EFFECT OF VARIOUS INPUT COMBINATIONS ON THE GROWTH, NODULATION AND YIELD OF INOCULATED SOYBEAN IN MINNA, NIGERIA.

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Abstract
Soil nutrient deficiencies are major cause of failure in nodulation and/or effective fixation of nitrogen in legumes. In addition to phosphorous and, to some extent, potassium deficiencies, several cases of micronutrient deficiencies have been reported in some parts of the Nigeria Savanna. A field experiment was conducted in Minna southern Guinea savanna zone, during the 2012 rainy season, to evaluate soybean (TGX 1835-10E) response to different nutrient sources and combination. The experiment consisted of ten treatments laid out in a randomized complete block design (RCBD) replicated three times. The treatments were ; Control, TSP (20 kg P ha^{-1}), TSP + KCl (20 kg K ha^{-1}), SSP (30 kg P ha^{-1}) + KCl, SSP + KCl + Agrolyzer (1.8 kg $ha^{-1}$of Agrolyzer), SSP+KCl+$ZnCl_2$(5 kg Zn ha^{-1}), SSP+KCl+H_3BO_3 (3 kg B ha^{-1}), SSP+KCl+$NaMoO_4$ (1 kg Mo ha^{-1}), SSP+KCl+$ZnCl_2$+H_3BO_3+$NaMoO_4$ and cattle manure (3 tons ha^{-1}). The results showed a significant ($P \leq 0.05$) treatment effect on days to 50% podding, dry shoot biomass, nodule dry weight, pod load, pod clearance, 1000 seed weight and haulms yield of soybean. SSP+KCl+$NaMoO_4$ had longer days to pod than all the treatments except TSP, SSP+KCl+H_3BO_3 and SSP+KCl+$ZnCl_2$. Cattle manure had greater nodule weight than treatments SSP+KCl+$NaMoO_4$ and SSP+KCl+$ZnCl_{2;}$ and also greater shoot biomass than treatments TSP + KCl, SSP + KCl + Agrolyzer and control. The combination of SSP + KCl + Agrolyzer had the shortest pod clearance, and greater pod load and 1000 seed weight. All treatments had similar haulms yields as the control, except SSP+KCl+$ZnCl_2$, Cattle Manure, SSP + KCl + Agrolyzer and SSP+KCl treatments. The results showed the need for the application of phosphorus for a good soybean yield and also indicates the benefits of cattle manure and Agrolyzer as useful sources of nutrients for soybean cultivation.

Keywords: Soybean, nodulation, inoculation, savanna, Nigeria.

Introduction

Nutrient availability in the soil has a prime factor in determining the overall growth and yield of crops (Tulnur and Badanur, 2003). Nutrients are usually added through fertilizer. Soybean (*Glycine max* L. Merrill) is one of the oldest crops grown in the world. Soybean is an important legume with multifarious uses (Vaughan and Geissler, 2008). Uses of soybeans include soy milk, and from the latter tofu and tofu skin. Fermented foods include soy sauce, fermented bean paste, natto, and tempeh, among others. The oil is used in many industrial applications (Padgette,*et al.*,1995). There is a growing demand for soy foods such as soymilk, soy nuts, soybean sprouts, cottage cheese like soybean curd, rich in protein, and various vitamins and minerals (Rao *et al*., 2002). The production and utilization of soybean has expanded approximately 10 – fold in Nigeria over the past 10 – 15 years (Sanginga, 2003). It is mainly for maintaining soil fertility for agriculture soils which are often constrained in their ability to sustain productive farming systems due to factors associated with low fertility, sodicity, salinity and extremes of acidity and alkalinity (Uzoma *et al*., 2011). These same attributes can also have negative impact on the Soybean - Rhizobium symbiotic relationship reducing the ability of indigenous rhizobia to form nodules with optimal N_2 fixing capacity, hence impeding the continued success of soybean in Nigerian agricultural systems. Symptoms associated with most micronutrients deficiency in plants include inter-veinal chlorosis, necrotic spots on leaves, rosetting of leaves and stunting of plants due to disturbances in metabolism of auxins, especially indole-acetic acid, which is a growth hormone (Alloway, 2008) . Application of micronutrients to crops in combination with macro fertilizers (N, P, K) was found to help break the cycle of low yields, poverty and poor human nutrition in sub – Sahara Africa (Nube and Voortman, 2006). Soybeans obtain up to 70 percent of their total nitrogen requirement from biological nitrogen fixation conducted by Rhizobia bacteria colonies (nodules) living on soybean roots. If the nodules fail to form, the plants will become deficient in nitrogen and significant yield reductions can occur. The objective was to study soybean (TGX 1835-10E) response to different nutrient inputs and combination.

Materials and Methods

Study Area

The study was carried out at Teaching and Research Farm of Federal University of Technology, Gidan Kwano, Minna (lat 09^0 32.738′ N and long. 006^0 27.189′ E), in the Southern Guinea Savanna zone of

Nigeria. The physical features around Minna consist of gently undulating high plains developed on basement complex rocks made up of granites, migmatites, gneisses and schists. Inselbergs of "Older Granites" and low hills of schists rise conspicuously above the plains. Beneath the plains, bedrock is deeply weathered and constitutes the major soil parent material (saprolites) (Ojanuga, 2006). Climate of Minna is sub – humid with mean annual rainfall of about 1284 mm and a distinct dry season of about 5 months duration occurring from November to March. The mean maximum temperature remains high throughout, about 33.5 ^oC , particularly in March and June (Ojanuga, 2006). The soil was classified as Typic Plinthustalf (Lawal, *et al*., 2012).

Treatments and experimental design

The treatments were ten different inputs combination: Control, TSP (20 kg P ha^{-1}), TSP + KCl (20 Kg K ha^{-1}), SSP (30 kg P ha^{-1}) + KCl, SSP + KCl + Agrolyzer (1.8Kg per hectare of Agrolyzer), SSP+KCl+$ZnCl_2$ (5Kg Zn ha^1), SSP+KCl+H_3BO_3 (3Kg B ha^{-1}), SSP+KCl+$NaMoO_4$ (1Kg Mo ha^{-1}), SSP+KCl+$ZnCl_2$+H_3BO_3+$NaMoO_4$, Cattle Manure (3 tons/ ha^{-1}). The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replications.

Agronomic practices

The land was cleared, ploughed and ridged. The land was divided into 3 blocks i.e one block representing one replicate. Each block was further divided into plots of size 10 m by 2.5m with 0.5m space between the plots. The spacing between blocks was 1m and the soybean variety was TGX 1835–10E. The soybean seed was inoculated using soya inoculants and planted on 13th August, 2012 at two seed per hole at 10 cm between plant stand and treatments were applied at two weeks after planting (WAP) by spot placement, manual weeding was carried out at four WAP and seven WAP. Foliar application of Agrolyzer was applied four WAP, Insects were controlled using insecticide.

Soil sampling analysis

The initial soil sample was collected at the depth of 0 – 20 cm. Soil samples were air-dried, gently crushed and passed through 2-mm sieve to obtain fine earth separates. The processed soil samples were analyzed for some physicochemical properties following the procedures outlined by the International Soil Reference and Information Centre and Food and Agricultural Organization (ISRIC/FAO, 2002). Particle size analysis was determined by Bouyoucos hydrometer method. The soil pH was measured in 1:2.5 soil/$CaCl_2$ suspensions with glass electrode pH meter and organic C by Walkley-Black method. Total nitrogen (TN) was determined by micro-Kjeldahl digestion procedure. Available phosphorus (P) was extracted by Bray P1 method. The P concentration in the extract was determined colorimetrically using the spectrophotometer. Exchangeable bases, $Ca^{2+,}$ Mg^{2+}, K^+ and Na^{2+} were extracted with 1N NH_4OAC. The Ca^{2+} and Mg^{2+} in the extract were determined using atomic absorption spectrophotometer (AAS) while K^+ and Na^+ were determined by flame photometry. Exchangeable acidity was determined by titrimetric titration with standard NaOH.

Growth and yield components analysis

Days to flowering was recorded for each plot when about 50% of the plots have flowered, the days to 50 % podding was observed and recorded in the same manner. At mid-podding stage, above the ground biomass of all plants within 0.5 m^2 were cut at the ground level and oven dried at 75 ^oC for three days to obtain dry shoot biomass. The root of the plants harvested for biomass assessment were carefully pulled out of the soil with spade and gently washed under running tap water with the aid of sieve the nodules were picked and counted to obtain nodule number per plant. The nodules were dissected into two parts to assess nodule activities. The nodule were enveloped and oven dried at 75 ^oC to obtain nodule dry weight. At maturity, number of pods per plant were recorded as pod load, distance between the ground level and the first pod was recorded as pod clearance, pods were harvested weighed and recorded within the net plot. The sub samples were oven dried at 75 ^oC to a constant weight and their weight determined, this was later thrashed manually and grain was weighed and converted to grain yield. Haulms yield was determined.

Statistical analysis

All data were subjected to analysis of variance (ANOVA) with means separation using Least Significant Differences (LSD) at 5% level of significance. This was done using GLM proc of SAS (SAS, 2002).

Results and Discussion

Soil Physichochemical Properties

The results of the physicochemical properties of the soil are shown in Table 1. The textural class of the soil was loamy sand, with a slightly acidic soil reaction. It implies that some plant nutrients may be readily available in the soil. Brady and Weil (2010) reported that release of some plant nutrients fall between pH 5.5 – 7.0. It contains low available P and organic carbon. The low organic contents of the soils are characteristics of the savanna due partly to rapid decomposition and mineralization of organic matter is by annual burning of crop residues by farmer. Exchangeable Ca was rated medium and it was dominant cation on the exchange sites of the soil, the dominance of Ca on the exchange site may be attributed to Ca being the least easily lost from the soil exchange complex. The Ca has being said to be the most abundant cation in exchange complex of most of our soils that are not strongly acidic as to have a high aluminium saturation (Brady and Weil, 2010).

Table 1: Some physico-chemical properties of the soil prior to planting of soybean

Parameters	Values
Sand (g kg^{-1})	800
Silt (g kg^{-1})	90
Clay (g kg^{-1})	110
Textural classes	Loamy sand
pH in H_2O (1:2.5)	6.80
pH in $CaCl_2$ (1 : 2.5)	6.20
Total Nitrogen (g kg^{-1})	0.45
Available P (mg kg^{-1})	10.00
Organic Carbon (g kg^{-1})	4.52
Exchangeable Cation (cmol kg^{-1})	
Mg^{2+}	1.20
Ca^{2+}	3.20
K^+	1.50
Na^+	2.00
Exchangeable Acidity (cmol kg^{-1})	0.18
ECEC (cmol kg^{-1})	8.08

ECEC = effective cation exchange capacity

.

Table 2. Effect of various input combinations on soybean growth, phenology and nodulation

Treatment	Days to 50% flowering	Days to 50% podding	Dry shoot biomass (g)	Nodule number	Nodule Dry weight(g)	Nodule activities (%)
SSP + KCl + $NaMoO_4$	48	55	87.33	28.00	0.32	50.00
TSP	47	53	94.00	37.00	0.47	63.00
SSP + KCl + H_3Bo_3	47	53	110.67	41.00	0.59	63.00
SSP+KCl+$ZnCl_2$+$NaMoO_4$+H_3Bo_3	46	53	94.00	40.00	0.48	50.00
TSP + KCl	45	52	70.67	27.00	0.38	53.00
SSP + KCl+$ZnCl_2$	45	53	98.00	27.00	0.32	60.00
Cattle Manure	45	52	143.33	70.00	0.67	53.00
SSP + KCl+ Agrolyser	45	52	70.67	57.00	0.60	60.00
SSP + KCl	45	52	114.00	47.00	0.43	67.00
Control	45	52	60.67	42.00	0.35	57.00
$LSD_{0.05}$	NS	2.91	63.12	NS	0.32	NS

Table 3. Effect of various input combination on soybean yield and yield attributes

Treatments	Pod load (No. $plant^{-1}$)	Pod clearance (cm $plant^{-1}$)	1000 seed weight (g)	Grain yield (kg ha^{-1})	Haulms yield (kg ha^{-1})
SSP + KCl + $NaMoO_4$	70.00	8.67	78.80	388.70	226.67
TSP	69.00	7.67	83.67	435.00	202.33
SSP + KCl + H_3Bo_3	82.00	7.33	83.70	508.00	246.33
SSP+KCl+$ZnCl_2$+$NaMoO_4$+H_3Bo_3	70.00	6.33	83.93	532.30	214.33
TSP + KCl	87.00	7.67	84.37	505.00	176.00
SSP + KCl+$ZnCl_2$	75.00	8.67	83.10	580.70	278.67
Cattle Manure	72.00	7.33	86.53	592.70	318.00
SSP + KCl+ Agrolyser	88.00	6.33	89.17	482.00	279.67
SSP + KCl	73.00	7.33	83.60	533.30	268.33
Control	60.00	6.67	85.40	379.09	153.33
$LSD_{0.05}$	19.80	1.68	6.76	NS	101.76

Growth, nodulation and yield parameters

The effects of various inputs combination on growth and nodulation were shown in Table 2. Cattle manure had significantly greater nodule weight ($P \leq 0.05$) than treatment SSP + KCl + $NaMoO_4$ and SSP + KCl + $ZnCl_2$ and greater shoot biomass than treatments TSP + KCl, SSP + KCl + Agrolyzer and control. These results shows that application of cattle manure can be a source of organic matter and plant nutrients (Farage *et al.*, 2003). The combination of SSP = KCl

+ Agrolyzer had the shortest pod clearance and greater pod load. The variability in the numbers of pods per plant is observed and it was in accordance with Magyarosi and Sodin (1976) reported that number of pods per plant greatly dependent upon the magnitude of the number of pods per plant were the most important factors in determining seed yield and was confirmed by several plant scientists in many crops (Malik *et al.*, 2006). Cattle manure had the highest grain yield (0.59 tonnes ha^{-1}) but not significantly different to that of the other treatments. The treatments had similar haulms yield as control except SSP + KCl + Agrolyzer, SSP + KCl + $ZnCl_2$, Cattle

manure and SSP + KCl treatments. The highest haulm yield obtained with to cattle manure may be attributed to increase soil fertility as results of added manure resulting in increasing the plant growth and therefore accumulating biomass. Decomposition increase the total organic carbon content of the soil most of which are retained in the macro aggregation fraction (Tisdall and Oades 1982). Agbenin and Goladi (1997) recorded higher organic matter content with an addition of farmyard manure. The inclusion of Agrolyzer supply micro nutrients that are probably enhanced nutrients assimilation and dry matter accumulation. Agrolyzer contains micronutrients such as boron and zinc that enhanced the production of homones (Adjeil *et al.,* 2002).

Conclusion

The study revealed that application of cattle manure is a good source of nutrients, it is significantly increased nodule weight, shoot biomass, haulms and yield grain of soybean (TGX 1835 – 10E). It shows the need for the application of phosphate fertilizer for a good soybean yield and also indicate the benefits of Agrolyzer as useful source of nutrients for soybean cultivation.

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