ADVANTAGES OF INTERCROPPING COWPEA WITH MAIZE CROP UNDER DIFFERENT TILLAGE METHODS AND INORGANIC FERTILIZER RATES

M. Usman [1] M.G. Nangere [1] and S.D. Audu [2]

[1]Department of Agricultural Science Education, Federal College of Education (Technical) Potiskum, Yobe State-Nigeria

[2]National Cereals Research Institute, Badeggi, Niger State-Nigeria

Corresponding Author e-mail: usmanm2020@gmail.com

ABSTRACT

Field experiments were conducted during 2014 and 2015 cropping seasons at the Teaching and Research Farm, Federal University of Agriculture, Makurdi-Nigeria to determine the yield advantages of intercropping cowpea with maize under different tillage methods and inorganic fertilizer rates. The experimental design consisted of three factors: cropping systems at two levels (sole and intercropping), tillage methods at two levels (No-tillage and Ridges) and inorganic fertilizer rates at three levels (0, 150 and 300 kg/ha 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 methods to sub-plots and the inorganic 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 cowpea were subjected to the Analysis of Variance (ANOVA) after which significant means were separated using Least Significant Difference (LSD) at $P<0.05$. Results obtained from the study showed that higher yields were obtained from crops cultivated on ridges than in no-tillage. Inorganic fertilizer significantly ($P<0.05$) increased the yield of the component crops *than when no fertilizer was applied. There was interaction effect of cropping system, tillage methods and inorganic fertilizer rates with respect to most maize and cowpea crop parameters in both cropping seasons. Intercropping resulted in yield advantage; the land equivalent ratio (LER) was (1.52) in 2014 and (1.29) in 2015 indicating 34 % and 23 % land saved in 2014 and 2015 cropping seasons respectively. Ridge tillage method increased porosity and penetrability thus allowing roots to have better access to water and nutrients when compared with no- tillage. Based on yield and productivity advantage obtained from intercropping, the effect of different rates of inorganic fertilizer on the growth and yield of maize and cowpea intercrop deserve further investigation using higher fertilizer rates. Integrating cowpea into the maize production system is a viable option for maximizing land use efficiency in the study area.*

Key Words: Advantages, Intercropping, Cowpea, Maize, Tillage methods and Inorganic fertilizer

INTRODUCTION

Cowpea is an important grain legume in Nigeria which is usually grown as an intercrop with major cereals by traditional farmers in the Nigerian savanna (Elemo *et al*., 1990). Maize constitutes the staple food for the bulk of the Nigerian population in the Sudan and Guinea savanna zones (Ali *et al.,* 2015). The idea of sustainable agriculture among others includes the adoption of agricultural practices used in low-input traditional farming such as growing arable crops in mixtures (intercrops). Intercropping of cereals with legumes has been popular in tropics (Hauggard-Nielsen *et al*., 2001) and rain-fed areas of the world (Banik *et al*., 2000) due to its various advantages (Chen *et al*., 2004). Mixed cropping or intercropping is an important practice in the savanna agro-ecology of Nigeria and is considered as part of the subsistence farming designed to meet the increase in domestic food requirements (Egbe, 2010).

The essential features of intercropping systems are that they exhibit intensification in space and time, competition between and among the system components for light, water and nutrients and the proper management of these interactions. The peasants farmers in Nigeria have developed and improved on the traditional systems of mixed cropping, but have maintained relative yield stability at a low level (Ijoyah *et al.,* 2012). Similarly, the yield advantage of intercropping has not been so marked in several situations possibly due to the use of supra-optimal plant population proportions and, in some cases, to the use of sub-optimal population proportions for component crops (Ali *et al.*, 2015).

However, intercropping is being looked at as an efficient and most economical production system as it not only increase the production per unit area and time but also improve the resource use efficiency and economic standard of farmer in the sub-Saharan Africa. Presently, interest in intercropping is increasing and fast becoming important among the small scale farmers because of their diversified needs and low farm income from the mono-cropping system. The challenge therefore is to identify crops capable of sustaining their potential yield when grown in specific row arrangements with other crops. A number of research activities carried out on the effect of tillage on soil chemical properties and yield of cowpea and maize in Nigeria revealed that tillage methods significantly improved the total yield of both crops (Ali *et al.,* 2006; Memon *et al.*, 2012). Though, a number of studies have been conducted on mono-cropped maize and cowpea as affected by tillage methods and inorganic fertilizer rates, documented information on the yield advantages of maize and cowpea under intercropping systems using different tillage methods and fertilizer rates in Makurdi is scanty. Therefore, the present study was designed to determine the yield advantages of intercropping cowpea with maize under two different tillage methods and three inorganic fertilizer rates for better resources management and higher crop productivity in the study area.

MATERIALS AND METHODS

The experiment was conducted during 2014 and 2015 cropping seasons at the Teaching and Research Farm of the Federal University of Agriculture, Makurdi-Nigeria to determine the yield advantages of intercropping cowpea with maize under two tillage methods and three inorganic 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). Cowpea variety (IT80D-699) and the maize variety (TZESR-W) were used as planting material for the experiment. Both varieties are grown by farmers in the study area.

Experimental Treatments and Design

The experimental design consisted of three factors: cropping systems at two levels (sole and intercropping), tillage methods at two levels (No-tillage and Ridges) and inorganic fertilizer rates at three levels (0, 150 and 300 kg/ha 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 methods to sub-plots and the inorganic 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 at the NICANSOL Soil Testing Laboratory of the Federal University of Agriculture, Makurdi-Nigeria, 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 to see if there was a change in the soil properties after the experiment for both cropping seasons.

Crop data collection and analysis

Data collected for the yield parameters of maize include cob length, cob diameter, weight of 100 seeds, number of cobs per plant and grain yield per hectare while data collected for the yield parameters of cowpea include number of pods per plant, number of seeds per pod, weight of 100 pods, weight of 100 seeds and grain yield per hectare. All data collected were subjected to Analysis of Variance (ANOVA) and 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).

$$\text{LER} = \frac{\text{Intercrop yield Maize}}{\text{Sole crop yield of Maize}} + \frac{\text{Intercrop yield of Cowpea}}{\text{Sole crop yield of Cowpea}} \quad \text{------------------ (1)}$$

$$\text{Percentage Land Saved} = 100\text{-}1/\text{LER} \times 100 \quad \text{------------------------------------ (2)}$$

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.

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 %) 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) and Ojeniyi *et al.,* (2009) who reported that farmers in Africa requires adequate soil amendment for good crop production as a result of low inherent soil fertility.

Effect of Intercropping and Tillage Practices on Yield Components

The ridge method of tillage was observed to have increased soil porosity and soil organic matter contents compared to no-tillage. Fan *et al.,* (2006) reported increase 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 enhanced soil organic matter decomposition (Cheng and Coleman, 1990). Soil organic carbon content also showed slight increase in maize- cowpea intercropped plots in both years. These changes are considered favorable as decrease in bulk density favors aeration and water storage.

Maize and cowpea 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 methods 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 cowpea 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 cowpea had lower yields under no-tillage compared with those cultivated on the ridges. It is probable that deep root growth was enhanced by planting on a ridge than on a no-tillage.

Tillage methods showed significant increase in mean number of both crop parameters studied. Yield components of both crops were significantly lower in no-tillage than ridge tillage (Table 2). Grain yields in the no-tilled plots were also lower compared to other tillage method. This may be partly attributed to reduced vertical root distribution in no-tilled plots, which reduced the soil depth explored by their roots, except for intercropped maize- cowpea where differences were observed to be small. This indicated that certain stress prevailed in no-tilled plots (Scopel *et al.*, 2001) that must have led to the poor performance of both crops.

Effect of Cropping System on the Yield Components

In 2014 and 2015, 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 2 and 4). 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 cowpea and maize in the intercropping system were higher than the nutrient need of the sole crops. This agrees with Baker (1979) and Mbah *et al.,* (2007) who reported that the nutrient demand of the component crops were always higher than for sole crops.

Cropping system had significant (P<0.05) effect on 100 pods weight, 100 seeds weight, number of pods per plant and number of seeds per pod of cowpea. However, the grain yield was significantly (P<0.05) influenced by intercropping in 2014. The variable yield response of sole cowpea compared to the intercrop agreed with the findings of Enyi (1973) and Mbah *et al.,* (2007) in maize-cowpea and maize-soybean mixtures as well as Olasantan and Lucas (1992) in maize-melon, and Lesoing and Francis (1999) in corn-soybean and sorghum- soybean intercrops that the sole crop components yielded higher than the intercrop.

Effect of Inorganic Fertilizer on the Yield Components of Maize

In 2014 and 2015, 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 4). Maize yield components (100 seeds weight, grain yield and number of cobs per plant) increased with increased application of inorganic 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 cowpea 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 Inorganic Fertilizer Rates on the Yield Components of Cowpea

The cowpea yield components increased with increase in inorganic fertilizer application. Similar positive responses of cowpea to inorganic 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 cowpea benefited more from the highest fertilizer rate (300 kg/ha) in the two cropping seasons, hence corroborate these reports. The zero fertilizer 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 fertilizer application while the highest values (56.00) were obtained under sole cropping at 300 kg/ha inorganic fertilizer in 2014. A similar trend was obtained in 2015 cropping season. There was interaction effect of cropping system, tillage practices and inorganic fertilizer rates with respect to most maize and cowpea crop parameters in both cropping seasons (Table 3 and 5).

Assessment of the Yield Advantages of Intercropping

The experiment in 2014 and 2015 resulted in yield advantage; the total land equivalent ratio (LER) was (1.52) in 2014 and (1.29) in 2015 indicating 34 % and 23 % land saved in 2014 and 2015 cropping seasons respectively (Table 6) due to intercropping compared to sole crop of both maize and cowpea.

CONCLUSION

Results obtained from the study showed that higher yields were obtained from crops cultivated on ridges than in no-tillage. Fertilizer significantly ($P<0.05$) increased the yield of the component crops than when no fertilizer was applied. There was interaction effect of cropping system, tillage methods and inorganic fertilizer rates with respect to most maize and cowpea crop parameters in both cropping seasons. Intercropping resulted in yield advantage; the land equivalent ratio (LER) was (1.52) in 2014 and (1.29) in 2015 indicating 34 % and 23 % land saved in 2014 and 2015 cropping seasons respectively. Ridge tillage method increased porosity and penetrability thus allowing roots to have better access to water and nutrients when compared with no- tillage. Based on yield and productivity advantage obtained from intercropping, the effect of different rates of inorganic fertilizer on the growth and yield of maize and cowpea intercrop deserve further investigation using higher fertilizer rates. Integrating cowpea into the maize production system is a viable option for maximizing land use efficiency in the study area.

Table 1: Soil Physical and Chemical Properties of the Experimental Site before Planting

Property	2014	2015
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, Tillage Methods and Inorganic 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 Systems	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
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
LSD (0.05)	2.96	0.78	NS	NS	0.06	NS	1.87	1.04	231.0	682.5
Tillage										
No- Tillage	10.19	11.66	11.13	12.13	0.87	1.41	18.19	21.60	850.00	775.00
Ridge	12.77	12.69	12.15	13.15	1.92	1.99	19.69	22.60	960.00	1075.00
LSD (0.05)	1.77	1.22	1.35	1.88	0.15	0.13	0.98	1.11	98.1	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	901.00	1125.00
300	12.14	12.27	13.36	14.36	1.01	1.49	19.45	24.12	979.00	1250.00
LSD (0.05)	1.07	1.03	1.09	2.09	0.13	0.12	1.23	1.29	74.7	121.0

NS = Not Significant

Table 3: Interaction Effect of Cropping Systems, Tillage Methods and Inorganic Fertilizer Rates on Yield and Yield Parameters of Maize

C/Sys.	T/Prac.	F/Rates (Kg/ha)	COB DIA 2014	COB DIA 2015	COB LNT(cm) 2014	COB LNT(cm) 2015	COB/PLT 2014	COB/PLT 2015	100SWT (g) 2014	100SWT (g) 2015	Grain Yield (kg/ha) 2014	Grain Yield (kg/ha) 2015
Sole	**No-Till**	0	11.31	11.80	8.62	9.62	1.00	1.00	15.13	21.59	540.00	125.00
		150	11.34	12.20	10.37	11.37	1.00	1.50	15.33	22.63	680.00	1375.00
		300	12.23	12.30	12.77	13.77	1.11	2.00	19.07	23.54	790.00	1900.00
	Ridge	0	11.40	11.60	9.80	10.80	1.00	1.33	17.53	21.61	1050.00	1250.00
		150	12.38	11.87	11.86	11.87	1.11	1.33	18.79	22.70	1175.00	1275.00
		300	13.23	13.13	14.70	15.80	1.11	1.67	18.90	28.83	1900.00	1930.00
Intercrop	**No-Till**	0	7.47	10.70	9.20	10.24	0.64	1.00	15.73	19.24	375.00	375.00
		150	7.55	10.90	11.50	10.80	0.81	1.00	15.07	20.57	550.00	500.00
		300	11.22	12.25	13.90	14.99	0.97	2.00	15.44	21.94	678.00	650.00
	Ridge	0	7.80	10.71	9.22	10.28	0.72	1.33	15.00	20.03	461.00	475.00
		150	9.00	11.95	11.62	11.57	0.88	1.50	15.60	21.20	670.00	950.00
		300	11.89	13.03	14.00	15.07	0.99	1.67	18.00	24.43	930.00	1250.00
	LSD (0.05)		1.78	2.01	1.18	2.11	1.01	1.11	2.09	1.22	7.18	131.2

NS = Not Significant

Table 4: Main Effect of Cropping System, Tillage Methods and Inorganic Fertilizer Rates on Yield and Yield Parameters of Cowpea

Cropping Systems	**100 Pods WT(g)**		**100 Seeds WT(g)**		**No of Pods/PLT**		**No of Seeds/P**		**Grain Yield (kg/ha)**	
	2014	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
Sole Cowpea	31.85	36.50	11.01	14.02	45.87	50.70	2.15	2.18	1300.00	1300.00
Intercropped Cowpea	31.75	36.40	10.98	13.50	45.01	49.80	2.13	2.14	1000.00	1175.00
LSD (0.05)	NS	NS	1.11	1.12	NS	1.61	NS	NS	281.80	121.30
Tillage Practices										
No- Tillage	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	1.98	1.29	1.39	2.09	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	59.60	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)	1.06	1.51	0.49	0.66	9.08	19.58	NS	NS	221.50	351.10

NS = Not Significant

Table 5: Interaction Effect of Cropping Systems, Tillage Methods and Inorganic Fertilizer Rates on Yield and Yield Parameters of Cowpea

C/Sys.	T/Prac.	F/Rates	100Pods Wt(g)		100 seeds Wt(g)		No of Pods/PLT		No of Seeds/P		Grain Yield (kg/ha)	
		(Kg/ha)	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Sole	**No- Till**	0	28.91	33.94	9.88	12.63	26.19	27.30	2.00	1.10	675.00	425.00
		150	31.20	35.21	10.98	13.60	33.20	41.00	2.10	2.11	1000.00	1000.00
		300	31.47	37.53	11.28	14.00	48.10	52.30	2.30	2.13	1550.00	1825.00
	Ridge	0	32.30	35.96	10.77	12.82	51.00	54.00	2.00	2.20	1000.00	1000.00
		150	33.00	36.51	10.77	13.57	52.60	54.30	2.10	2.20	1725.00	1250.00
		300	33.53	39.45	12.17	14.48	58.17	65.30	2.30	2.30	1850.00	2325.00
Intercrop	**No- Till**	0	31.20	35.38	10.27	13.20	25.18	24.30	2.10	2.10	500.00	500.00
		150	31.23	37.50	11.07	13.67	28.15	45.70	2.10	2.14	680.00	1250.00
		300	31.53	37.90	11.37	14.37	30.11	61.00	2.20	2.15	1200.00	1575.00
	Ridge	0	31.87	32.0	10.67	13.60	43.00	34.00	2.10	2.11	600.00	425.00
		150	32.50	37.10	11.13	13.80	46.15	46.30	2.20	2.12	975.00	1325.00
		300	32.77	38.70	11.57	15.47	55.20	67.70	2.20	2.15	1225.00	1925.00
	LSD (0.05)		1.12	1.01	1.33	1.40	2.19	2.33	NS	NS	4.81	73.09

NS = Not Significant

Table 6: Productivity from Mean Yield Data of Component Crops

Cropping Systems	Maize 2014	Cowpea 2014	Maize 2015	Cowpea 2015
Sole crop yield (Kg)	1030.00	1300.00	1275.00	1400.00
Intercrop yield (Kg)	777.00	1000.00	575.00	1180.00
LER	1.52		1.29	
Land saved (%)	34		23	

REFERENCES

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.

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.

Ali, A., Ijoya, M.O.and Usman, M. (2015). Productivity of maize-soybean intercrop as influenced by tillage practices in Makurdi, Guinea Savanna Zone of Nigeria. *International Multidisciplinary E-Journal,* Vol-IV, Issue-VII, 114-127.

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

Banik, P., Sasmal, T., Ghosal, P.K. and Bagchi, D.K. (2000). Evaluation of mustard (Brassica compestris var.Toria) and legume intercropping under 1:1 and 2:1 row-replacement series systems. *Journal Agronomy and Crop Science*, 185, 9-14.

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.

Chen, C., Westcott, M., Neill, K., Wichman, D. and Knox, M. (2004). Row configuration and nitrogen application for barley-pea intercropping in Montana. *Agronomy Journal*, 96, 1730-1738.

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

Chiezey, U.F.(2001). Pod abortion and grain yield of soybean (*Glycine max* (L.) Merrill) as influenced by nitrogen and phosphorus nutrition in the northern guinea savanna zone of Nigeria. *Tropical Oilseeds Journal.* 6: 1 – 10.

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.

Elemo, K.A., Kumar, V., Olukosi, J. O. and Ogungbile, A. O. (1990). Review of Research work on mixed cropping in the Nigerian savanna. *Samaru Miscellaneous Paper,* 127, Pp.125.

Enyi, B.A.C. (1973). Effects of intercropping maize or sorghum with cowpeas, pigeon peas or beans. *Experimental Agriculture*. 9: 83-90.

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.

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

Hauggard-Nielson, H., Ambus, P. and Jensen, E.S. (2001). Evaluating pea and barley cultivars for complementary in intercropping at different levels of soil N availability. *Field Crops Research*, 72, 185-196.

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.

Kang. T.A. (1975). Effects of inoculation and nitrogen fertilizer on soybean in western Nigeria. *Experimental Agriculture.* 11: 23 -31.

Lesoing, G.W. and Francis, C.A. (1999). Strip intercropping effects on yield and yield components of maize and soybean. *Agricultural Ecosystem and Environment.* 55:17-26.

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.

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.

Ojeniyi, S.O., Owolabi, O., Akinola, O.M. and Odedina, S.A. (2009). Field study of effect of organomineral fertilizer on maize growth yield, soil and plant nutrient composition in Illesha, southwest Nigeria. *Nigerian Journal of Soil Science.* 19(1): 11-16.

Okpara, D.A., Nwajiugo, U.C. and Ibiam, B. (2002).The response of soybean to nitrogen and potassium fertilization in the forest belt of south eastern Nigeria. *Tropical Oilseeds Journal.* 7: 53 – 61.

Olasantan, F.O. and Lucas, E.O. (1992). Intercropping maize with crops of differing canopy heights and similar or different maturities using different spatial arrangements. *Journal of Agricultural Science and Technology*. 2: 13-22.

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.

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.

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.

Scopel, E., Tardieu, F. Edmeades, G. and Sebillotte, M. (2001). Effects of Conservation Tillage on Water Supply and Rainfed Maize Production in Semi–arid and Zones of West Central Mexico. NRG Paper 01–01, CIMMYT. Pp. 60-71.

Willey, R.W. (1986). Evaluation and presentation of intercropping advantages. *Journal of Experimental Agriculture.* 21:119-133.