Original Research Article

Effect of different organic and inorganic inputs on growth and yield of Soybean (Glycin max) in southeastern Nigeria.

Abstract

This study was carried out at the teaching and Research farm, Department of Horticulture and Landscape Technology, Akanu Ibiam Federal Polytechnic, Unwana, to investigate the integrated effects of organics (lime, Inoculum) and mineral fertilizers,(single superphosphate and muriate of potash) on the growth, nodulation and yield of soybean**.** The input omission trial was composed of 16 treatment combinations of phosphorus (75kg/ha), potassium (88kg/ha), lime (1500kg/ha), and inoculum (400g/100kg seed). Each set of 16 treatments were randomized and replicated 3 times. The soybean variety "TGX1951-3F" was planted in 0.5m by 1m plots with a seed spacing of 5cm. Data on number of nodules and nodule viability at 45 days after planting, plant height at 90 days after planting, number and weight of 100 seeds per plot and yield per plot at harvest were collected and analyzed using Analysis of Variance (ANOVA) in R using the package "car" to test the main treatment effects, 2-way, 3-way, and 4-way treatment interactions in the omission trial. Results showed highly significant effects of treatments on the growth, nodulation and yield of soybean. The no input treatment generally had the most appreciable improvement in plant height, nodule viability, weight of 100 seeds and yield. Inoculated seeds had the highest number of nodules and percent nodule viability (5 and 69% respectively). . 2.12ton/ha yield generated by the no input treatment shows the potential for future higher yield especially when climatic and good agronomic strategies are employed.

Keywords: Soybean, Rhizobium, Lime, Phosphorus and Potassium

Introduction

Nigeria has been struggling on the path of food sufficiency with manifest symptoms of stunted growth in children, malnutrition-related illnesses and high mortality rate. A close look at the nutritional content of most staple foods in Nigeria shows that protein content is an abysmal percentage of the total nutrient content, often less than 1%. Protein insufficiency puts a lot of growth and health strains on infants, children, pregnant and lactating women in Nigeria, partially because starchy foods are widely consumed and animal protein often too expensive and out of reach of low-income families. Therefore, urgent search for cheap, available alternative protein sources is needed to address the problem of protein- related malnutrition in Nigeria.

Soybean is a cheap and protein-rich grain that contains 40%of quality protein, 20% edible vegetable oil and other important nutrients (El-Shemy 2011). It has therefore tremendous potential to improve nutritional status and welfare of resource-poor households in Nigeria. Soybean can also contribute to enhanced sustainability of intensified cropping systems by improving soil fertility through nitrogen fixation (Milic *et al.*, 2002), permitting longer duration of ground cover in the cropping sequence and providing residues for feeding livestock. Developmental agenda aimed at sustainable increased production of soybean must be targeted. To achieve this, there is need to identify the agronomical constraints to soybean production in Nigeria. This will help to fashion out realistic and sustainable farming systems that will enhance its production.

Several attempts have been made by many studies to understand the effect of single and compound mineral fertilizers on yield of soybean in tropical soils (Nastasija et al., 2008; Achmad and Utomo, 2016). However, information on combined effects of lime, inoculums, phosphorus, and potassium on soybean production is still scanty. Thus, this study was carried out to fill this information gap.

Materials and Method

This study was carried out in the Research Farm of Department of Horticulture and Landscape Technology, Akanu Ibiam Federal Polytechnic Unwana, (coordinates: latitude 5^{0}48’N and longitude 7^{0}55’E). The air temperature is generally high all year round and the current temperature range is $32^{o}C$ -$21^{o}C$ with total annual rainfall exceeding 3,500 mm (Njoku, 2006). The soil of the experimental area is a Typic Hapludult (Federal Department of Agriculture and Land Resources, 1985). The area has being use for cassava cultivation for more than ten years.

The input omission trial is composed of 16 treatment combinations (Table 1) of phosphorus (75kg/ha), potassium (88kg/ha), lime (1500kg/ha), and inoculum (400g/100kg seed). Each set of 16 treatments were randomized and replicated 3 times. The soybean variety “TGX1951-3F” from the International Institute of Tropical Agriculture (IITA) was planted in 0.5m by 1m plots with a seed spacing of 5cm. Seeds were treated with Hi-Stick inoculum 1 hour prior to planting. Calcium carbonate agricultural lime was applied as a 10cm top-dress at planting. Approximately 21 days after germination, single super phosphate and muriate of potash were applied to treated plots as a side-dress 5cm from the furrow, and 5cm deep.

Data collected included the following: number of nodules and nodule viability at 45 days after planting, plant height at 90 days after planting, number and weight of 100 seeds per plot and yield per plot at harvest.

An Analysis of Variance (ANOVA) was conducted in R using the package “car” to test the main treatment effects, 2-way, 3-way, and 4-way treatment interactions in the omission trial. The Shapiro's Wilk and Brown-Forsythe test were employed to confirm residual normality and homogeneity of variance respectively

Table 1. Treatment combinations for lime, phosphorus, potassium, seeds and inoculum

Treatment	Lime	Phosphorus	Potassium	Inoculum	Seed
1					+
2				+	+
3		+			+
4			+		+
5		+		+	+
6			+	+	+
7		+	+		+
8		+	+	+	+
9	+				+
10	+			+	+
11	+				+
12	+		+		+
13	+	+		+	+
14	+		+	+	+
15	+	+	+		+
16	+	+	+	+	+

Results and Discussion

Pre-planting soil properties

The fertility property of the soil of the study site is seen in table 2. The soil has a pH of 6.45. Optimal soil pH ranges between 6.5-7.0, so no additional liming is recommended for this location. Phosphorus (threshold 30mg/kg) and potassium levels (threshold 110mg/kg) are both below the sufficient thresholds for soybean production and would benefit from amendments. Phosphorus deficiencies have been widely reported in most soils of southeastern Nigeria (Eneje and Azu, 2009). Osodeke and Ubah, (2005) has attributed the phosphorus limitations in soils of southeastern Nigeria to high concentration of oxides of iron and aluminum in these soils. Phosphorus is adsorbed on these sexquioxides, especially in acidic conditions to prevent its availability to growing plants (Brady and Weil, 2008). Similarly, Azu *et al.,* (2018), has related phosphorus deficiencies in soils of Ebonyi State to their mineralogical compositions. According to them, most soils of Ebonyi State, Nigeria are formed from shale with high concentration of 2:1 clay minerals. These minerals have the tendency of adsorbing phosphate ions, thereby making them unavailable to growing plants.

Table 2. Fertility properties of soil of the experimental site

Test	Method	Units	Value
Soil pH	1:1 - Water pH	-	6.45
Sand	-	%	75
Silt	-	%	11
Clay	-	%	14
Phosphorus (P)	Mehlich 3	ppm	23
Potassium (K)	Mehlich 3	ppm	64
Calcium (Ca)	Mehlich 3	ppm	860
Magnesium (Mg)	Mehlich 3	ppm	228
Sodium (Na)	Mehlich 3	ppm	52
Organic Matter	Loss on Ignition	%	1.62

Effect of treatments on growth, nodulation and yield of soybean

Results showed highly significant effects of treatments on the growth, nodulation and yield of soybean (Table 3). According to Azu *et al.,* (2018), addition of organic and mineral fertilizers led to significant increase of legumes. The no input treatment generally had the most appreciable improvement in plant height, nodule viability, weight of 100 seeds and yield. This result contradicts the reports of earlier studies on fertilizer effect on growth and yield of soybean (Nastasija et al., 2008; Achmad and Utomo, 2016). However, this result could be explained on the basis that the initial soil properties of the experimental site were relatively suitable for soybean production. Liming may have pushed the pH above 8. At this pH level, phosphorus becomes fixed and made unavailable to the growing plants (Brady and Weil, 2008). Inoculated seeds had the highest number of nodules and percent nodule viability (5 and 69% respectively). This indicates a good nitrogen economy and potential soil residual fertility effects. Mineral fertilizers have been reported to have harmful effects on soil microbes including rhizobium bacteria (Azu *et al.*, 2016). Inoculating leguminous seeds with rhizobium inoculants has the potential of increasing and sustaining nitrogen availability to both present and subsequent crops. The least amount of soybean yield (0.25 ton/ha) was obtained in the plot that had a combination of lime, inoculums and phosphorus. This also suggests the effect of liming a soybean suited soil o the yield. Primarily, at high pH, phosphorus becomes unavailable, thus adversely impacting on the growth and yield of the crop.

These results therefore show that the soil and climate of Unwana can potentially support commercial soybean production. But to ensure sustainability in production, it is important to inoculate seeds with rhizobium inoculants.

Table 3. Effect of treatments on growth, nodulation and yield of soybean

Treatment	Plant height 90 days(cm)	nodule count	nodule weight(g)	nodule viability(%)	Weight of 100 seeds(g)	Yield ton/ha
No Input	53	1	0.06	34	16	2.12
L+I (**)	53	1	0.06	27	15	1.60
P+K	49	0	0.01	4	15	1.00
K	42	1	0.04	27	15	0.77
L+K	50	3	0.15	58	7	0.70
L+I+K	47	2	0.05	12	15	0.69
I+K	46	1	0.07	42	13	0.66
L+P+K	47	1	0.08	35	14	0.62
L+I+P+K	45	3	0.11	49	16	0.56
I	47	5	0.23	69	14	0.54
L	50	0	0.03	21	15	0.62
I+P+K	56	1	0.06	23	16	0.41
I+P	44	1	0.07	24	14	0.37
P (**)	46	1	0.05	29	12	0.35
L+I+P	48	2	0.12	36	14	0.25
L+P	44	1	0.07	24	15	0.16
AVG	47	1	0.08	32	14	0.70
LSD	7.4	0.5	0.1	41.2	4. 7	0.90
CV%	11.6	142.7	109.8	93.3	25.7	104.8

Averages, Least Significant Differences (LSD) at an alpha of 0.05, and Coefficient of Variations (CV%) for yield, nodule count, weight, and viability, R8 stand count and 100 seed weight omission trials. In the treatment column: I-inoculum, P-phosphorus, K-potassium, L-lime. P-values for each treatment main-effect or interaction are represented as follows: (.)<0.10, (*)<0.05, (**)<0.01, (***)<0.001.

Conclusion

This trial provides information on which inputs are best suited to maximize soybean yield and a valuable resource for developing an input bundle approach to soybean production. The No Input bundle performing as well as it did seem to be a lucky coincidence. However, it does serve as a benchmark for what is possible at Unwana. 2.12ton/ha yield generated by the no input treatment shows the potential for future higher yield especially when climatic and good agronomic strategies are employed.

References

Achmad, Y.P. and Utomo, T.W.(2016), Effect of various levels of NPK Fertilzer on the yield Attributes of soybean (Glycine max) varieties. Journal of Tropical Crop Science, vol 3, No. 1, pp. 7 – 12.

Azu, D.E.O., Osodeke, V.E., Ukpong, I.M. and Osisi, A.F. (2018): Chemistry and mineralogy of soils derived from different parent materials in Southeastern Nigeria. *Int. J. of Plant and Soil Science,*pp 43 – 48.

Azu, Donatus E.O, Nweke, Peter and Essien, B.A. (2019): Soil fertility, growth and yield of Groundnut (Arachis hypogeal L.) as influenced by the application of wood ash and NPK fertilizers in an ultisol of Southeastern Nigeria. East African Scholars Journal of Agriculture and Life 2(3):98-103.

Brady, N.C. and Weil, R.R. (2008). The Nature and properties of soil. 13th edn, prentice Hall Inc. New Jersy.

El-Shemy, H.A.(2011).Soybean and Nutrition, 486 pp. Intech Open. Croatia.

Eneje, R. C. and Azu E. O. (2009). Algae compost effect on soil nutrient status and aggregate stability. Journal of Soil Society of Nigeria. Vol 19, no 2,pp118-126

Federal Department of Agriculture and Land Resources (1985). Soil Map of Nigeria project. Pp63-148.

Milic, V., Naastasja, M. and Milica, H. (2002). Interrelationship of nitrogen fixation potentials and soybean yield. A periodical Scientific Research on Field and Vegetable Crops. 36,133- 139.

Naastasja, M., Jelena, M and Acimovic, R (2008). Effect of N Application on growth and yield of inoculated soybean. Not. Bot.Hort. Agrobot.clay36(1) 48-51.

Njoku, J. C., Okpara, D. A. and Asiegbu, J. A. (2006). Growth and yield response of sweet potato to inorganic nitrogen and potassium in a tropical ultisol. *Nig. Agric. J.* 32:30-41.

Osodeke, V. E. and Uba, A. F. (2005). Determination of Phosphorus Fraction in Selected Soils of Southeastern Nigeria. *International Journal of Natural and Applied Sciences,***1**(1):10-14.