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Assessment of Nutrient Combinations Affecting Soybean (Glycine Max (L.) Merrill) Growth Performance in Sudan Savannah of Nigeria

Madu A. L., Musa A., Hauwa Y. I., Halima, M. I.

Abstract— **A field experiment was conducted in the savanna zone of Nigeria during the 2015 wet season at Shanono and Bagwai in Kano state on latitude (110 500 N and 80 300 E) to find the effect of Inoculant and Nutrients Combination Affecting Soybean Growth Performance. The experimental design was RCBD with the six treatments combination replicated ten times. Treatment sets were the replicate, five in each location with distance of 2Km. The treatment had 28 soybean seed planted in each of the plot combined with six fertilizer rate as follows; Plot 1 = Control, Plot 2 = Inoculants (I), Plot 3= Inoculant + Phosphorus (I+P) Plot 4 = Inoculant + Phosphorus + Potassium (I+P+ K) Plot 5 = Inoculant + Phosphorus + Potassium + Micronutrients (I+P+ K+ Mic) Plot6 =Inoculant + Phosphorus + Potassium+ Micronutrients + organic matter (I+ P+ K+ Mic+ OM). All cultural practices, soil physical and chemical properties using standard procedure for wet season production of soybean are carried out. Data collected included; number of plant established, plant height, canopy spread, days to 50% flowering and grin weight (kgha-1) at harvest. The study revealed that inoculant and application of all rates and combinations of fertilizers shows effect across plots and locations but application of I+P+K Mic and I+P+K Mic+ OM recorded statistically better performance and grin weight (kgha-1) at harvest than I, I+P, I+P+K and the control.**

Index Terms— **field experiment, Growth Performance.**

I. Introduction

Soybean [*Glycine max* (L.) Merrill] is a member of the family Fabaceae. It takes 5-7days after planting to start growing and about 90 to 150 days after sowing to mature. Soybean produce pods and seeds on both the main stem and the branches originating from main stem nodes (Board, 1987). The pod of soybean is usually green but turns yellowish brown when mature with the beans being hard and dry. However, there are other varieties of soybean which are black, brown or green colour, although these varieties are rare (Dugje *et al.*, 2009). Temperature of at least 15^0C is needed to germinate the seed and mean temperature of $20\text{-}25^0$C is needed to grow the crop. It can be grown on a wide variety of soils but does best in rich, well drained, sandy loam FAO (2005). The present distribution of the wild soybean covers parts of China and the eastern ex-USSR, Taiwan, Japan and Korea, domestication occurring most likely in northeast-China where the plant has been cultivated for the past three millennia (Akande *et al.*, 2007).

Madu A. L., Musa A., Hauwa Y. I., Halima, M. I., Department of Crop Production, Faculty of Agriculture Food Science and Technology, Kano University of Science and Technology, Wudil, Nigeria.

In Nigeria, it may have been introduced as early as 1980 and gaining popularity because of its numerous potentials that rank it even better than cowpea in the supply of high quality protein and its cultivation as a crop can be attributed to the introduction of the Malayan variety in 1937 by British Colonial Officers in Benue state (Single *et al.*, 1987).

Soybean is a multipurpose crop and its importance ranges from its use in human consumption, milk production, oil processing, medical, industrial, livestock feeds and more recently, as a source of bio-energy (Adedoyin, 1998 and Myaka, 2005). Soil fertility which is another important issue is improves through soybean production and controls the parasitic weed, *Striga hermonthica* (Dugje *et. al.*, 2009). They also fix atmospheric nitrogen and thus reduce fertilizer used by farmers (Michael, 2011). In spite of the stated importance yet performance is still very low in sub-Saharan Africa FAO (2005) particularly the study area. Among other reason could be due to low soil fertility which is an important factor in crop production and its degradation is one of the limiting factors for sustainable agriculture FAO (2005). Soybean which require less nutrient and has the ability to symbolically fix nitrogen but not all the soybean nitrogen needs are met through fixation (Sawyer *et al.*, 2006). Additionally available information in literature also shows that inoculant, addition of fertilizer or in combination under good soil and crop management practices improve soybean performance. Thus, it is view of this that the study to assess the effect of inoculant fertilizer combinations was conducted through;

Objectives:

1-Effect of inoculant, phosphorous, potassium, micronutrients and organic manure on the growth performance of soybean.

2-To find out the right combination between inoculant, inorganic and organic fertilizer that gives optimum growth performance of soybean.

II. Materials and Methods

The experiment was conducted at Shanono and Bagwai in the Sudan Savannah agro-ecological zone of Nigeria on latitude (11^0 50^0 N and 8^0 30^0 E). Soil samples from each of the experimental site from 0-30cm depth were taken and analyzed the physical and chemical composition using standard procedure. The Experimental Design was RCBD with the six treatments and replicated ten times. Each set of treatment was considered as a replicate. Thus, there were five replicates in each location separated by a distance 2Km apart.

Plot 1 = Control (No input)

Plot 2 = Inoculant (I) only (Legumefix)
Plot 3 = Inoculant + Phosphorus (I+P)
Plot 4 = Inoculant + Phosphorus + Potassium (I+P+ K)
Plot 5 = Inoculant + Phosphorus + Potassium + Micronutrients (I+P+ K+Micro nutrients)
Plot 6= Inoculant + Phosphorus + Potassium + Micronutrients +organic matter (I+P+ K>Micronutrients + OM)

The site were cleared, harrowed, ploughed to a fine tilts, ridged and transformed into 6 plots each of 10m x 10m = 100m^2. Plots has distance of 0.5m between and 2km between replicates. Inoculant, fertilizer, manure and certified variety (TGX1835-10E) of soybean were source from IITA, Kano. Sowing involved seed per hole with spacing of 10cm by 75cm and 4cm depth. Treatments were allocated according to plots. Weeds were manually control using hand hoe. Through planting method double application of fertilizer; single super phosphate (SSP), MOP and cow dung are applied at the recommended rate of 30kg/ha, 50 kg /ha and 40Kg/ha respectively. Micronutrients were also added at the rate of 20 kg /ha at 3 weeks after sowing.

Statistical Analysis:
Data collected on growth performance were subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1976) using Statistix (Version 10). Where significant means of treatments were separated using LSD All-Pairwise Comparisons

Result

Results of soil analysis of the two locations are presented in Table 1. The textural class of the soils were sandy-loam with sand having higher proportion of more than 82%. Chemically, the two soils varied with respect to location, soil in Bagwai have higher values for available soil nutrients like Na, K, Mg, organic carbon and Ca. However, pH of the soil in Bagwai was found to be more acidic than that of Shanono. Cation Exchange Capacity (CEC) was also higher in Bagwai. Result presented in Table 2 reveals that inoculant and application of combination of fertilizers statistically indicated non-significant effect on number of plant established across the locations. Interaction effect also indicated non-significant effect across the locations. At 3WAS effect of inoculant and application of combined fertilizer on plant height (cm) in (Table 3) indicated significant (P≤ 0.01) effect with application of I+P and statistically indicated similarity in plant height recorded in application of all other treatment combinations except at control which produced shorter plants across locations. Although control rate recorded shorter plants at both locations but statistically indicated similar plant height in application of I+p, I+P+K, I+P+K +K+mic and I+P+K+mic+OM except in application of I+P which recorded taller plants. At 9WAS effect of treatments recorded significantly (P≤ 0.01) taller plant in application of I+p+K+mic+OM, I+P+K+mic fallowed by application I+P+K and I+P and shorter plants in application of I. The two location recorded shortest plants at control and shows statistical similarity with application of I+p and I+p+K.

Table 1: Physical and Chemical Properties for Soils (0-30 cm) at Bagwai and Shanono

Location	Bagwai	Shanono
Physical Properties		
Sand (%)	86	89.8
Silt (%)	6	7.2
Clay (%)	8	6
Texture	Sandy-loam	Sandy-loam
Chemical Properties		
pH (H_20)	6.7	6.1
Organic carbon (%)	0.19	0.49
Available P (ppm)	17.65	15.55
Ca	1.85	0.30
Mg	1.17	4.12
K	0.23	0.61
Na	0.17	0.32
CEC mol/kg	2.33	4.33

Source IITA-Kano station

Table 2: Effect of Inoculant, Fertilizer Combination on Number of Soybean Plants Established at Shanono and Bagwai during the 2015 wet Season.

Treatment	Shanono	Bagwai
CONTROL	1157.6	1111.2
I	1257.6	1103.0
I+P	1173.6	1083.3
I+P+K	1199.8	1125.2
I+P+K+mic	1173.6	1074.4
I+p+K+mic+OM	1140.0	1079.4
SE±	68.73	83.72
Significant	NS	NS

Interaction		
(T x E)	NS	NS

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparisons Test. NS= not significant and SED=standard error of comparisons

Table 3: Effect of Inoculant, Fertilizer Combination on Plant Height of Soybean (*Glycine max* L. Merril) at 3, 6 and 9WAS at Shanono and Bagwai during the 2015 wet Season.

Treatment	**Shanono**			**Bagwaai**		
WKS	3	6	9	3	6	9
CONTROL	20.61^{b}	42.00	61.44^{b}	21.71^{b}	40.00	64.41^{b}
I	22.38^{ab}	42.06	64.12ab	26.38^{ab}	41.12	67.80^{ab}
I+P	27.34^{a}	42.12	64.80^{ab}	28.34^{a}	42.06	68.12a^{b}
I+P+K	24.7^{ab}	44.40	67.48^{ab}	27.72^{ab}	40.35	68.58^{ab}
I+P+K+mic	25.86^{ab}	43.14	70.90^{a}	26.38ab	42.14	72.60^{a}
I+p+K+mic+OM	23.60^{ab}	44.72	73.70^{a}	27.60^{ab}	41.72	70.70^{a}
SE$\pm$	3.00	1.33	2.65	2.99	1.37	2.56
Significant	**	NS	*	*	NS	*
Interaction						
(T x E)	NS	NS	NS	NS	NS	NS

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparisons Test. NS= not significant, *= significant at P≤ 0.05, **= significant at P≤ 0.01 and SED=standard error of comparison.

The effect of inoculant and application of combined fertilizer on number of branches of soybean at 3, 6 and 9 WAS at Shanono and Bagwai during the 2015 wet season are presented in (Table 4). Statistically non-significant effects were observed at 3, 6 and 9WAS. Interactions effect also indicated no significant effect.

Table 5 shows the effect of inoculant and application of combined fertilizer on canopy spread of soybean. Wider canopy spread were recorded significantly (P≤ 0.05) in seeds sworn with I across locations at 3WAS and were statistically similar in application of I+P, I+P+K and I+P++K+MIC+OM. Narrow canopy spread were recorded at control and application of I+P++K+MIC and a shows statistical similarity in canopy spread in application of I+P, I+P++K and I+P++K+MIC+OM. Effect of inoculant and fertilizer combinations recorded non-significant effect at 6WAS across the locations. At 9WAS in Shanono, treatment effect recorded significantly (P≤ 0.05) wider canopy spread in application of I+P++K+MIC+OM and indicated statistical similarities in application of I, I+P, I+P+K and I+P++K+MIC. However narrow canopy spread recorded at control and application of I and shows similarities in application of I+P, I+P+K and I+P+K+Mic.

Table 5: Effect of Inoculant, Fertilizer Combination on Canopy Spread of Soybean (*Glycine max* L. Merril) at 3, 6 and 9 WAS at Shanono and Bagwai during the 2015 wet Season.

Treatment	**Shanono**			**Bagwai**		
	3	6	9	3	6	9
CONTROL	290.42^{b}	1745.6	2285.3^{b}	290.42^{b}	1755.3	2601.6
I	550.48^{a}	2129.5	2601.6^{ab}	550.48^{a}	2229.5	2710.6
I+P	416.18^{ab}	2145.9	2710.6^{ab}	426.18^{ab}	2245.9	2285.3
I+P+K	462.12^{ab}	1672.7	2831.7^{ab}	462.12^{ab}	1672.7	2831.7
I+P+K+mic	362.06^{b}	2681.4	3971.5^{ab}	362.06^{b}	2781.4	3971.5
I+p+K+mic+OM	455.80^{ab}	2450.5	4637.5^{a}	455.80^{ab}	2450.5	4637.5
SE$\pm$	89.19	884.69	1039.4	90.20	887.69	1049.4
Significant	**	NS	**	**	NS	NS
Interaction						
(T x E)	NS	NS	NS	NS	NS	NS

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparisons Test. NS= not significant, **= significant at P≤ 0.01 and SED=standard error of Comparisons.

The Effect of inoculant fertilizer combination on days to 50% flowering of soybean at Shanono and Bagwai during the 2015 wet season is presented in (Table 6). Across the location no recorded significant difference in number of days to 50%

flowering in soybean growth performance and non-significant interaction was also recorded.

Table 6: Effect of Inoculant, Fertilizer Combination on Days to 50% Flowering and Grain Weight of Soybean (kgha^{-1}) at Harvest at Shanono and Bagwai during the 2015 wet season.

Treatment	Shanono	Bagwai
CONTROL	48.80	48.80
I	50.80	50.80
I+P	50.80	50.80
I+P+K	50.80	50.80
I+P+K+mic	50.80	50.80
I+p+K+mic+OM	50.80	50.80
SE$\pm$	1.15	1.15
Significant	NS	NS
Interaction		
(T x E)	NS	NS

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparisons Test. NS= not significant, **= significant at P≤ 0.01 and SED=standard error of comparisons.

III. Discussion

According to the finding of the research, soybean performance at control is low when compared with treated plants and the reason could be due contribution of inoculant and nutrient combination applied. This was in line with assertion made by (Jogloy and Sansayawichai, 1996; Ndjeunga, *et al.*, 2008) that, the major reasons for the low performance in soybean fields in Nigeria include low or lack of manure and nitrogen fertility of many savanna soil. The inoculant and fertilizer P, K, Mic, OM combination indicated significance effect on measured growth characters and could probably be due to the role they play in growth performance of some crops;

Effects of Inoculants on Soybean Productivity

Seed inoculation with proper rhizobium strain together with minor amounts of phosphorus at early growth stage stimulated the root nodulation and increase biological nitrogen fixation eventually improving growth component such as number of branches per plant (Smith, 1995). It is documented that the Soybean Brady rhizobium symbiosis can fix up to 300Kg Nha^{-1} under good condition (Smith and Hume, 1987).

Soybean Response to Phosphorus

Phosphorus (P) is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next (Better crop, 1999). Studies conducted by researchers in Savanna regions of Nigeria showed that application of P at the rate 20-40 kgha-1 significantly improved the performances of soybean (Kamara *et al.*, 2007). Application of phosphorus significantly enhanced all the parameters tested in the legume crops but differed significantly (P < 0.05) in their responses to P fertilizer. (Yakubu, *et al.*). The increase of whole plant growth and plant nitrogen concentration in response to increased soil P supply has been noted for several leguminous species including) soybean (Kwari, 2005).

Soybean Response to Potassium

Staton, M. (2014) stated that potassium is especially important because it is essential for the plant to properly regulate the stomata (leaf openings), and insufficient potassium levels can induce stomatal closure, lowering the plant's ability to perform photosynthesis.[1] Not only can insufficient potassium interfere with photosynthesis but because of its effect on the stomata, insufficient potassium can especially affect the plant's ability to perform in heat and water-stressed situations. It is also in very high demand for the soybean plant and seed development, removing 1.4 pounds of K_2O per bushel.

Soybean Response to Micronutrients

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 (Alpha *et. al*, 2006).

Effect of Organic Fertilizer on Soybeans

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. Poultry manure has been known to improve biodiversity and long-term production of soil (Raemekers, 2001).

IV. Recommendation

Application of I+P+K+ MIC could be recommended as it recorded statistically higher growth performance than the control. But I+P+K+ MIC+ OM is much better as organic manure has long term effect.

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