Novelty Journals

ISSN 2394-7357

International Journal of Novel Research in Civil Structural and Earth Sciences
Vol. 2, Issue 2, pp: (12-22), Month: May - August 2015, Available at: www.noveltyjournals.com

Intercropped Maize and Soybean under Tillage Practices and Fertilizer Rates in Makurdi, Southern Guinea Savanna Zone of Nigeria

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Abstract: **Field experiment was conducted for two years to determine the response of maize-soybean intercrop to tillage practices and fertilizer rates at the Teaching and Research Farm, University of Agriculture, Makurdi. The experimental design consisted of three factors: cropping system at two levels (sole and intercrops), tillage practices at two levels (zero tillage and ridges) and fertilizer rates 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-split plot arrangement and replicated three times. The cropping systems were assigned to the main plots, tillage practices to sub-plots and the fertilizer rates were in the sub-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 according to the treatments 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) to see if there was a change in the soil properties after the experiment for both cropping seasons. Data collected for the yield parameters of maize and soybean for both cropping seasons were subjected to the Analysis of Variance (ANOVA) after which means were separated using Least Significant Difference (LSD) at $P<0.05$. Results showed that Intercropping reduced the yields of maize and soybean compared with their sole crops. There were higher yields from crops cultivated on ridges as a result of improved access to soil moisture than no-tillage. Soybean yields were generally low due to the shading effect of the maize component. Applying fertilizer significantly ($P<0.05$) increased the yield of the component crops in both seasons than when no fertilizer was applied. Intercropping resulted in yield advantage; the 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. Based on yield and productivity advantage obtained from the intercropping, effect of different rates of NPK fertilizer on the growth and yield of maize and soybean intercrop deserve further investigation using higher fertilizer rates. Soybean should be integrated into the maize production system to enhance increased soil organic carbon content, CEC, N, Ca, Mg and P level. Maize-soybean should be planted on ridges instead of in no-tillage to improve the acquisition of both water and nutrients by the plants.**

Keywords: **Maize-Soybean Intercrop, Tillage Practices, Fertilizer Rates, Yield Advantage and Guinea Savanna.**

1. INTRODUCTION

Intercropping is important because it offers potential advantages for resource utilization, decreased inputs and increased sustainability in crop production (Egbe, 2010), but our understanding of interactions among intercropping species is still very limited. A number of studies on intercropping have been reported (Osunde *et al.*, 2004; Mbah *et al.*, 2007). Thole (2007) reported that intercropping increases total yield per given piece of land and resulted in higher land equivalent ratio.

Also, intercropping cassava with maize and egusi melon significantly depressed tuber weight and yield of cassava when compared to sole cassava (Ijoyah *et al.*, 2012).

In spite of the predominance of intercropping among farmers in the Nigerian savanna, there is more emphasis on developing sole crop technologies because experimentation with mixtures is tedious to execute and evaluate as a result of the complexity of interaction of the component crops (Ibrahim, 2004). It has also been argued that the greatest difficulty in intercropping is the application of modern inputs like machinery, fertilizer and chemical protectants. However, Egbe (2005) contended that intercropping might positively impact on the future food problems in developing countries. This may be through efficient use of solar energy and other growth resources. Also optimization of land resources use could be achieved when crops are grown under intercropping.

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 modern tillage practices and 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).

The commonest crop mixtures practiced in the guinea savanna agro-ecology of Nigeria 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).

A number of research activities carried out on the effect of tillage and fertilizer on the soil chemical properties and yield of soybean and maize in Nigeria revealed that tillage practices and fertilizer application significantly improved the total yield of both crops (Ali *et al.*, 2006; Memon *et al.*, 2012). Intercropping soybean with maize was found suitable under different tillage and 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 tillage practices or 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 present study was undertaken to provide documented information on the response of maize- soybean intercrop to tillage practices and fertilizer rates with a view to identify the appropriate tillage practice(s) that will be suitable for maize-soybean intercrop and appropriate optimal fertilizer rate that will give optimal yield of maize-soybean intercrop in the study area.

2. 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 to evaluate the response of maize-soybean intercrop to tillage practices and fertilizer rates. 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. Both varieties are grown by

ISSN 2394-7357

International Journal of Novel Research in Civil Structural and Earth Sciences
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farmers in the study area. The trial consisted of three factors: cropping system at two levels (sole maize, soybean and intercropping), tillage at two levels (zero tillage and ridges) and fertilizer treatments 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-split plot in RCBD with cropping system occupying the main plots, tillage sub-plots and fertilizer treatments sub-sub plots which gave 18 treatments that were replicated thrice giving to a total of 54 treatment combinations on a land area of 1059.5m^2.

The experimental area was cleared manually using cutlass. Thereafter it was demarcated into experimental units. Each plot was measured 4m x 4m = 16m^2. Planting was done on 15th July, 2013 and 17th July, 2014 for both cropping seasons. Soybean and maize seeds were sown the same day after seed treatment with apron-plus. Two maize seeds were sown per hole at an inter and intra row spacing of (0.75 x 0.25 m) which were later thinned to 1 plant per hole at 2 weeks after sowing to give a plant population of 53,333 plants ha^{-1}. Soybean seeds were drilled along ridges (and straight lines on flat) and were later thinned to have plants within 5 cm of each other with an inter row spacing of 0.75 m to achieve a population of 266,000 plants ha^{-1}.

Two hoe weedings at 3 and 8 weeks after planting (WAP) were done during the period of the experiments. Soil mounds were built around the plant stands at each weeding. The fertilizer application was done at 3 WAP by band placement on sole crop soybean / sole crop maize and maize-soybean intercrop in alternate rows. Crop harvested from the net plots were used for grain yield determination. 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)].

Meteorological Data Collection:

Records of temperatures (maximum and minimum), rainfall and relative humidity at Makurdi for the 2013 and 2014 cropping seasons were collected from the Tactical Air Command, NAF Base Makurdi.

Data Collection on Maize and Soybean:

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 per hectare. Data were collected for the yield parameters of soybean for both cropping seasons. These includes number of pods per plant, number of seeds per pod, weight of 100 pods, weight of 100 seeds and grain yield per hectare.

Crop Data Analysis:

Data collected for the yield parameters of maize and soybean for both cropping seasons were subjected to the Analysis of Variance (ANOVA) after which significant 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).

$$LER = \frac{\text{Intercrop yield of Crop A}}{\text{Sole Crop yield of Crop A}} + \frac{\text{Intercrop yeild of Crop B}}{\text{Sole crop yeild Crop B}} \text{ ------------------ } (3)$$

Percentage Land Saved = 100-1/LER x 100 ------------------------------------ (4)

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.

3. RESULTS AND DISCUSSION

Effect of Rainfall on Yield Components:

Maize-soybean mixture like other arable crops requires rainfall for its normal growth and reproduction. Higher amount of rainfall was recorded in 2013 compared to 2014 (Tables 1). The total amount rainfall in 2013 and 2014 were 1287.8 and 1266.1 mm respectively. The low yield of both crops recorded in 2013 as compared to 2014 may be attributed to the high amount of rainfall in 2013 which most probably interfered with the fertilization and root development during flowing stage of the crops and consequently reducing yield.

Delouche (1980) and Adeniyan and Ayoola (2007) had suggested that frequent or prolonged rainfall during the post maturation and pre-harvest period results in alternate wetting and drying of the crop seeds and may lead to severe deterioration. This is an indication that the yield of both crops grown during the first cropping season will have been reduced compared to the one grown during the second cropping season. The frequent and or prolonged rainfall during the first season could prevent the ability of the plants to flower; however, this would encourage the vegetative growth to the disadvantage of seed production.

Pre-Planting Soil Analysis:

The pre-planting soil analysis (Table 2) 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.

Table 1: Meteorological Data for Makurdi (2013/2014)

Month	Rainfall (mm)		Min Temp (^{0}C)		Max. Temp (^{0}C)		RH (%)	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
January	00	4.0	17.9	18.3	35.3	35.5	48	55
February	00	4.0	20.9	21.2	36.7	37.0	57	51
March	44.2	33.7	23.3	24.2	37.7	33.7	66	69
April	122.9	56.4	21.5	23.1	34.4	35.2	75	72
May	183.4	160.5	20.4	22.3	32.2	33.1	81	78
June	141.8	165.0	20.5	21.6	31.0	31.6	82	81
July	243.6	129.3	22.6	21.5	30.0	30.6	85	83
August	131.0	274.6	22.7	21.8	29.5	29.4	85	86
September	285.3	306.9	22.4	22.0	30.3	30.2	84	86
October	125.5	100.6	23.0	22.8	31.9	31.5	85	81
November	00	26.4	23.0	21.3	34.3	33.3	75	77
December	10.1	4.7	19.5	17.9	34.6	33.7	58	56

Source: *Tactical Air Command, NAF Base Makurdi.*

Table 2: 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

Effect of Fertilizer Treatments on Soil Chemical Properties:

The pH of the soil after harvest in 2013 and 2014 (Tables 3 and 4) decreased in all the treatments but increased with the application of 300 kg/ha NPK fertilizer on zero tillage plots. The increase in soil pH can be adduced to addition of high inorganic fertilizer and also consistent with the findings of Chuwku *et al.*, (2012) who reported that application of 300 kg/ha of NPK fertilizer could lead to increase in soil pH in the south eastern Nigeria. The decrease in the pH of the tilled plots with low application of inorganic fertilizer could be attributed to complete decomposition of organic matter as a result of enhanced activities of microorganisms and low level of inorganic fertilizer application (Agbede, 2009).

The use of inorganic fertilizer increased SOM (Table 3 and 4) in both seasons. The soil organic matter was consistently low in no-tilled plots with zero application of fertilizer. This can be attributed to the absence of fertilizer which would have enhanced the decomposition of organic matter in the soil. According to Plaster (1992), organic matter content of the soil can be maintained through incorporation of crop residues, mulching, and addition of organic and inorganic fertilizers.

The total nitrogen status of the soil increased with increased application of NPK fertilizer. The increase in N content of the soil observed with addition of NPK fertilizer can be adduced to release of N from its composition which further enhanced microbial activities as a result of increased concentration of nutrients (Adeniyan and Ojeniyi, 2003). The depletion in total N observed in the zero fertilizer treatment plots may be attributed to nutrient up take by component crops and absence of fertilizer application.

Novelty Journals

ISSN 2394-7357

International Journal of Novel Research in Civil Structural and Earth Sciences
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Similarly, the available P was depleted in zero fertilizer treated plots. The depletion may be attributed to uptake of the nutrients by component crops and probably due to fixation of the element which usually occurs at low soil pH (Brady and Weil, 2007). A higher buildup of available P was observed with the application of 300 kg/ha NPK fertilizer. Similar trend was observed with the exchangeable bases. The release of nutrients to the soil by fertilizer application most probably explains the increase in Mg and K. The increases in Mg and K upon application of fertilizer have been reported by Adeniyan and Ojeniyi (2003).

The ECEC of the soil was affected by addition of inorganic fertilizer (Tables 5 and 6). This is an indication that soils with high organic matter content will have high ECEC as reported by Plaster (1992) and Agbede (2009). This observation is consistent with Brady and Weil (2007) who reported that inorganic fertilizer application significantly ($p<0.05$) increased ECEC of soils.

Table 3: Physical and Chemical Properties of Soil at Harvest during the 2013 Cropping Season

Table 3: Physical and Chemical Properties of Soil at Harvest during the 2013 Cropping Season

Treatments /Plot	Particle Size Distribution Sand (%)	Silt (%)	Clay (%)	Textural Class	pH H_2O 1:1	pH KCl 1:1	Org C (%)	Org M (%)	N (%)	Bray -1 P (ppm)	Exch. Cations Ca (Cmol/Kg)	Mg	K	Na	CEC (Cmol/Kg)	Base Saturation (%)
T_1	76.6	11.0	12.4	Sandy Loam	6.60	5.88	0.95	1.64	0.080	3.00	3.07	1.40	0.25	0.60	6.12	87.90
T_2	72.3	12.4	15.3	Sandy Loam	6.50	5.70	0.88	1.90	0.077	4.20	3.29	1.51	0.26	0.65	6.40	89.10
T_3	76.2	11.2	12.6	Sandy Loam	6.65	5.90	0.90	1.56	0.070	3.50	3.01	1.30	0.21	0.52	6.10	88.60
T_4	77.6	11.2	11.2	Sandy Loam	6.45	5.65	0.74	1.80	0.091	3.10	2.96	1.26	0.21	0.50	5.80	87.40
T_5	77.5	11.3	11.2	Sandy Loam	6.60	5.85	0.90	1.56	0.077	4.60	2.77	1.30	0.23	0.48	5.20	90.20
T_6	71.8	11.2	17.0	Sandy Loam	6.65	5.90	0.92	1.75	0.088	4.00	3.80	1.60	0.30	0.71	6.00	86.70
T_7	73.3	13.0	13.7	Sandy Loam	6.40	5.60	0.80	1.81	0.097	2.90	2.84	1.28	0.24	0.55	5.40	89.40
T_8	72.1	14.0	13.9	Sandy Loam	6.70	5.95	0.87	1.87	0.091	3.30	3.57	1.37	0.26	0.58	6.22	88.50
T_9	71.4	13.5	15.1	Sandy Loam	6.45	5.65	0.77	1.88	0.079	4.50	3.11	1.40	0.22	0.50	6.30	87.60
T_{10}	72.0	12.4	15.6	Sandy Loam	6.75	5.96	0.91	1.89	0.070	3.70	3.46	1.55	0.24	0.57	6.50	89.30
T_{11}	65.4	15.4	19.2	Sandy Loam	6.58	5.90	0.86	1.73	0.090	3.60	4.12	1.70	0.30	0.76	6.70	90.40
T_{12}	69.6	13.1	17.3	Sandy Loam	6.71	5.94	0.93	1.72	0.086	3.10	3.85	1.54	0.27	0.69	6.52	88.80
T_{13}	65.2	15.4	19.4	Sandy Loam	6.53	5.77	0.80	1.38	0.077	4.00	4.00	1.80	0.33	0.75	6.80	87.90
T_{14}	73.5	13.0	13.5	Sandy Loam	6.48	5.70	0.73	1.26	0.088	3.80	3.08	1.40	0.24	0.43	6.27	89.00
T_{15}	75.2	13.5	11.3	Sandy Loam	6.60	5.93	0.91	1.57	0.080	3.50	2.71	1.20	0.20	0.40	5.10	90.30
T_{16}	65.1	15.4	19.5	Sandy Loam	6.40	5.70	0.88	1.69	0.077	2.90	4.20	1.86	0.33	0.75	6.77	87.80
T_{17}	67.2	15.2	17.6	Sandy Loam	6.55	5.86	0.86	1.66	0.091	3.30	4.11	1.81	0.31	0.68	6.60	88.10
T_{18}	72.4	12.6	15.0	Sandy Loam	6.59	5.83	0.83	1.65	0.070	3.10	3.75	1.50	0.29	0.56	5.90	86.50

T_1= SMT_0F_0, T_2= SMT_1F_1, T_3= SST_0F_0, T_4= SST_1F_1, T_5= $MSIT_0F_0$, T_6= $MSIT_1F_1$, T_7= SST_1F_2, T_8= SST_0F_2, T_9= $MSIT_1F_2$, T_{10}= $MSIT_0F_2$, T_{11}= SMT_1F_2

T_{12}= SMT_0F_2, T_{13}= SMT_1F_0, T_{14}= SST_1F_0, T_{15}= $MSIT_1F_0$, T_{16}= SMT_0F_1, T_{17}= SST_0F_1, T_{18}= $MSIT_0F_1$, SM= Sole Maize, SS= Sole Soybean, MSI= Maize-Soybean Intercrop, T_0= Zero Tillage, T_1= Ridging, F_0= 0 kg/ha, F_1= 150 kg/ha and F_2= 300 kg/ha NPK 20:10:10

Table 4: Physical and Chemical Properties of Soil at Harvest during the 2014 Cropping Season

Treatments /Plot	Particle Size Distribution Sand (%)	Silt (%)	Clay (%)	Textural Class	pH H_2O 1:1	KCl 1:1	Org C (%)	Org M (%)	N (%)	Bray -1 P (ppm)	Exch. Cations Ca (Cmol/Kg)	Mg	K	Na	CEC (Cmol/Kg)	Base Saturation (%)
T_1	76.0	10.8	13.2	Sandy Loam	6.50	5.72	0.97	1.68	0.070	2.90	3.05	1.38	0.23	0.58	6.16	86.40
T_2	73.2	11.9	14.9	Sandy Loam	6.38	5.68	0.90	1.86	0.076	4.50	3.25	1.50	0.23	0.63	6.30	88.00
T_3	74.6	11.5	13.9	Sandy Loam	6.51	5.80	0.95	1.64	0.070	3.00	3.00	1.28	0.20	0.50	6.06	87.60
T_4	76.9	11.9	11.2	Sandy Loam	6.45	5.67	0.78	1.70	0.093	3.20	2.93	1.23	0.21	0.48	5.60	87.10
T_5	76.5	12.0	11.5	Sandy Loam	6.50	5.80	0.96	1.66	0.070	3.00	2.77	1.30	0.22	0.45	5.30	90.00
T_6	71.6	13.7	14.7	Sandy Loam	6.62	5.88	0.95	1.71	0.087	4.30	3.78	1.50	0.29	0.70	5.90	87.30
T_7	74.0	12.9	13.1	Sandy Loam	6.32	5.62	0.81	1.80	0.099	4.40	2.83	1.23	0.22	0.50	5.30	89.50
T_8	73.0	14.0	13.0	Sandy Loam	6.79	5.91	0.89	1.85	0.092	3.50	3.56	1.30	0.24	0.55	6.10	88.60
T_9	72.1	13.8	14.1	Sandy Loam	6.48	5.67	0.79	1.80	0.078	4.60	3.10	1.36	0.20	0.49	6.28	87.00
T_{10}	73.3	13.4	13.3	Sandy Loam	6.80	5.95	0.93	1.80	0.071	3.60	3.47	1.51	0.22	0.50	6.47	88.30
T_{11}	70.0	14.9	15.1	Sandy Loam	6.85	5.88	0.88	1.70	0.089	3.80	4.11	1.59	0.27	0.70	6.65	90.10
T_{12}	70.2	14.6	15.2	Sandy Loam	6.85	5.95	0.96	1.70	0.086	3.30	3.86	1.50	0.25	0.64	6.48	89.90
T_{13}	70.2	14.4	15.4	Sandy Loam	6.58	5.70	0.83	1.44	0.070	4.30	3.91	1.76	0.33	0.70	6.75	87.30
T_{14}	75.1	12.9	12.0	Sandy Loam	6.50	5.70	0.75	1.30	0.089	3.9 0	3.07	1.38	0.23	0.41	6.20	88.60
T_{15}	75.2	12.5	12.3	Sandy Loam	6.58	5.90	0.93	1.61	0.079	3.70	2.70	1.25	0.21	0.38	5.00	90.00
T_{16}	68.0	14.8	17.2	Sandy Loam	6.39	5.72	0.90	1.68	0.076	3.00	4.10	1.79	0.32	0.70	6.70	86.90
T_{17}	68.3	14.7	17.0	Sandy Loam	6.51	5.87	0.89	1.65	0.092	3.40	4.06	1.70	0.30	0.63	6.50	88.00
T_{18}	71.8	13.0	15.2	Sandy Loam	6.55	5.80	0.88	1.64	0.073	3.30	3.73	1.47	0.27	0.52	5.81	86.00

T_1= SMT_0F_0, T_2= SMT_1F_1, T_3= SST_0F_0, T_4= SST_1F_1, T_5= $MSIT_0F_0$, T_6= $MSIT_1F_1$, T_7= SST_1F_2, T_8= SST_0F_2, T_9= $MSIT_1F_2$, T_{10}= $MSIT_0F_2$, T_{11}= SMT_1F_2 T_{12}= SMT_0F_2, T_{13}= SMT_1F_0, T_{14}= SST_1F_0, T_{15}= $MSIT_1F_0$, T_{16}= SMT_0F_1, T_{17}= SST_0F_1, T_{18}= $MSIT_0F_1$, SM= Sole Maize, SS= Sole Soybean, MSI= Maize-Soybean Intercrop, T_0= Zero Tillage, T_1= Ridging, F_0= 0 kg/ha, F_1= 150 kg/ha and F_2= 300 kg/ha NPK 20:10:10

Effect of Intercropping and Tillage Practices on Soil Chemical Properties and Yield Components:

The ridge as a method of tillage was observed to have increased soil porosity and soil organic matter contents compared to no-tillage. Fan *et al.*, (2006) reported increased in soil porosity after tillage due to increased root biomass. This may be partly attributed to the stimulatory effect of living roots on microbial activities that enhancing soil organic matter decomposition (Cheng and Coleman, 1990). Soil organic carbon content also showed slight increase in maize- soybean intercropped plots in both years. These changes are considered favourable as decrease in bulk density favours aeration and water storage.

Maize and soybean crops grown in no-tillage conditions may have experienced soil compactness which impeded the acquisition of both water and nutrients and growth of roots. Soil disturbance by tillage practices increased porosity and penetrability thus allowing roots to have better access to water and nutrients (Fan *et al.*, 2006). Carlesso *et al.*, (2002) also reported that maize and soybean yield components was high when cultivated under ridge or conventional tillage as a result of improved access to soil moisture than no-tillage. However, present results indicated that maize intercropped with soybean had lowest yields under no-tillage compared with those cultivated on the ridges. It is probable that deep root growth was more enhanced by planting on a ridge than on a no-tillage.

International Journal of Novel Research in Civil Structural and Earth Sciences
Vol. 2, Issue 2, pp: (12-22), Month: May - August 2015, Available at: www.noveltyjournals.com

Effect of Cropping System and Fertilizer Rates on the Yield Components of Maize:

In 2013 and 2014, cob diameter, cob length and number of cobs per plant were not affected by intercropping while grain yield was significantly (P<0.05) affected by intercropping (Table 5). Maize yield components (100 seeds weight, grain yield and number of cobs per plant) increased with increased application of NPK fertilizer in both seasons. 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 Cropping System and Fertilizer Rates on the Yield Components of Soybean:

Cropping system had no significant (P<0.05) effect on 100 pods weight, 100 seeds weight, number of pods per plant and number of seeds per pod of soybean. However, the grain yield was significantly (P<0.05) influenced by intercropping in 2013. The yield components increased with increase in NPK fertilizer application. 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 (56.00) were obtained under sole cropping at 300 kg/ha NPK fertilizer in 2013. A similar trend was obtained in 2014 cropping season.

Assessment of the Productivity of the Mixture:

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 7) due to intercropping compared to sole crop of both maize and soybean.

Table 5: Main effect of cropping system, tillage practices and fertilizer rates on yield and yield parameters of maize

	COB DIA		COB LNT (cm)		COB/PLT		100 S WT(g)		Grain Yield (kg/ha)	
Cropping system	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Sole maize	11.98	12.10	11.50	12.20	1.06	1.47	19.40	22.80	1025.00	1275.00
Intercropped maize	8.97	11.20	11.00	12.00	0.73	1.41	17.40	21.30	775.00	575.00
LDS (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	231.0	682.5
Tillage										
Zero	10.19	11.66	11.13	12.13	0.87	1.41	18.19	21.60	850.00	775.00
Ridge	10.77	11.69	11.15	12.15	0.92	1.49	18.69	22.60	950.00	1075.00
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	281.0
Fertilizer Rates (kg/ha)										
0	9.23	10.99	8.61	9.61	0.79	1.41	16.45	20.40	800.00	375.00
150	10.06	11.77	11.45	12.45	0.89	1.46	19.42	21.70	900.00	1125.00
300	12.14	12.27	13.36	14.36	1.01	1.49	19.45	24.12	975.00	1250.00
LSD (0.05)	1.07	NS	1.09	2.09	0.13	NS	1.23	1.29	NS	121.0

NS = Not Significant

Table 6: Main effect of cropping system, tillage practices and fertilizer rates on yield and yield parameters of Soybean

Cropping system	100 Pods WT(g)		100 Seeds WT(g)		No of Pods/PLT		No of Seeds/P		Grain yield (Kg/ha)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Sole Soybean	31.85	36.50	11.01	14.02	45.87	50.70	2.15	2.18	1300.00	1300.00
Intercropped Soybean	31.75	36.40	10.98	13.50	45.01	49.80	2.13	2.14	1000.00	1175.00
LDS (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	281.80	NS
Tillage Practices										
Zero	30.92	34.50	10.88	13.60	41.61	43.60	2.13	2.13	1075.00	1075.00
Ridge	32.66	36.00	11.18	14.00	43.78	56.90	2.15	2.17	1225.00	1375.00
LSD (0.05)	1.53	NS	NS	NS	NS	11.10	NS	NS	142.20	281.20
Fertilizer Rates (kg/ha)										
0	31.46	34.70	10.79	13.16	32.03	35.00	2.13	2.14	800.00	500.00
150	31.87	36.50	10.87	13.80	42.05	49.60	2.15	2.16	1200.00	1250.00
300	32.04	38.30	11.32	14.50	56.00	66.20	2.15	2.16	1425.00	2000.00
LSD (0.05)	NS	1.51	NS	0.66	9.08	19.58	NS	NS	221.50	351.10

NS = Not Significant

Table 7: 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	

4. CONCLUSION AND RECOMMENDATIONS

A field experiment was conducted during 2013 and 2014 cropping seasons at the Teaching and Research Farm of the University of Agriculture, Makurdi to determine the response of maize-soybean intercrop to tillage practices (zero, ridge) and fertilizer rates (0, 150 and 300 kg/ha). Results showed that intercropping reduced the yields of maize and soybean compared with their sole crops. Higher yields were obtained from crops cultivated on ridges as a result of improved access to soil moisture than in no-tillage. Fertilizer significantly ($P<0.05$) increased the yield of the component crops in both seasons than when no fertilizer was applied. Increasing the quantity of NPK fertilizer resulted in increase in the yield components of maize and soybean crops.

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 crop yields were obtained at the highest fertilizer rate used in the study. This implies that the optimum productivity of maize-soybean intercrop should be investigated beyond 300 kg/ha NPK fertilizer application. The increase values of soil pH, organic matter, total nitrogen and exchangeable cations is an indication that soil fertility can be improved by application of NPK fertilizer for sustainable agricultural production in the study area. Soybean should be integrated into the maize production system to enhance increased soil organic carbon content, CEC, N, Ca, Mg and P level. Maize-soybean planted on ridges instead of in no-tillage to improve acquisition of both water and nutrients by the plants.

REFERENCES

[1] Adeniyan, O. N. and Ayoola, O. T. (2007). Evaluation of four improved soybean varieties under different planting dates in relayed cropping system with maize under soybean/maize/cassava intercrop. African Journal of Biotechnology. 6(19): 2220 – 2224.

[2] Adeniyan, O.N. and Ojeniyi, S.O. (2003). Comparative effectiveness of different levels of poultry manure with NPK fertilizer on residue soil fertility, nutrient uptake and yield of maize. Moor Journal of Agriculture. Ibadan 2: 191-197.

[3] Agbede, O.O. (2009). Understanding Soil and Plant Nutrition. Lafia: Salman Press. 2nd Edition. Pp 42-66.

[4] Agboola, A.A. (1975). The problem of improving soil fertility by the use of green manure in tropical farming system. FAO Soil Bulletin. 27: 147-163.

[5] Ali, A., Ayuba, S. A. and Ojeniyi, S.O. (2006). Effect of tillage and fertilizer on soil chemical properties, leaf nutrient content and yield of soybean in the guinea savanna zone of Nigeria. Nigerian Journal of Soil Science. 16:126-135.

[6] Awe, G. O. and Abegunrin, T. P. (2009). Effect of low input tillage and amaranth intercropping systems on growth and yield of maize (Zea mays). African Journal of Agricultural Research. 4(7): 578-583.

[7] Ayoola, O. T. and Makinde, E. A. (2007). Fertilizer treatment effects on performance of cassava under two planting patterns in a cassava based cropping system in south west Nigeria. Research Journal of Agriculture and Biological Science. 3(1): 13-20.

[8] Baker, E. F. I. (1979). Mixed cropping in northern Nigeria. III. Mixtures of cereals. Experimental Agriculture. 15: 41 – 48.

[9] Brady, N.C. and Weil, R.R. (2007). The Nature and Properties of Soils (13th Ed.) Prentice Hall, New Jersey.

[10] Carlesso, R., Zimmerman, F.L., Petry, M.T., Mario da Rosa, G., Daniel da Bona, F. and Kunz, J.H. (2002). Soil Water Storage and Maize Growth and Development Under two Tillage Systems in Southern Brazil. American Society of Agricultural and Biological Engineering Publication, Michigan–USA. Pp. 35-39.

[11] Cheng, W. and Coleman, D.C. (1990). The effect of living roots on soil organic matter decomposition. Soil Biology and Biochemistry. 22: 781–7

[12] Chukwu, L.I., Ano, A.O. and Asawalam, D.O. (2012). Effects of poultry manure and NPK fertilizer on soil properties and nutrient uptake of maize (Zea mays L.) plants growth in an Ultisol. Proceedings of the 36th Annual Conference of the Soil Science Society of Nigeria (SSSN) on 7th – 11th March. University of Nigeria Nsukka.

[13] Delouche, J.C. (1980). Physiological changes during storage that affect soybean seed quality and stand establishment. INTSOY Series 22: 12-19.

[14] Dugje, I. Y., Omoigui, L. O., Ekeleme, F., Bandy Opadhyay, R. Lava Kumar, P. and Kamara, A.Y. (2009). Farmers Guide to Soybean Production in Northern Nigeria. International Institute of Tropical Agricuture, IITA Ibadan, Nigeria. Pp. 21.

[15] Egbe, O. M. (2005). Evaluation of Some Agronomic Potential of Pigeonpea Genotypes for Intercropping with Maize and Sorghum in Southern Guinea Savanna. Ph.D Thesis, Univerisity of Agriculture Makurdi, Nigeria. Pp. 23-30.

[16] Egbe, O. M. (2010). Effect of Plant density of intercropped soybean with tall sorghum on competitive ability of soybean and economic yield at Otobi, Benue State, Nigeria. Journal of Cereals and Oil seeds. 1(1): 1-10.

[17] Fagbemi, A. and Akamigbo, F.O.R. (1986). Soils of Benue State and their capabilities. Proceedings of the 14th Annual Conference of Soil Science Society Nigeria. Held at Makurdi on the 4th -7th November. Pp. 49-52.

[18] Fan, A., Chen, X. and Li, Z. (2006). Effects of intercropping systems of trees with soybean on soil physico–chemical properties in juvenile plantations. Journal of Forestry Research. 17: 226–30

[19] Ibrahim, A. H. (2004). Performance of Cowpea (Vigna unguiculata L. Walp) Varieties Intercropped into Maize (Zea mays L.) Under Different Planting Patterns. Msc. Thesis, Ahmadu Bello University, Zaria, Nigeria. Pp. 5-9.

[20] Ijoyah, M.O., Bwala, R.I. and Iheadindueme, C. A. (2012). Response of cassava, maize and egusi melon in a three crop intercropping system at Makurdi, Nigeria. International Journal of Development and Sustainability. 1(2): 1- 10.

[21] Mbah, E.U., Muoneke, C. O. and Okpara, D. A. (2007). Effect of Compound fertilizer on the yield and productivity of soybean and maize in soybean/maize intercrop in southeastern Nigeria. Tropical and Subtropical Agroecosystems. 7:87-95.

[22] Memon, S. Q., Mirjat, M.S., Mughal, A. Q and Amjad, N. (2012). Effects of different tillage and fertilizer treatments on growth and yield components of maize. Pakistan Journal of Agricultural Engineering and Veterinary Science. 28(2): 160-176.

[23] Olatunji, O. and Ayuba, S.A (2012). Effect of combined applications of poultry manure and NPK 20-10-10 fertilizer on soil chemical properties and yield of maize (Zea mays L.). Proceedings of the 35th Annual Conference of the Soil Science Society of Nigeria (SSSN). 7th – 11th March. Federal University of Technology Minna.

[24] Osunde, A.O., Tsado, P.A., Bala, A. and Sanginga, N. (2004). Productivity of a maize – promiscuous soybean intercrop as affected by fertilizer in the southern Guinea Savanna Zone of Nigeria. West African Journal of Applied Ecology. 5:51- 62.

[25] Plaster, E.J. (1992). Soil Science and Management. Newyork: Delmar Publishers Inc. Pp 173- 320.

[26] Prasad, B. and Singh, S.K. (2000). Long term effects of fertilizers and organic manures on crop yields, nutrients balance and soil properties in rice-wheat cropping system in Bihar. In: Long- term soil fertility Experiments in Rice-Wheat Cropping System. Advances in Soil Science. 20:105-119.

[27] Raji, J. A. (2007). Intercropping soybean and maize in a derived savanna ecology. African Journal of Biotechnology. 6(16): 1885 – 1887

[28] Thole, A. (2007). Adaptability of Soybean (Glycine max (L.) Merr) Varieties to Intercropping Under Leaf Stripped and Detasselled Maize (Zea mays L.). M.Sc. Thesis, University of Zimbabwe. Pp. 23-30.

[29] Undie, U. L. Uwah, D. F and Attoe, E. E (2012). Effect of intercropping and crop arrangement on yield and productivity of late season maize/soybean mixtures in the humid environment of south southern Nigeria. Journal of Agricultural Science. 4(4): 37-40.

[30] Willey, R. W. (1985). Evaluation and presentation of intercropping advantages. Journal of Experimental Agriculture. 21:119-133.