Effect of Three Levels of NPK Fertilizer on Growth Parameters and Yield of Maize-Soybean Intercrop

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Abstract- Field experiments were conducted at the Teaching and Research Farm, University of Agriculture, Makurdi to determine the effect of three levels of NPK fertilizer on growth parameters and yield of maize-soybean intercrop. The experimental design consisted of two factors: cropping system at two levels (sole and intercrops) and NPK fertilizer at three levels (0, 150 and 300 kg/ha of NPK 20:10:10). The treatments were laid out in a Randomized Complete Block Design (RCBD) in a split plot arrangement and replicated three times. The cropping systems were assigned to the main plots while the fertilizer levels were in the sub plots. A composite soil sample was obtained from a plough layer (0-15 cm) at the beginning and at the end of the experiment and analyzed for particle size distribution, pH, organic carbon, total nitrogen, available phosphorus and exchangeable cations [Mg^{2+}, Ca^{2+}, Na^{+} and K^{+}] as well as cation exchange capacity (CEC). Data collected for the yield and growth parameters of maize and soybean were subjected to the Analysis of Variance (ANOVA) after which significant means were separated using Least Significant Difference (LSD) at $p<0.05$. From the results, application of fertilizer significantly ($p<0.05$) increased the growth parameters and yield of the component crops in both seasons. Increasing the quantity of NPK fertilizer resulted in significant increase in the yield and growth parameters of maize and soybean in both years. Intercropping resulted in yield advantage in 2013 and 2014 showing 35 % and 26 % land saved respectively. Also, from the results and productivity advantage obtained from the intercropping, the effect of different rates of NPK fertilizer on the growth and yield of maize and soybean intercrop deserve further investigation using higher fertilizer rates.

Index Terms- Three Levels of NPK Fertilizer, Yield, Maize-Soybean Intercrop and Growth Parameters

I. INTRODUCTION

Maize is a major staple food of the people and a very important constituent of animal feed that had led to an increase in its utilization resulting in the huge demand to expand production through intercropping (Ayoola and Makinde, 2007; Awe and Abegunrin, 2009). Soybean on the other hand is among the major industrial and food crops grown in every continent. The crop can be successfully grown in many states of Nigeria using low agricultural input (Dugje *et al.,* 2009). Also, it has been found to be agronomically compatible with other common arable crops (Raji, 2007).

In the guinea savanna agro-ecology of Nigeria, the commonest crop mixtures practiced involve cassava, okra, sorghum, maize and yam as major food crops in all possible combinations, with each other, with little or no attention given to legumes in the combinations. Cereal-legume mixtures have been adjudged the most productive form of intercropping since the cereals may benefit from the nitrogen fixed in the root nodules of the legumes in the current year (Undie *et al*., 2012). Intercropping soybean with maize was found suitable under fertilizer combinations but data on the nutrient requirements in intercropping system is very scanty (Adeniyan and Ayoola, 2007).

Responses of soybean and maize to N and P have been documented in soybean growing areas of Nigeria but little has been done to establish the scale of macro (N, P and K) and micronutrient (Zn, Mo) deficiencies. Similarly, little effort has been made in research to establish the best nutrient management strategies in maize-soybean intercrop under variable soil conditions as a way of improving maize/soybean production and productivity (Mbah *et al.,* 2007). Though, a number of studies have been conducted on mono-cropped maize and soybean as affected by fertilizer rates, documented information on the optimum productivity of maize and soybean under intercropping systems in Makurdi is scanty, hence the need for this enquiry. The objective of the study is to determine the effect of three levels fertilizer on growth parameters and yield of maize-soybean intercrop with a view to identify the appropriate NPK fertilizer level (s) that will give optimal growth parameters and yield of maize-soybean intercrop in the study area.

II. MATERIALS AND METHODS

The experiment was conducted during 2013 and 2014 cropping seasons at the Teaching and Research Farm of the University of Agriculture, Makurdi-Nigeria. The study location falls within the Southern Guinea Savanna Zone of Nigeria with mean rainfall of 1, 250 mm per annum and temperature of 25-30 ^{0}C. The site had not been cultivated for about two years. It is located between latitude $7^0$40'N to $7^0$53'N and longitude $8^0$22'E to $8^0$35'E at an elevation of 97 m above mean sea level and with a slope of 4 %. The soil is classified as Typic Ustropepts (USDA) (Fagbemi and Akamigbo, 1986). TGX 1485 – 1D variety of soybeans was sourced from the International Institute for Tropical Agriculture (IITA) Ibadan, Nigeria. Also the maize variety used (TZESR – W) was sourced from the same institute.

Experimental treatments and design

The trial consisted of two factors: cropping system at two levels (sole maize, soybean and intercropping) and NPK fertilizer at three levels (0 kg/ha, 150 kg/ha and 300 kg/ha of NPK 20:10:10) and were laid out in a split plot in RCBD with cropping system occupying the main plots and fertilizer levels at sub plots and were replicated thrice. The experimental area was cleared manually using cutlass. Thereafter it was ploughed, harrowed and demarcated into experimental units. Each plot was measured 4 m x 4 m = 16 m^2. Soybean and maize seeds were sown the same day after seed treatment with apron-plus.

Manual weeding was carried out at 3 and 8 weeks after planting (WAP). Fertilizer application was done at 3 WAP by band placement on sole crop soybean / sole crop maize and maize-soybean intercrop in alternate rows. Maize was harvested when the cobs were dry. Further sun-drying of the maize cobs was done before shelling. Soybean was harvested later, when the leaves had turned yellow and pods sufficiently dried.

Soil Data Collection and Analysis

A composite soil sample was obtained from a plough layer (0-15 cm) at the beginning and at the end of the experiment according to the treatments for routine analysis to see if there was a change in the soil properties after the experiment for both cropping seasons. The soil samples taken from each plot according to treatment and the composite were analyzed at NICANSOL Soil Testing Laboratory of the University of Agriculture, Makurdi, for particle size distribution, pH, Organic Carbon, Total Nitrogen, Available phosphorus and exchangeable cations [Mg^{2+}, Ca^{2+}, Na^{+} and K^{+}] as well as Cation Exchange Capacity (CEC) using standard analytical procedures.

Maize/Soybean Data Collection and Analysis

Data were collected for the yield parameters of maize for both cropping seasons. These include cob length, cob diameter, weight of 100 seeds, number of cobs per plant and grain yield while that of soybean include number of pods per plant, number of seeds per pod, weight of 100 pods, weight of 100 seeds and grain yield.

Data for the yield parameters of both crops were subjected to the Analysis of Variance (ANOVA) and means were separated using Least Significant Difference (LSD) at 5 % level of probability. The productivity from the mean yield data of both sole and intercropping system were determined by the land equivalent ratio (LER), (Willey, 1985).

$$LER = \frac{\text{Intercrop yield of maize}}{\text{Sole crop yield of maize}} + \frac{\text{Intercrop yield of soybean}}{\text{Sole crop yield of soybean}}$$

Percentage Land Saved = 100-1/LER x 100

Where LER is equal to 1.0, it means that there is no advantage to intercropping over sole crop. LER above 1.0 shows an advantage to intercropping while number below 1.0 shows a disadvantage in intercropping.

III. Results and Discussion

Pre-Planting Soil Analysis

The pre-planting soil analysis (Table 1) indicates a poor soil fertility status that requires fertilizer application to replenish nutrients taken out from the soil through crop harvest and to supplement nutrients to boost yields (Olatunji and Ayuba, 2012). The total N before planting in the two cropping seasons (0.06 and 0.08 %) falls below the optimum value of 0.150 % (Agboola, 1975). Similarly, the values of SOM (1.56 and 1.64 %) for the two cropping seasons were below the average range of 2.5- 2.6 % considered for good crop growth (Prasad and Singh, 2000) in the study area. The results of the pre-planting soil analysis thus indicated that soil amendment was required in line with earlier observation by Agboola (1975) who reported that farmers in Africa requires adequate soil amendment for good crop production as a result of low inherent soil fertility.

Effect of Fertilizer Rates on the Growth Parameters and Yield of Maize

Maize yield and growth parameters increased with increased application of NPK fertilizer in both seasons (Table 2). Higher yield components of maize were recorded under sole cropping compared to intercropping indicating that crops in sole plots suffered less from competition. The implication of this finding is that the nutrient requirements of soybean and maize in the intercropping system were higher than the nutrient need of the sole crops as Baker (1979) and Mbah *et al.*, (2007) reported that the nutrient demand of the component crops were always higher than for sole crops.

Effect of Fertilizer Rates on the Growth Parameters and of Soybean

The soybean yield and growth parameters increased with increase in NPK fertilizer application (Table 3). Similar positive responses of soybean to NPK fertilizer application have been observed by some researchers (Osunde *et al.*, 2004; Mbah *et al.*, 2007). In addition, Kang (1975) reported a significant linear increase in yield of soybean to nitrogen (N) applied at 0, 30, 60 and 120 kg N/ha but noted that N at 30 kg/ha with inoculation gave higher yields. Okpara *et al.*, (2002) in their study with straight nitrogen within the range (0-100 kgN/ha) and potassium (0-80 kg K_2O/ha) fertilizers in the humid rainforest zone reported high response of soybean to fertilizer application and concluded that nitrogen alone was very effective in increasing soybean yield with application of up to 100 Kg N/ha.

Similar work by Chiezey (2001) in the guinea savanna showed increased soybean grain yield with increased nitrogen fertilizer application from 0 to 80 kgN/ha. The results of the present investigation showed that soybean benefited more from the highest fertilizer rate (300 kg/ha) in the two cropping seasons, hence corroborate these reports. The zero NPK treatment gave the least yield components assessed. Averaged over the two cropping seasons, the lowest numbers of pods per plant were obtained from intercropping at zero level of NPK fertilizer application while the highest values were obtained under sole cropping at 300 kg/ha NPK fertilizer in 2013. A similar trend was obtained in 2014 cropping season.

The productivity from the mean yield data of both sole and intercropping system was determined by the land equivalent ratio (LER) according to Willey (1985). In 2013 and 2014, intercropping resulted in yield advantage; the total land

equivalent ratio (LER) was (1.53) in 2013 and (1.35) in 2014 showing 35 % and 26 % land saved in 2013 and 2014 cropping seasons respectively (Table 4) due to intercropping compared to sole crop of both maize and soybean.

IV. Conclusion and Recommendations

The results of the experiments showed that intercropping reduced the yields and growth parameters of maize and soybean compared with their sole crops. Fertilizer significantly ($p<0.05$) increased the yield and growth parameters of both crops in both seasons than when no fertilizer was applied. Increasing the quantity of NPK fertilizer resulted in significant increase in the yield and growth parameters of maize and soybean crops in both years.

The productivity of maize-soybean mixture showed yield advantage of 1.53 at 35 % land saved (2013) and 1.35 at 26% land saved (2014). The highest crops yields and growth parameters were obtained at the highest fertilizer rate used in the study. Based on yield and productivity advantage obtained from the intercropping, the effect of different rates of NPK fertilizer on the growth and yield of maize and soybean intercrop deserve further investigation using higher fertilizer rates.

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Table 1: Soil physical and chemical properties of the experimental site before planting

Property	2013	2014
Chemical Property		
pH H_2O (1:1)	6.43	6.30
pH KCl (1:1)	5.70	5.50
Organic Carbon (%)	0.90	0.95
Organic Matter (%)	1.56	1.64
Total Nitrogen (%)	0.06	0.08
Available p (ppm)	3.00	3.80
Exchangeable Cation (Cmol Kg^{-1})		
Ca	3.28	3.06
Mg	1.40	1.37
K	0.26	0.25
Na	0.61	0.60
CEC	6.26	6.21
Base Saturation (%)	89.5	87.5
Particle size Distribution		
Sand (%)	78.4	76.0
Silt (%)	10.3	10.9
Clay (%)	11.3	13.1
Textural Class	Sandy loam	Sandy loam

Table 2: Main effect of cropping systems and fertilizer rates on yield and growth parameters of maize

	NOL (4WAP)		NOL (8WAP)		LA (12WAP)		PLT HT (12WAP cm)		Grain Yield (kg/ha)	
Cropping Systems	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
Sole maize	3.68	4.13	11.85	12.06	571.00	898.00	109.40	120.90	1025.00	1275.00
Intercropped maize	2.00	4.00	10.77	11.94	480.00	877.00	100.80	111.70	775.00	575.00
LSD (0.05)	1.79	NS	1.91	NS	82.3	18.00	7.13	8.15	231.0	682.5
Fertilizer Rates (Kg/ha)										
0	2.22	3.43	10.64	11.25	391.00	879.00	85.60	89.00	800.00	375.00
150	2.37	7.58	10.71	12.17	570.00	962.00	109.70	100.00	900.00	1125.00
300	2.43	7.97	11.08	14. 11	615.00	112.00	120.00	130.00	975.00	1250.00
LSD (0.05)	NS	3.99	NS	2.09	87.70	77.4	12.21	27.8	139.0	121.0

NS = Not Significant

Table 3: Main effect of cropping systems and fertilizer rates on yield and growth parameters of soybean

Cropping Systems	NOL (4WAP)		NOL (8WAP)		LA (12WAP)		PLT HT (12WAP cm)		Grain Yield (kg/ha)	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
Sole Soybean	16.22	36.50	68.90	14.02	38.00	50.70	40.00	2.18	1300.00	1300.00
Intercropped Soybean	15.33	36.40	63.10	13.50	35.90	49.80	39.00	2.14	1000.00	1175.00
LSD (0.05)	1.99	NS	4.49	1.09	2.99	1.95	NS	NS	281.80	239.0
Fertilizer Rates (Kg/ha)										
0	15.25	16.33	57.70	68.00	26.00	39.00	37.61	38.00	800.00	500.00
150	15.42	16.99	61.10	69.65	38.00	59.60	39.03	39.00	1200.00	1250.00
300	16.67	17.76	79.20	80.00	44.00	66.20	42.74	45.00	1425.00	2000.00
LSD (0.05)	1.09	1.51	15.76	18.66	5.83	19.58	3.39	6.91	221.50	351.10

NS = Not Significant

Table 4: Productivity from mean yield data of sole and intercropping system

Cropping System	Maize 2013	Soybean 2013	Maize 2014	Soybean 2014
Sole crop yield (Kg)	1025.00	1300.00	1275.00	1300.00
Intercrop yield (Kg)	775.00	1000.00	575.00	1175.00
LER	1.53		1.35	
Land saved (%)	35		26	