

Variability in Six Medium Maturing Soybean (*Glycine max* (L.) Merrill) Genotypes as Influenced by Lime Applications: Yield, Yield Components and Weeds

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Abstract Field experiments were conducted during the 2006 and 2007 cropping seasons at the National Horticultural Research Institute, Okigwe, Nigeria, to determine the effect of liming on the yield, yield components and weeds of six medium maturing soybean genotypes (TGX 1844-18E, TGX 1448-2E, TGX 1444-1E, TGX 1740-1E, TGX 1440-1E and TGX 923-2E). In each year, the experiment was laid out as a split-plot in a randomized complete block design using three replications. Five lime rates of 0, 0.45, 0.90, 1.35, 1.80 and 2.25 t/ha were the main plots while the soybean genotypes were the subplots. In both years, seed yield differed significantly among the genotypes. Liming had significant effect on seed yield in 2006 but not in 2007 while the interaction between lime rate and soybean genotypes was significant only in 2006. Seed yield tends to increase in 2006 as lime rates increases. The inconsistency in seed yield in both years was attributed to the rainfall pattern which was higher in 2007 than 2006. Significant genotypic effect was also observed for the yield components while liming had no significant effect on weed density and biomass in both years. This study has shown that farmers could obtain better yield and improve soybean production by planting TGS 1834-18E and TGX 1444-1E and apply lime at the rate of 0.9t/ha.

Keywords Variability, Medium maturing, Soybeans, Lime application

1. Introduction

Soybean (*Glycine max* (L.) Merrill) is an important source of high quality but inexpensive protein and oil. It contains about 41% proteins and 21% Oil (Wilcox, 1987). Its cultivation is increasing in the savannas of Nigeria and also in the rainforest agro ecological zone because it is a major cash crop widely used in food and feeds (Brader, 1998; Sangiga *et al.*, 2002; Okpara and Ibiam, 2000; Ofor and Okpara, 2005; and Okpara, *et al.*, 2007). Farmers have adopted some new varieties that store well without chemical pest control (Okogun *et al.*, 2004) and these nodulate freely with native rhizobia strains and take care of a large proportion of their nitrogen requirement through biological n-fixation once the plants are established (Asiegbu and Okpara, 2002; Singh *et al.*, 2003 and Okogun *et al.*, 2004).

Although development and introduction of new varieties of soybean have lead to an increase in the production of this

important crop in Nigeria, sustainable production is constrained by poor soil fertility (Ogoke *et al.*, 2003). Soybean yield is low in acid soils because of low pH, high level of Al, Mn and low levels of Ca, Mg, P, K, and micronutrients such as boron and zinc (Fageria, 1994), low population of beneficial microorganisms like rhizobia, vesicular arbuscular mycorrhizal fungi and the inhibition of root growth (Maddox and Soileus, 1991). Liming improves microbiological activities of acidic soils which in turn can lead to an increase in N-fixation and promotes mineralization of organic materials (Okogun *et al.*, 2004).

Variability in crop response to liming have been shown in maize (Jennifer and Edmeades, 1997) and some early maturing varieties of soybean (Okpara *et al.*, 2007), however, the response of medium maturing soybean varieties have not been fully documented, therefore obtaining information on lime use in the medium maturing soybean varieties is necessary as part of the management programme to boost the production of this important crop in this agro ecology. The objective of this study was to determine the variability in yield, yield components of six medium maturing soybean genotypes and weeds under different liming regimes.

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2. Materials and Methods

The experiment was conducted in 2006 and 2007 cropping seasons at the National Horticultural Research Institute, substation (NIHORT) at Mbato, Okigwe (Longitude 07° 23' E, Latitude 05° 33' N; 130 m above sea level). Soil characteristics of the experimental site and monthly rainfall (mm) in 2006 and 2007 are shown in Table 1 and in Figure 1.

Table 1. Characteristics of soils in Mbato, Okigwe in 2006 and 2007 cropping season

Soil properties	2006	2007
Sand (%)	67.5	74.4
Silt (%)	5.1	12.2
Clay (%)	27.4	31.4
Textural class	Sandy Loam	Sandy loam
pH (H ₂ O)	5	5.25
Organic Matter (%)	0.21	0.22
Available P (mg kg ⁻¹)	64	31
K (mg kg ⁻¹)	0.193	0.192
Ca (mg kg ⁻¹)	3.2	3.2
Na (mg kg ⁻¹)	0.34	0.32
Mg (mg kg ⁻¹)	1.6	1.8
N (%)	7	6.8

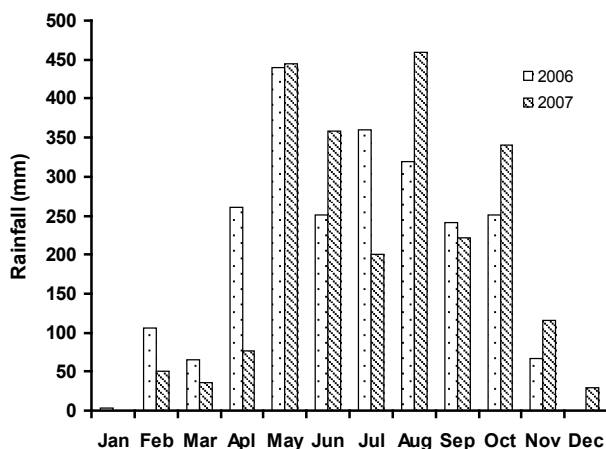


Figure 1. Monthly rainfall (mm) at the experimental site in 2006 and 2007

2.1. Land Preparation; Experimental Design and Management

The experimental site was slashed, ploughed and harrowed and composite soil sample obtained from a depth of 0-20cm from representative locations after harrowing for soil analysis. The experimental design was a split-plot in randomized complete block design with three replications. The main plot consists of the six lime rates (0, 0.45, 0.90, 1.35, 1.80 and 2.25 t/ha) while the subplots consist of six medium maturing soybean genotypes: TGX 1844-18E, TGX 1448-2E, TGX 1444-1E, TGX 1740-1F, TGX 1440-1E and TGX 923-2E. In each year, lime was applied two weeks before planting (WBP) and the seeds planted on July 26 in 2006 and on July 27 in 2007. Two seeds were planted per

hole at a spacing of 5 cm x 50 cm intra and inter –row spacing and later thinned to one/stand giving a plant population of 400,000 plants/ha. Nitrogen at the rate of 30 kg/h was applied to each plot at 2 weeks after planting (WAP) and weeding was done at 4 and 8 weeks while insects was controlled with Deltamethrine at 2 ml/litre of water when needed.

2.2. Data Collection

Weed density and weed biomass was obtained at 4 WAP before weeding. The data was obtained from two 50 cm x 50 cm quadrats placed along a diagonal transect in each plot. The weeds were counted to obtain the density and then clipped and bulked in each plot and then oven dried at 80 °C for 48 hours to obtain the weed biomass.

At the sampling age of 8 weeks after sowing (WAS), six soybean stands were randomly sampled from the inner rows of each plot. The plants were carefully uprooted with the aid of a spade to minimize any root damage to the barest level. The roots were dipped in 80 liter of water filled in a bucket and the attached soils carefully washed away. They were then rinsed under running water and subsequently rinsed again with distilled water and allowed to dry. The number of nodules per plant was obtained by counting the nodules on the sampled plants and recording the mean values. Data on plant height and leaf area per plant were taken. Plant height of soybean was measured with a meter rule, as the height from the base of the plant (ground level) to the tip of the plant while leaf area was obtained by taking the length and width of the trifoliolate leaves on the sampled soybean plants and the total leaf area per plant was calculated following the procedure outlined by Weirsmas and Bailey (1975) using the derived equation: $A = 0.411 + 2.008 LW$; where A = trifoliolate leaf area, L and W are the maximum length and width of the terminal leaflet of a trifoliolate leaf, respectively, while 0.411 and 2.008 were constants. Leaf area index (LAI) was obtained by calculation using the formula: $LAI = (\text{Total leaf area/plant}) / \text{Ground area occupied by plant}$. Days to 50 % flowering was obtained by recording the number of days from sowing to when half of the plants sown in each plot has flowered.

Soybean was harvested at 4 months after planting (MAP) when 95 % of the pods had turned brown (attained physiological maturity) by pulling whole dry plants with the roots. Harvested soybean pods were sun-dried and threshed. The yield and yield components of soybean were taken from the net plots. Records were collected on number of pods/plant and seed-yield (kg/ha). Seed size (100 seed weight) was obtained by weighing three samples of 100 air dried seeds that were sampled from the grain lot of each experimental plot.

2.3. Data Analysis

Statistical analysis was conducted using the Mixed Procedure (Littel *et al.*, 1996) of SAS (SAS Institute, 2001) with replicate treated as random effect, lime rates and

soybean genotypes were considered as fixed effects. Mean separation was done using the least significant difference while correlation coefficient was calculated using the PROC CORR of SAS (SAS Institute, 2001).

3. Results and Discussion

The soil texture was a sandy loam (Table 1). The soil is acidic with low organic matter and N while the available P is high. Monthly rainfall of over 300 mm occurred in July to October I 2007 but in 2006 rainfall in September and October (when the crop was in full blown) was less than 300 mm (Figure 2).

In both years, seed yield differed significantly ($P < 0.001$) among soybean genotypes (Table 2). Liming had a significant ($P < 0.001$) effect on seed yield in 2006 but not in 2007. The interaction between genotype and lime rate was significant only in 2006 (Table 2). Average across lime rate, TGX 1844-18E and TGX 1444-1E had the best yield in 2006 (1961.88 kg/ha and 1905.45 kg/ha, respectively) while TGX 1440-1E had the best yield in 2007 (6964.14 kg/ha) and distantly followed by TGX 1844-18E (3190.50 kg/ha). Seed yield was generally higher in 2007 than in 2006. This yield difference can be attributed to the rainfall pattern in 2007 where there were more rains at the time the crops were in the field. This may have helped the lime to be better incorporated in the soil thereby reducing the soil pH and leading to an increase in nutrient availability and the resultant increase in seed yield. A similar trend was reported by Okpara *et al.* (2007) and Ebeniro *et al.* (2010). In 2006 cropping season, the application of 1.356 t/ha lime significantly gave the highest seed yield (1,790.06 kg/ha) while the lowest seed yield (1437.80 kg/ha) was obtained under 0.0 t/ha liming. The interaction between soybean genotype and lime rate showed that TGX 1844-18E that received 0.90 t/ha lime gave the highest seed yield (2,606.00kg/ha) followed by the same genotype (2,400.67 kg/ha) at 1.35 t/ha lime application. In 2006 cropping season, the application of 1.356 t/ha lime significantly gave the highest seed yield (1,790.06 kg/ha) while the lowest seed yield (1437.80 kg/ha) was obtained under 0.0 t/ha liming. The interaction between soybean genotype and lime rate showed that TGX 1844-18E that received 0.90 t/ha lime gave the highest seed yield (2,606.00kg/ha) followed by the same genotype (2,400.67 kg/ha) at 1.35 t/ha lime application. In 2006 cropping season, the application of 1.356 t/ha lime significantly gave the highest seed yield (1,790.06 kg/ha) while the lowest seed yield (1437.80 kg/ha) was obtained under 0.0 t/ha liming. The interaction between soybean genotype and lime rate showed that TGX 1844-18E that received 0.90 t/ha lime gave the highest seed yield (2,606.00kg/ha) followed by the same genotype (2,400.67 kg/ha) at 1.35 t/ha lime application. Okpara *et al.* 2007 had earlier shown that 1.0 t/ha of lime was effective increasing the yield of soybean while Ebeniro *et al.* 2010 recommended

1.5 t/ha of lime. This result tends to agree more with Okpara *et al.* (2007) but disagrees with Ebeniro *et al.*, 2010.

Significant genotypic effects ($P < 0.001$) was observed for plant biomass/plant, number of pods/plant, number of nodules/plant, 100 seed weight (g), plant height, leaf area index and number of days to 50% flowering (Table 3). Lime rates and interaction between variety and lime was not significant for these attributes (Data not shown). TGX 1448-2E had the highest biomass in 2006 while TGX 1844-18E had the best biomass in 2007 (Figure 2). TGX 1444-1E and TGX 1844-18E had more pods than the other genotypes in 2006 and 2007, respectively. The 100 seed weight ranged from 8.60 g- 10.70 g in 2006 and 10.1 – 12.6 g in 2007 while number of nodules/plant varied from 22-30 in 2006 and 19-28 in 2007. TGX 923-2E had more nodules/plant in both years than the other genotypes. TGX 1448-2E had taller plants in 2006 while TGX 1444-1E plants were taller in 2007. The LAI ranged from 0.8 to 1.3 and was significant only in 2006 while 50% flowering was achieved in all the genotypes between 47 to 48 DAP in 2006 and 45-50 DAP in 2007. This result is in support of the earlier report of Chiezey (2001).

Number of pods/plant, plant height, number of nodules/plant, LAI, plant biomass, 100 seed weight and days to 50% flowering were positively and significantly ($P < 0.01$) corrected with seed yield in both years. This result suggests that selecting these traits will ultimately lead to an increase in seed yield of soybeans. Similar studies by Walson, (1987) in his studies on pea crops and Ojo *et al.* (2007) in their works on biological nitrogen fixation traits in twenty five tropical soybean crops showed that these are the main traits associated with yield in legumes.

Liming had no significant effect on weed density and biomass in both years. In 2007, weed density and biomass showed significant varietal effect ($P < 0.05$). The interaction between lime rate and variety was not significant in both years. TGX1444-1E and TGX1448-2E had the highest weed density and biomass (Figure 2 and 3). TGX1844-18E and TGX923-2E had the lowest weed biomass. The result tends to suggest that some of the medium maturing varieties suppressed weeds growth better than the other varieties. The medium maturing varieties had better LAI and this may have enhanced their ability to suppress weed. Several studies have reported negative association between crop LAI and weed growth (Malek *et al.*, 2012 and Wiatrak and Chen, 2011). Although some of the varieties depressed weed growth, seed yield was negatively correlated with weed density ($r = -0.71$, $P = <0.05$) and weed biomass ($r = -0.54$, $P = <0.05$). The negative association between seed yield and weed density and biomass suggests the need for early weed removal in soybean.

This study has shown that famers could obtain better yield and improve soybean production in the derived savanna of Southeastern Nigeria if they plant these two varieties TGX 1834 -18E and TGX 1444-1E and apply lime at the rate of 0.90 t/ha.

Table 2. Effect of lime application and soybean varieties on seed yield kg/ha in 2006 and 2007

Soybean varieties	Lime rates (t/ha) 2006						Lime rates (t/ha) 2007							
	0.00	0.45	0.90	1.35	1.80	2.25	Mean	0.00	0.45	0.90	1.35	1.80	2.25	Mean
TGX1440-1E	1093.33	1346.67	935.33	977.33	963.67	1180.80	1082.86	3352.80	29933.8	2106.90	2847.53	1775.5	1768.33	6964.14
TGX1444-1E	1879.33	1784.67	1644.70	2054.67	2085.67	1983.67	1905.45	2945.90	1840.00	2468.63	2027.77	2580.77	2028.17	2315.21
TGX1448-2E	1422.33	1632.00	1395.00	1392.33	1774.67	2160.67	1629.50	1938.57	2320.40	2588.73	2354.67	3328.10	2187.23	2452.95
TGX1740-1F	1462.33	1534.33	1562.00	1828.00	1642.33	2297.00	1721.00	2571.33	2668.47	2457.87	2980.73	4217.63	2502.53	2899.76
TGX1844-18E	1081.67	2018.60	2606.00	2400.67	1954.67	1709.67	1961.88	3407.80	3092.63	3175.47	3167.73	3147.07	3152.27	3190.50
TGX923-2E	1686.00	1711.67	777.67	2087.33	1889.67	1118.67	1545.17	2225.87	2140.20	2117.67	2294.07	2294.07	2443.20	2252.51
Mean	1437.50	1671.32	1486.78	1790.06	1718.45	1741.75		2740.38	6999.25	2485.88	2612.08	2890.52	2346.96	

Variety x Lime Interaction = 932.80 ***

Variety x Lime Interaction = ns

Table 3. Main effects of number of pods/plant, 100 seed weight, number of nodules/plant, plant height (cm), leaf area index and number of days to 50% flowering in six medium maturing soybean genotypes

Genotype	Number of Pods/plant		100 seed weight (g)		Number of nodules/Plant		Plant height (cm)		LAI		Days to 50% Flowering	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
TGX1440-1E	36.2	36.5	10.1	10.9	22.2	21	28.7	30.46	0.8	0.6	47.9	45.7
TGX1444-1E	49.3	35.5	10.6	11.5	23.3	21.8	29.2	37.07	0.8	0.7	48	47
TGX1448-2E	48.6	40.4	10.7	12.6	26.3	19.7	34.4	30.29	1.2	0.6	47.7	45.2
TGX1740-1F	41.1	32	10.6	11.8	22.9	19.4	29.8	31.09	0.9	0.6	48	47.2
TGX1844-18E	46.8	49.5	10.3	11.5	23.5	20.9	27.5	34.99	1.1	0.6	47.1	45.3
TGX923-2E	46.5	39.6	8.6	10.1	30	27.6	29.4	33.25	1.3	0.6	47.4	50.6
LSD Variety= 0.05	7.86**	6.86**	0.47**	0.49**	3.17**	5.4**	2.49**	4.50**	0.23**	ns	0.24**	0.42**

Table 4. Effect of lime application and soybean varieties on total weed density at 4 WAP per m² in 2006 and 2007

Soybean varieties	Lime rates (t/ha) 2006						Lime rates (t/ha) 2007								
	0.00	0.45	0.90	1.35	1.80	2.25	Mean	0.00	0.45	0.90	1.35	1.80	2.25	Mean	
TGX1440-1E	301.33	334.00	329.33	265.33	306.67	293.33	305.02	42.67	38.67	45.33	61.33	26.67	38.67	42.20	
TGX1444-1E	394.67	378.67	202.67	260.00	226.67	256.00	286.40	33.33	40.00	40.00	42.67	40.00	32.00	38.00	
TGX1448-2E	181.33	205.33	209.33	180.67	218.67	146.67	190.70	45.33	42.67	37.33	65.33	48.00	34.67	45.60	
TGX1740-1F	272.00	337.33	325.33	325.33	341.33	276.00	312.90	46.67	52.00	46.67	37.33	49.33	50.67	47.10	
TGX1844-18E	364.00	230.67	206.67	193.33	225.33	324.00	257.30	40.00	41.33	38.67	40.00	40.00	38.67	39.80	
TGX923-2E	209.33	182.67	152.00	166.67	178.67	172.00	176.90	46.67	44.00	66.67	70.67	53.33	61.33	57.10	
Mean	287.10	278.10	237.60	232.20	249.60	244.70		42.40	43.10	45.80	52.90	42.90	42.70		
LSD 0.05	Variety	54.12**						Variety	9.39*						
	Lime	ns						Lime	ns						
		Variety x Lime Interaction = ns							Variety x Lime Interaction = ns						

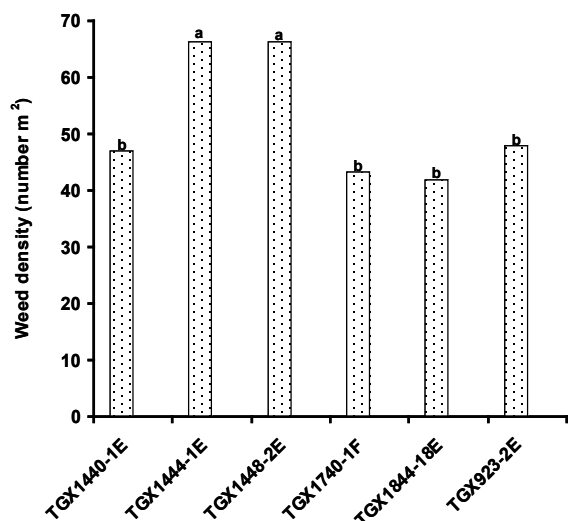


Figure 2. Weed density at 4 weeks after sowing in 2007

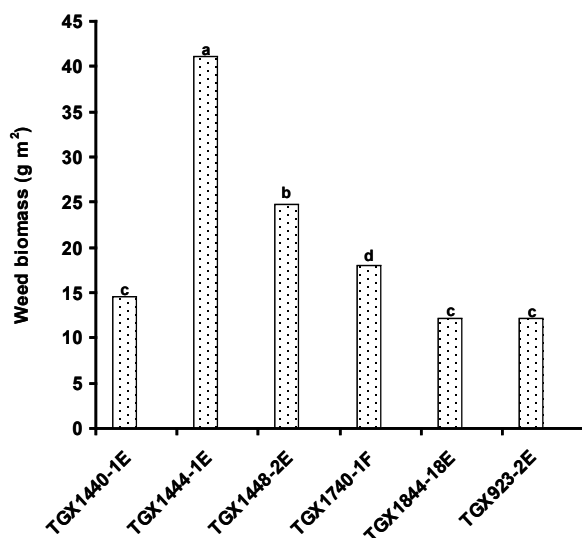


Figure 3. Weed biomass (g m⁻²) at 4 weeks after sowing in 2007

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