unit area. A contrary explanation is that an ideal soybean cultivar is one that achieves the greatest yield across many environments (Fasoula and Fasoula, 2002). Thus, the genotype by environment interaction might have made it difficult for breeders to identify the best genotypes, during selection and recommendation. The positive and significant correlation estimated between seed yield and other traits agreed with the findings of Malik *et al*. (2006). This implies that selections aimed at increasing seed yield would invariably select for higher plant height, higher leaf number and earliness to flower. This finding was in agreement with Karasu *et al*. (2002) who revealed that crop yield variations are strongly influenced by growth and yield parameters. The highest and the lowest seed yields level attained by the genotypes were mostly due to plant height, number of leaves, number of branches per plant and number of pods per plant. In this study, it could be cited that the correlation coefficient of the genotypes across the environments in two years indicated that plant height had significant correlation with seed yield. This finding conformed to the report of Rajanna *et al*. (2000). The chlorophyll content was significantly associated with seed yield. This indicated that with the greenish nature of the leaves more efficient utilization of solar radiation could be achieved. The finding was in agreement with Kumudini *et al*. (2001) who explained that the higher the chlorophyll content, the more improved the yield due to increased intercepted solar radiation and enhanced carbon exchange rate. The little variability recorded among genotypes was due to their response to climate changes in the three environments. This agrees with Kang (2002) findings that environment played major role in phenotypic expressions of agronomic traits. To overcome genotype by environment effect, Cucolotto *et al*. (2007) partitioned genotype by environment interaction into two; adaptability and phenotypic stability. These researchers defined adaptability as the capability that a genotype has to make use of the environmental effects that warrants a high yield level and phenotypic stability was related to yield maintenance or yield predictability in diverse environment. However, in the present study, genotype by environment was not partitioned. Phenotypically, all the studied genotypes followed similar trend of performance over two years. According to Eberhart and Russell (1966), an ideal cultivar would have both a high average performance over a wide range of environments plus stability. Although genotypic main effect was highly significant this shows difference in genotypic performance across environments resulting in genotype by environment interaction. The existence of genotype by environment interaction raised the need to identify stable and high yielding genotypes.

Table 1: Mean seed yield (kg ha^{-1}) of soybean genotypes as affected by inoculation during the 2015 and 2016 cropping seasons across the environments

Treatment	2015	2016	Combined
Genotypes (G)			
TGx 1989-11F	1659.2cd	1545.1dc	1602.1c
TGx 1990-110FN	2717.5a	1839.0ab	2278.3a
TGx 1989 -42FN	1590.6cd	1676.5bc	1633.6c
TGx 1990 -95F	1514.2d	1544.6cd	1529.4c
TGx 1989-45F	1989.8ab	1820.1ab	1905.0ab
TGx 1990-114FN	1558.8cd	1611.3cd	1585.0c
TGx 1989-53FN	1613.0cd	1498.9d	1556.0c
TGx 1993-4FN	1581.8cd	1601.0cd	1591.4c
TGx 1989-75FN	1573.1cd	1592.3cd	1582.7c
TGx 1990-78F	1563.6cd	1582.8cd	1573.2c

TGx 1967-62F(Check)	1722.7bc	1738.6bc	1730.7bc
TGx 1448-2E(Check)	1658.7cd	1655.7bc	1657.2c
TGx 1989-40F	1583.3cd	1647.0bc	1615.2c
TGx 1990-52F	1657.3cd	1693.2bc	1675.3c
TGx 1989-48FN	1752.9bc	1816.5bc	1784.7bc
TGx 1990-40F	1699.1bc	1762.7bc	1730.9bc
TGx 1989-49FN	1996.4ab	1982.3ab	1989.4ab
TGx 1990-57F	1707.4bc	1771.1bc	1739.2bc
TGx 1989-68FN	1696.7bc	1727.0bc	1711.9bc
TGx 1990-46F	2060.0a	2145.9a	2102.9a
TGx 1990-55F	1859.5ab	1801.0bc	1830.2bc
TGx 1987-10F(Check)	1741.8bc	1794.4bc	1768.1bc
TGx 1835-10E(Check)	1743.7bc	1851.9ab	1797.8bc
TGx 1485-1D(Check)	1753.0bc	1872.2ab	1812.6bc
SE±	112.7	109.3	122.2
Inoculation(I)			
Without inoculation	1204.0c	1250.2b	1239.7c
NoduMax	1882.1b	1912.8a	1892.0b
LegumeFix	1988.1a	2008.3a	1991.0a
SE±	38.3	42	39.5
Interaction			
G x I	NS	*	NS

Means followed by the same letter(s) within a set of treatment column are not significantly different at P=0.05 using DMRT; NS= Not significant;
*= Significant at P=0.05; SE = Standard error of the mean

Table 2: Interaction effect of genotypes and inoculation on the seed yield (kg ha^{-1}) of soybean during the 2016 cropping season across the environments

Genotypes	Without inoculation	NoduMax	LegumeFix
TGx 1989-11F	1189.1j	1530.9f	1915.2b
TGx 1990-110FN	1299.4i	2118.3a	2099.3a
TGx 1989 -42FN	1236.1i	1777.5d	2016.0a
TGx 1990 -95F	1185.6j	1836.3c	1611.8e
TGx 1989-45F	1122.7j	1965.6b	1772.1d
TGx 1990-114FN	1172.6j	1746.4d	1915.0b
TGx 1989-53FN	1158.9j	1701.9d	1636.0e
TGx 1993-4FN	1197.9j	1828.7c	1776.4d
TGx 1989-75FN	1270.5i	1743.7d	1762.6d
TGx 1990-78F	1181.5i	1696.4e	1870.7c
TGx 1967-62F(Check)	1238.1i	1814.3c	2163.5a
TGx 1448-2E(Check)	1317.6h	1734.7d	1914.9b
TGx 1989-40F	1317.8h	1874.3c	1748.8d
TGx 1990-52F	1244.3i	1931.3b	1904.0b
TGx 1989-48FN	1345.6h	2125.2a	1978.7b
TGx 1990-40F	1212.7i	2148.9a	1926.5b
TGx 1989-49FN	1168.3j	2229.3a	2549.3a
TGx 1990-57F	1329.9h	1904.0b	2079.1a
TGx 1989-68FN	1341.6h	1759.0d	2080.3a

TGx 1990-46F	1326.8h	2588.8a	2521.9a
TGx 1990-55F	1144.8i	1911.6b	2346.3a
TGx 1987-10F(Check)	1314.1h	1987.0b	2081.8a
TGx 1835-10E(Check)	1245.0i	2025.7a	2284.7a
TGx 1485-1D(Check)	1443.7g	1929.2b	2243.7a
SE±		88.2	

Means followed by the same letters are not significantly different at P=0.05 using DMRT; SE = Standard error

Table 3: Correlation matrix between growth and yield attributes against seed yield of some soybean genotypes as influenced by inoculation type during the 2015 and 2016 cropping seasons across environments

	1	2	3	4	5	6	7	8	9	10
1	1									
2	0.564*	1								
3	0.621*	0.719*	1							
4	0.581*	0.603*	0.709*	1						
5	0.156*	0.298*	0.253*	0.186*	1					
6	0.599*	0.696*	0.752*	0.589*	0.240*	1				
7	0.599*	0.696*	0.752*	0.589*	0.240*	0.000*	1			
8	0.242*	0.335*	0.340*	0.307*	0.145*	0.333*	0.333*	1		
9	0.478*	0.424*	0.539*	0.393*	0.177*	0.455*	0.455*	0.199*	1	
10	0.591*	0.597*	0.696*	0.509*	0.234*	0.789*	0.789*	0.264*	0.889*	1

*= Significant at 5%, 1= Chlorophyll content, 2= Plant height, 3= Number of leaves, 4= Number of pods per plant, 5= Number of branches per plant, 6= Above ground biomass yield, 7= Total biomass yield, 8= Harvest index, 9= 100-seed weight, 10= Seed yield

Table 4: Combined analysis for sensitivity and stability coefficients for seed yield from soybean genotypes across environments during the 2015 and 2016 cropping seasons

Genotype	Mean	Sensitivity (b value)	Static Stability	Mean square Deviation
TGx 1989-53FN	1493	0.7377	62849	909
TGx 1989-45F	1631	0.7381	64383	3846
TGx 1989-75FN	1571	0.8235	79986	12118
TGx 1990-114FN	1539	0.8239	83799	4325
TGx 1990-110FN	1594	0.8509	91675	17353
TGx 1485-ID(CK)	1570	0.8553	98997	32982
TGx 1993-4FN	1564	0.9010	100316	19412
TGx 1989-68FN	1537	0.9180	100367	7392
TGx 1990-78F	1488	0.9270	102786	973
TGx 1989-42F	1568	0.9485	104917	3565
TGx 1987-62F(CK)	1585	0.9533	105135	1887
TGx 1835-10E(CK)	1567	0.9676	118586	22522
TGx 1990-95F	1607	0.9848	118601	61738
TGx 1989-40F	1577	1.0000	124557	4196
TGx 1990-40F	1592	1.0414	136271	426
TGx 1989-11F	1579	1.0881	139353	18149
TGx 1987-10F(CK)	1566	1.0900	142051	125
TGx 1990-52F	1587	1.0970	144824	2772
TGx 1448-2E(CK)	1596	1.1146	146514	8178
TGx 1990-55F	1632	1.1271	149189	7093
Grand mean	1570			

CK= Check

CONCLUSION AND RECOMMENDATIONS

Out of the twenty-four genotypes evaluated for genotype by environment interaction and yield stability, TGx 1987-10F, TGx 1990-55F, TGx 1990-46F, TGx 1990-57F, TGx 1989-49FN, TGx 1989-48FN, TGx 1989-40F and TGx 1989-40F were identified by the analytical tools used as the overall best in relation to seed yield and stability as compared to the grand mean performance of the genotypes. The performance of inoculated seeds by B. *japonicum* was statistically higher than that without inoculation seeds. Therefore, symbiotic N_2 requirement and optimum yield potential of soybean genotypes grown in the savanna region of Nigeria may be met by rhizobia population. Therefore, soybean genotypes should be recommended for cultivation across the environments. Appropriate soybean inoculation with LegumeFix and or NoduMax should be adopted in order to enhance soybean yield and productivity

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