Growth and Yield of Soybean (*Glycine Max* (L.) Merrill) as Influenced by Organic and Inorganic Fertilizers

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Abstract

A pot experiment was conducted in the Screen House of the Department of Agronomy, Faculty of Agriculture, Bayero University, Kano to determine the effects of organic and inorganic fertilizers on the growth and yield of Soybean (Glycine max (L.) Merrill*). The treatments consisted of factorial combinations of three Soybean varieties (TGx 1835-10E, TGx 1987-62F, and TGx 1740-2F) and five levels of fertilizers (control, 244.44 kg ha^{-1} NPK, 10 t ha^{-1} poultry manure, 5 t ha^{-1} poultry manure + 244.44kg ha^{-1} NPK, and 2.5t ha^{-1} poultry manure + 355.55kg ha^{-1} NPK). This was laid out in a Completely Randomized Design (CRD) replicated three times. Vegetative traits were taken at 5, 7 and 9 weeks after sowing and yield attributes were measured at maturity stage. Variety effect was significant on plant height, number of branches plant^{-1}, leaf area, number of pods plant^{-1}, weight of grains plant^{-1} and 100 seed weight. Variety TGx 1835-10E proved superior to TGx 1987-62F and TGx 1740-2F. Combination of 2.5 t ha^{-1} + 355.55 kg ha^{-1} NPK resulted in the tallest plant, highest number of branches plant^{-1}, widest leaf area and higher number of pods plant^{-1}. Applying 5 t ha^{-1} poultry manure + 244.44 kg ha^{-1} of NPK to TGX1740-2E recorded heavier seed weight than other treatment combinations. Variety TGX1835-10E out yielded other varieties tested while combination of 2.5 t ha^{-1} of poultry manure and 355.5 kg ha^{-1} of NPK proved to be superior to other rates and combinations of fertilizers.*

Introduction

Soybean (*Glycine max* (L.) Merr) is a legume that grows in tropical, subtropical, and temperate climates. Nigeria is the largest producer of Soybean in sub-Saharan Africa (SSA), followed by South Africa. Low yields (<1 tha^{-1} in tropical Africa) and a shortage of fertilizer constrain the ability of some countries to increase production (IITA, 2008). The crop has been described as the world's chief source of edible vegetable oil and high protein feed for livestock which compares favourably with animal protein source containing all the essential amino acid required by man (Manral and Saxena, 2003). Organic matter acts directly as a source of plant nutrients and indirectly influences the physical and chemical properties of the soil.Poultry manure is very cheap and effective as a good source for Nigerian sustainable crop production, but it's availability remains an important issue due to its bulky nature while inorganic fertilizer is no longer within the reach of resources of poor farmers due to its high cost (Rahman, 2000).

Among the means available to achieve sustainability in agricultural production, organic manure and bio fertilizer play an important and key role on the desired soil properties and exerts a beneficial effect on all soil characteristics (Soleimanzadeh and Ghooshchi, 2013). One of the ways of increasing nutrients status is by boosting the soil nutrient content either with the use of organic materials such as poultry manure, other animals waste and the use of compost with or without inorganic fertilizers (Dauda *etal*., 2008).Therefore, this experiment aimed at determining the influence of Organic and Inorganic fertilizers on the Growth and Yield of Soybean.

Materials and Methods

A pot experiment was conducted in the Screen House of the Department of Agronomy, Faculty of Agriculture Bayero University Kano (11058[1]N, 8025[1]E and 475m above sea level). The treatments evaluated were three Soybean varieties (TGX 1835-10E, TGX 1987-62F and TGX 1740-2E) and five levels of fertilizers (control, 244.44 kg ha^{-1} NPK, 10 t ha^{-1} poultry manure, 5 t ha^{-1} poultry manure + 244.44 kg ha^{-1} NPK, and 2.5t ha^{-1} poultry manure + 355.55 kg ha^{-1} NPK). These were factorially combined and laid in a Completely Randomized Design (CRD) with three replications. Forty-five perforated pots were filled with top soil with each pot weighing 14kg. The organic fertilizer was applied one week before sowing, and the in-organic fertilizer was applied two weeks after sowing. Data collected included plant height, number of branches $plant^{-1}$, leaf area, number of pods $plant^{-1}$, weight of grains $plant^{-1}$ and 100-seed weight. The data collected were subjected to Analysis of Variance (ANOVA) using Statistical Analysis System (SAS), and the significant treatment means were separated using Student-Newman-Keuls (SNK) method.

Results

Table 1 shows the soil analysis of the experimental site. The result indicated that the soil was sandy loam with 0.03 % nitrogen, 5.11 ppm available phosphorus, 1.40 organic carbon and a pH of 7.78.

Table 2 shows the growth components of Soybean (*Glycine max* (L.) Merr.) varieties in response to different levels of fertilizer in 2014 dry season at Bayero University, Kano. TGX 1740-2E produced significantly taller plants than the other varieties. TGX 1835-10E produced plants with significantly highest number of branches $plant^{-1}$ and greater leaf area than TGX 1987-62F and TGX 1740-2E at all the sampling periods. Application of fertilizers significantly influenced these characters. A combination of 2.5 tha^{-1} PM + 355.55 kg ha^{-1} NPK produced significantly the tallest plants, highest number of branches $plant^{-1}$ and greatest leaf area.

Table 1. **Physico – Chemical Properties of Soil of the Experimental Site**

Soil variable	**Composition**
Particle size distribution (%)	
Sand	67
Silt	17
Clay	16
Textural class	Sandy loam
Chemical properties	
pH (water)	7.78
pH ($CaCl_2$)	6.93
Organic Carbon (%)	1.40
Total Nitrogen (%)	0.03
Available Phosphorus (ppm)	5.11
Exchangeable bases	
Potassium (Cmol/kg)	0.27
Sodium (Cmol/kg)	0.18
Calcium (Cmol/kg)	1.30
Magnesium (Cmol/kg)	1.37

Table 2. **Effect of Variety and Fertilizer Rate on Plant Height, Number of Branches Plant^{-1} and Leaf of Soybean at 5, 7 and 9 Weeks after Sowing**

Treatment	Plant height Weeks after Sowing			Branches plant^{-1} Weeks after Sowing			Leaf area Weeks after Sowing		
	5	7	9	5	7	9	5	7	9
Variety (V)									
TGX 1835-10E	32.85	48.39	57.23b	3.26	5.03a	5.70a	60.26a	64.70a	79.07a
TGX 1987-62F	32.27	48.05	66.76a	2.80	4.13b	4.90b	45.33b	63.11a	75.06a
TGX 1740-2E	31.91	50.39	67.08a	3.00	3.97b	4.62b	42.96b	51.65b	57.29b
SE ±	1.352	1.637	1.840	0.147	0.227	0.246	3.641	3.695	3.116
Fertilizer (F)									
Control	21.25c	37.89b	55.27b	3.26	5.03a	5.70a	35.26c	49.86b	65.60
244.44 kg ha^{-1} NPK	31.76b	53.62a	67.55a	2.80	4.13b	4.90b	48.19abc	50.63b	67.40
10tha^{-1} Poultry manure	24.86c	39.04b	55.67b	3.00	3.97b	4.62b	45.21bc	56.39b	66.50
5tha^{-1} PM + 244.44 kg ha^{-1} NPK	42.63a	56.62a	69.13a	1.47	2.27b	2.46b	54.89ab	62.93b	71.68
2.5tha^{-1} PM + 355.55kg ha^{-1} NPK	41.20a	57.55a	70.83a	3.26	5.03a	5.70a	64.03a	79.30a	81.20
SE±	1.745	2.114	2.375	2.800	4.130	4.900	4.700	4.770	4.023
Interaction									
V × F	*	NS	*	NS	NS	NS	NS	**	NS

Means with the same letter (s) are not significantly different at 5% level of probability using Student-Newman-Keuls Test (SNK).
* = Significant at 5%
** = Highly significant at 1%

Table 3. **Chemical Properties/Composition of Poultry Manure (PM)**

Nutrients	Composition
pH (water)	8.50
pH (CaCl2)	8.17
Organic carbon (%)	85.79
Total Nitrogen (%)	0.08
Total Phosphorus (ppm)	20.89
Potassium (mg/kg)	250
Magnesium (mg/kg)	250
Calcium (mg/kg)	450
Sodium (mg/kg)	250

Table 3 shows the nutrient composition of the poultry manure. The result indicated 6.08 % nitrogen, 20.89 ppm available phosphorus, 85.79 organic carbon and a pH of 8.50.

Table 4 shows the yield components of Soybean (*Glycine max* (L.) Merr.) varieties in response to different levels of fertilizers. TGX 1987-62F had plants with significantly highest number of pods plant^{-1}. However, TGX 1835-10E had plants with the heaviest grain weight and 100 - seed weight. Combination of 2.5 tha^{-1} PM + 355.55kg ha^{-1} had plants with the highest number of pods plant^{-1}.

Table 5 shows the interaction between variety and fertilizer rates on leaf area of Soybean. Significant interaction was observed only with variety TGX 1835 – 10E where application of a combination of 2.5 t ha^{-1} + 355.55 kg ha^{-1}NPKhad plants with significantly wider leaf area while control had plants with narrow leaf area.

Table 4. **Effect of Variety and Fertilizer rate on Number of Pods Plant^{-1}, Grain Weight Plant^{-1} and 100 Seed Weight of Soybean**

Treatment	Number of Pods Plant^{-1}	Grain Weight Plant^{-1} (g)	100- Seed weight (g)
Variety (V)			
TGX 1835-10E	17.83b	4.06a	8.53a
TGX 1987-62F	21.76a	1.87b	6.88b
TGX 1740-2E	19.61ab	3.46a	9.07a
SE ±	0.776	0.333	0.290
Fertilizer (F)			
Control	16.28c	3.08	7.62
244.44 kg ha^{-1} NPK	19.58bc	2.62	8.21
10tha^{-1} Poultry manure	17.14c	2.77	7.75
5tha^{-1} PM + 244.44 kg ha^{-1} NPK	20.98b	4.08	8.42
2.5tha^{-1} PM + 355.55 kg ha^{-1} NPK	24.69a	3.09	8.80
SE±	1.001	0.430	0.375
Interaction			
V × F	NS	NS	**

Means with the same letter (s) are not significantly different at 5% level of probability using Student-Newman-Keuls Test (SNK).
** = Highly significant at 1%
NS = Not significant

Table 5. **Interaction between Variety and Fertilizer on Leaf Area (cm^2) at 7 WAS**

Variety Fertilizer	TGX1835 10E	TGX1987 62F	TGX1740 2E
Control	29.81c	45.62bc	28.98c
244.44 kg ha^{-1} NPK	74.97ab	55.72abc	66.36abc
10tha^{-1}Poultry manure	59.49abc	59.96abc	49.71bc
5tha^{-1} PM + 244.44 kg ha^{-1} NPK	64.61abc	70.83abc	53.35bc
2.5tha^{-1} PM+355.55kg ha^{-1} NPK	94.63a	83.40ab	59.86abc
SE±	8.262		

Means within and across column followed by the same letter (s) are not significantly different at 5% level of probability using Student-Newman-Keuls Test

Discussion

Application of 2.5 tha^{-1} PM + 355.5kg ha^{-1}NPK increased both growth and yield characters of Soybean measured. The taller plants recorded could be attributed to internodes elongation which led to increased number of branches plant^{-1} while the wider leaf area could be due to higher photosynthetic efficiency as leaf area is a medium of photosynthesis which translate to more assimilate production. The increased yield components could be due to the fact that increase in the fertility status of the soil and poultry manure led to vegetative growth of the crop which might translate into yield components such as high number of pods with heavier grain weight and 100 - seed weight. This result supported a well-known fact that poultry manure have been known to increase the abundance of soil organisms by providing organic matter and micro-nutrients such as fungal mycorrhiza (Pimentel *et al*., 2005) which aids plants in absorbing nutrients and can drastically reduce external inputs of pesticides and fertilizer. TGX 1987-62F variety gave the highest number of pods plant^{-1} than TGX 1835-10E TGX 1740-2E which might be probably due to better utilization of the nutrients applied. This supports the findings of Falodun *et al.* (2010) who reported that moderate rates of NPK fertilizer with low levels of organic manure improve yield and yield components of soybean. However, TGX 1835-10E had seeds with the heaviest grain weight and 100-seed weight. This could be due to the fact that this variety usually resist pod shattering and other prevalent diseases (Adeyeye, 2009).The significant interaction between variety and fertilizer rate on leaf area of Soybean recorded by TGX 1835 – 10E means that the variety is nutrient dependant and had respond favourably to fertilizer application which led to efficient utilization of poultry manure in combination with NPK that led to higher photosynthetic efficiency since the leaves are medium of photosynthesis. However variety TGX 1740 - 2E and TGX 1987 - 62F had non-significant response which means that being leguminous crops, they can fix atmospheric nitrogen with the aid of root bacteria and for this reason, these varieties are not dependent on nitrogen fertilization. In conclusion, variety TGX1835-10E out yielded other varieties tested while combination of 2.5 t ha^{-1}of poultry manure and 355.55 kg ha^{-1} of NPK proved to be superior to other rates and combinations of fertilizers.

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