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Full Length Research Paper

Intercrop performance of different varieties of soybean (*Glycine Max.* (L) Merril) in a cassava (*Manihot esculenta* Crantz) based cropping system within the derived savannah zone

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Field experiments to investigate intercrop performance of different varieties of soybean (*Glycine Max.* (L.) Merril) in a cassava (*Manihot esculenta* Crantz) based cropping system within the derived savannah zone were conducted at Nsukka Utisol in Southeast Nigeria ecological. Two varieties of cassava and six varieties of soybean of three different maturity groups were grown as sole and intercrop with four rates of N and K fertilizer, laid out in split plot design in RCBD. Fertilizer rate was the main plot treatment while cassava and soybean, sole and intercrop systems were the sub-plots, replicated three times. Effects of fertilizer rate and soybean residue management on growth and yield of the crops were studied. Soybean residue and grain yield were differentiated by their varieties and were significantly affected by fertilizer rates and cropping system rather than by cassava varieties as there was no significant cassava varietal effect on the cropping systems and no apparent shedding effect. Application of N_0K_{50} fertilizer rate gave the highest soybean dry matter accumulation, highest grain yield and highest fresh cassava tuber yield at 12MAP. Intercropping cassava (NR 8230) with soybean (TGX 1894-3E, medium maturing variety), gave the highest grain yield of Soybean and fresh tuber yield of cassava at 12MAP,

Key words: Cassava, soybean, intercrop.

INTRODUCTION

Cassava is one of the most important staple foods in Nigeria and plays a dominant role in the rural economy of the country which contributes to about 70% of energy requirement of the population. Cassava is well adapted to a wide range of ecological conditions and has become a basic component of cropping systems in many areas of south eastern Nigeria. Cassava cultivation for higher tuber yield has a high requirement for major elements especially nitrogen and potassium. Therefore, land use intensification for cassava production may result in serious land degradation and nutrient depletion within the derived savanna zone. The declining soil fertility due to loss of organic matter and excessive use of inorganic fertilizers increases soil acidity and poses real threats to both economic and biological sustainability of agricultural systems (Handerson and Atkins, 2003). FAO (2003) reported that agricultural intensification without adequate restoration of soil fertility, threatens the sustainability of agriculture. It is commonly observed that when soil organic matter in the farms, which accounts for the major cation exchange capacity and nitrogen content of the soil are not replenished, the soils become rapidly degraded and highly weathered, inorganic fertilizers become the major methods for soil nutrient replenishment. Long time use of these fertilizers has resulted in accumulation and leaching of nitrate which contaminates the ground water

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and aquatic environment, increased soil acidity and highly selective transport or absorption capacity of the crop (Erikson, 2001; Jenson and Hanggard–Nelson, 2003; Angle et al., 1993). Leihner (1983) suggested that the amount of fertilizer recommended for cassava at sole would be reduced if cassava were planted in association with efficient nitrogen fixing legume, such could increase yield of dry matter and crude protein content of cassava as reported by Ngo Tien Dung et al. (2005). From their report also, it was observed that intercropping cassava with cowpea resulted in 20 to 100% greater land use efficiency than for either of the crops grown alone. Research in cassava intercropping is relatively more recent than any other aspects of cassava production. Intercropping systems often results in better land use efficiencies than do sole cropping systems and are usually associated with greater production of total dry matter and crude protein (Natarajan and Willey, 1980). Intercropping is often considered to offer greater yield stability than sole cropping (Baker, 1980). Polthanee et al. (2001) reported that for subsistence farmers, greater stability in cassava food production in intercropping system is particularly meaningful due to its sustainability which substantially reduces the risk of total crop failure.

Legumes should occupy significant roles within the intercropping systems. In the tropics, use of legume for soil improvement is not yet maximized. Many studies on intercrop has provided indirect measurements of the legume nitrogen contribution to farming systems by comparing yield responses of non-legume crop to n-fertilizer with or without legume inclusion (Allison, 1992; Giller, 1992; Umeh, 2002). The consensus now exists in the research and development community that inorganic (fertilizer) inputs need to be complemented with organic matter. Growing legumes and recycling their biomass, or harvesting their residues and adding them to the soil, improves soil fertility, increases yield of the subsequent crop and reduces the requirement for chemical n-fertilizer (Bruno et al., 2003; Defoer et al., 2002). They help to maintain constant mineral availability and results in a balanced nutrient management system.

Soybean is a legume that can contribute to soil-N through biological n-fixation. Their contributions vary greatly according to soybean cultivar, genotype and maturity period. Soybean is desired not only for its grain high nutritive quality and industrial uses, but also because of its ability to fix atmospheric nitrogen. The nutritive value and quality of soybean and its industrial uses in Nigeria made the production and utilization of soybean to expand significantly over the past 10 -15 years (Oikeh et al., 2007). The crop was once a minor component of cropping system in some villages in 1986, accounted for 25% in 1997 but now is becoming the 2nd crop after maize (Sanginga, 2003). The objective of this study therefore is to examine the performance of six varieties of soybean and its suitability for intercrop with two varieties of cassava.

MATERIALS AND METHODS

Six varieties of soybean of three maturity classes (early, medium and late maturing) were intercropped with two varieties of cassava in a split plot design, having two factors; fertilizer rates and cropping systems. The four fertilizer rates were randomized in the main plot, while twenty cropping systems comprising six sole soybean, two sole cassava and twelve cassava/soybean intercrop were randomized in the sub-plots. Cassava varieties used were TMS 30572 and NR 8230. The six varieties of soybean used were TGX 1485-1D and Sam Soy-2, (early maturity varieties 96days); TGX 1894-3E and TGX 1805-31F (medium maturing varieties 110days); TGX 1889-12F and TGX 1864-17F (late maturing varieties 120days). The four fertilizer rates were N_0K_0, N_0K_{50}, $N_{45}K_0$, and $N_{45}K_{50}$ kg ha^{-1}; where N and K were nitrogen and potassium respectively, subscripts 0, 45 and 50 were levels of N and K kg ha^{-1} respectively. The nitrogen source was urea and potassium source was muriate of potash. A uniform application of 30 ha^{-1} of P as single supper phosphate was applied to all plots. Single dose, row application methods were used through out the experiment.

Before the trials were established, the sites which were under a three year grass-bush fallow was ploughed and harrowed, and then the treatment plots were marked out. Plot size was 4.0 X 3.0 m., containing 4 ridges at 1.0 m spacing. Plots were separated by 0.5 m with bonds to avoid drift of nutrients. Soybean was planted on both sides of the ridge at a plant distance of 10.0 cm to give a population of 400,000 plants ha-^{1} while cassava cuttings (20 cm long) was planted at a plant distance of 0.75 m to give plant population of 13,333 plants ha-^{1} on the crest of the ridges. Cassava was harvested at 12 months after planting. Soybean was harvested at the maturity stage. Soil samples at 0 - 30, 30 - 60 and 60 – 90 cm depths were taken at the beginning of experiment, at harvest of soybean and at harvest of cassava, and analyzed for total N, nitrate-N, K, organic matter and organic carbon. Planting was done in early August and weed was controlled manually.

Data analysis

Data collected were analysed using statistical analytical system (SAS institute, 2001). Combined analysis of variance (ANOVA) was done using the general linear model procedure (GLM) to determine differences and effects between cropping system, soil amendment effect, crop yield and system efficiency.

RESULTS AND DISCUSSION

Meteorological data during the years 2004, 2005 and 2006

A summary of annual precipitation (mm) and relative humidity (%) for the years 2004, 2005 and 2006 are presented on Table 1. The average relative humidity was 74.78% for 2004, 74.97% for 2005 and 75.55% for 2006. Total rainfall for the three years, 2004, 2005 and 2006 were 1905.44, 2062.8344 and 1982.3244 mm.yr.$^{-1}$, respectively. The distribution pattern of the rainfall for the three years was consistently bimodal, with heaviest rainfalls in April and October each year.

Table 1. Meteorological data during the years 2004, 2005 and 2006.showing relative humidity and Annual precipitation (mm).

Month	Relative humidity (%)			Total rainfall (mm)		
	2004	2005	2006	2004	2005	2006
January	72.12	61.13	75.29	0.00	0.00	0.76
February	73.68	73.14	76.00	32.00	52.67	33.72
March	71.56	73.81	73.65	85.34	84.33	86.21
April	73.83	74.17	74.88	258.57	237.84	256.33
May	75.81	76.18	77.90	204.27	206.32	243.55
June	76.83	78.91	77.67	228.59	225.77	228.77
July	77.90	79.42	79.68	207.52	255.32	206.55
August	79.58	79.71	80.00	266.19	299.02	276.83
September	77.63	79.67	79.07	242.74	254.33	268.02
October	76.35	77.90	76.94	379.48	415.02	381.26
November	73.03	73.60	65.47	0.76	32.21	0.32
December	69.09	70.74	70.14	0.00	0.00	0.00

Source: Department of Crop Science, University of Nigeria, Nsukka.

Table 2. Some soil properties of the experimental site at the beginning of the study.

Fertilizer	Soil dept (cm)	pH	OM (%)	C (%)	Meq/ 100 g K	$N0_3$ (%)	N (%)	Mechanical analysis			
								Clay	Silt	Fine sand	Coarse sand
N_0K_0	0 - 30	4.1	1.74	0.81	0.11	8.7	0.045	332.5	8.5	19.93	39.1
	30 - 60	4.2	1.18	0.68	0.12	6.7	0.043	40.5	6.5	26.7	26.3
	60 - 90	4.1	0.80	0.46	0.09	3.0	0.038	30.5	4.6	21.1	43.8
N_0K_{50}	0 - 30	4.2	1.45	0.84	0.12	9.1	0.050	33.6	8.7	26.6	31.1
	30 - 60	4.1	1.10	0.66	0.11	6.0	0.044	42.5	6.2	24.3	27.0
	60 - 90	4.0	0.82	0.47	0.09	2.9	0.033	35.5	4.3	21.9	38.3
$N_{54}K_0$	0 - 30	4.2	1.80	0.84	0.11	6.8	0.046	32.8	8.8	27.6	30.8
	30 - 60	4.1	1.21	0.70	0.13	6.5	0.041	41.6	6.6	21.6	30.2
	60 - 90	4.0	0.94	0.54	0.08	2.6	0.035	30.4	4.2	22.7	42.7
$N_{45}K_{50}$	0 - 30	4.2	1.43	0.83	0.12	8.6	0.048	30.5	8.5	24.5	36.5
	30 - 60	4.1	1.04	0.60	0.11	5.3	0.042	35.3	6.3	21.9	36.5
	60 - 90	4.0	0.76	0.44	0.08	2.1	0.032	29.8	5.1	15.3	49.8

Textural class = combination of sandy-clay and sandy-clay-loam.

Soil characteristics

The result of the soil analysis of plots before the study is shown in Table 2. The textural class of the soil was a combination of sandy-clay and sandy-clay-loam.

The pH range of the soil was 4.0 - 4.2 at different soil depths (0 – 90 cm), did not differ significantly. The Organic matter (OM) at the top soil (0 - 30 cm) ranged highest (1.43 – 1.74%), followed by 30 – 60 cm depth (1.04 – 1.18) while 60 – 90-depth had the lowest organic matter (0.76 – 0.94). Similarly the highest organic carbon (0.81 – 0.84%) was on the top soil (0 – 30 cm depth), followed by 30 – 60 cm depth (0.6 – 0.7%) while 60 – 90 cm depth had 0.44 – 0.54%.

Potassium content was similar in 0 – 60 cm depth in all the plots with a range of 0.11 – 0.13 meq/100g K while 60 – 90 depth had a range of 0.08 – 0.09 meq/100gK. Soil-N at 0 – 30 and 30 – 60 cm depths were similar and had the range of 0.041 – 0.050%, while 60 – 90 cm depth had the range of 0.032 – 0.038%. Soil-NO_3 was highest at the 0 – 30 cm depth followed by 30 – 60 cm depths. Lowest soil NO_3 was obtained at 60 – 90 cm depth.

Dry matter accumulation

Litter dry matter, stover dry matter and shoot dry matter (classified as soybean residue) are components of soy-

Table 3. Effects of fertilizer (N and K) and cropping systems on dry matter accumulation produced by three maturity groups of soybean at sole and at intercrop (kg.ha^{-1}).

Cropping systems	Fertilizer rates				
	N_0K_0	N_0K_{50}	$N_{45}K_0$	$N_{45}K_{50}$	Mean
TGX 1448-2E Sole	550.99	864.17	939.71	810.47	791.34
TGX 1448-2E/NR 8230	531.51	1017.85	760.55	744.87	765.70
TGX 1448-2E/TMS 30572	478.41	1206.66	626.77	498.08	702.48
Sam Soy-2 Sole	559.61	1007.08	1018.86	1024.94	802.63
Sam Soy-2/NR 8230	583.75	755.16	739.16	734.92	703.25
Sam Soy-2/TMS 30572	545.72	884.47	605.65	761.64	699.37
TGX 1894-3E Sole	663.68	872.96	907.25	1003.31	854.13
TGX 1894-3E/NR 8230	801.23	1336.79	1006.36	1003.00	1036.85
TGX 1894-3E/TMS 30572	664.80	1098.38	952.86	947.72	915.94
TGX 1805-31F Sole	668.80	861.96	986.17	1090.65	901.90
TGX 1805-31F/NR 8230	644.98	923.24	866.30	962.50	849.26
TGX 1805-31F/TMS 30572	612.94	982.73	868.98	800.73	816.35
TGX 1889-12F Sole	652.13	931.03	809.38	806.43	799.74
TGX 1889-12F/NR 8230	591.29	1003.25	756.74	562.82	725.55
TGX 1889-12F/TMS 30572	421.31	890.58	682.04	757.39	687.83
TGX 1864-17F Sole	455.85	753.77	825.12	806.87	732.65
TGX 1864-17F/NR 8230	562.38	752.35	741.71	748.06	701.13
TGX 1864-17F/TMS 30572	538.26	625.84	403.97	651.47	554.89
Mean	584.31	931.57	805.42	817.55	

$LSD_{0.05}$ fertilizer = 16.7; cropping system = 21.97; interaction = 58.93

soybean that contributed to soil improvement. They differed significantly with maturity class and varieties of soybean. Highest residue returns (total dry matter accumulation) were obtained in medium maturing varieties (Table 3). TGX 1894-3E intercropped with NR 8230 cassava variety gave the highest residue return which was significantly higher than the other medium maturing variety at both sole and intercrop. At other varieties, dry matter was higher at sole than at intercrop. Medium maturing varieties gave the highest dry matter at both sole and at intercrop than the late or early maturing varieties of soybean. Fertilizer mean effect was highest at N_0K_{50} which was significantly higher than any other fertilizer rate, while $N_{45}K_0$ and $N_{45}K_{50}$ did not differ significantly but higher than N_0K_0. The result showed that nitrogen fertilizer was not a better component of intercropping system for higher yield of soybean but serve as starter nitrogen in a poor soil with very low nitrogen content (lower than 0.04%N). This result agreed with Singh et al. (2002) who reported significant changes of soybean residue production with the maturity class of the varieties.

Grain yield of soybean

Grain yield of soybean (Table 4) was significantly affected by fertilizer rates. Highest grain yield (156.91 kg ha^{-1}) was obtained with N_oK_{50} fertilizer rate, while N_oK_o gave the lowest grain yield (66.67 kg ha^{-1}). Grain yields at $N_{45}K_0$ and $N_{45}K_{50}$ did not differ significantly but were 17 and 25% higher than N_0K_0 respectively.

The highest grain yield (144.95 kg ha^{-1}) among the cropping system was at sole TGX 1894-3E (medium maturing variety) which did not differ significantly with TGX 1894-3E intercropped with NR 8230 (133.60 kg ha^{-1}), and sole Tgx 1889-12F (136.60 kg ha^{-1}). The order of decreasing grain yield among the cropping systems was sole TGX 1894-3E > sole TGX 1889-12F > intercropped TGX 1894-3E with NR 8230 > intercropped TGX 1889-12F with TMS 30572 > sole TGX 1889-12F > sole Tgx 1448-2F > sole TGX 1864-12F > intercropped TGX 1894-3E with TMS 3572 > intercropped TGX 1889-12F with NR 8230 > sole Sam Soy-2 > intercropped TGX 1864-17F with NR 8230 > intercropped TGX 1448-2E with TMS 3572 > intercrop Sam Soy-2 with NR 8230 > intercropped TGX 1448-2E with NR 8230 > intercrop TGX 1805-31F with NR 8230 > intercropped Sam Soy-2 with TMS 30572 > sole TGX 1805-31F > intercropped TGX 1864-12F with TMS 30572 > intercropped TGX 1805-31F with TMS 30572.

The lowest grain yield obtained with TGX 1805-31F X N_0K_0 at sole crop showed that TGX 1805-31F is not suitable in the soils with very low soil nutrient. For other interaction of fertilizer and cropping system, the highest

Table 4. Effects of fertilizer rates (N and K) and cropping systems on grain yield of soybean (kg ha^{-1}).

Cropping systems	Fertilizer rates				
	N_oK_o	N_oK_{50}	$N_{45}K_o$	$N_{45}K_{50}$	Mean
TGX 1448-2E Sole	75.01	162.19	95.51	62.52	103.81
TGX 1448-2E/NR 8230	42.68	134.19	51.70	96.11	81.17
TGX 1448-2E/TMS 30572	19.23	159.68	35.76	70.38	91.26
Sam Soy-2 Sole	76.71	162.04	67.63	61.30	98.17
Sam Soy-2/NR 8230	53.94	103.18	100.97	98.48	89.14
Sam Soy-2/TMS 30572	43.13	163.98	37.69	58.43	75.81
TGX 1894-3E Sole	97.36	241.52	163.69	77.13	144.95
TGX 1894-3E/NR 8230	82.47	196.04	157.29	98.59	133.60
TGX 1894-3E/TMS 30572	75.97	190.32	44.15	91.57	100.50
TGX 1805-31F Sole	67.36	186.58	60.80	98.46	103.30
TGX 1805-31F/NR 8230	45.10	104.43	43.35	70.56	65.86
TGX 1805-31F/TMS 30572	47.41	104.79	48.61	80.07	70.22
TGX 1889-12F Sole	98.33	195.56	160.89	91.61	136.60
TGX 1889-12F/NR 8230	93.45	184.14	40.59	81.95	100.03
TGX 1889-12F/TMS 30572	87.96	169.46	92.36	125.45	118.81
TGX 1864-17F Sole	95.70	189.03	51.38	70.92	101.76
TGX 1864-17F/NR 8230	85.70	125.91	73.99	107.09	98.17
TGX 1864-17F/TMS 30572	52.63	116.31	83.37	60.09	78.10
Mean	66.67	156.91	77.76	83.37	

$LSD_{0.05}$ Fertilizer = 6.167; cropping system = 12.521; interaction = 20.214.

grain yield (241.52 kg ha^{-1}) involved N_0K_{50} X Sole TGX 1894-3E which was significantly higher than all other combinations. The next highest grain yield of 196.04 kg ha^{-1} was obtained from N_0K_{50} X TGX 1894-3E intercropped with NR 9230 which did not differ significantly from N_0K_{50} X sole TGX 1889-12F (195.56 kg ha^{-1}), N_oK_{50} X intercrop TGX 1889-12F and TMS 3572 (190.32 kg ha^{-1}), N_0K_{50} X sole TGX 1864-12F (189.03 kg ha^{-1}), N_oK_{50} X Sale SamSoy-2 (187.04 kg ha^{-1}) N_0K_{50} X intercrop TGX 1889-12F and NR 8230 (184.14 kg ha^{-1}), and N_0K_{50} X sole TGX 1448-2E (182.19 kg ha^{-1}). Other next high yielders include $N_{45}K_o$ X sole TGX 1894-3E (163.69 kg ha^{-1}) which did not differ significantly with $N_{45}K_o$ X sole TGX 1889-12F (169.89 kg ha^{-1}), N_0K_{50} X intercrop TGX 1889-12F and TMS 30572 (169.46 kg ha^{-1}), N_0K_{50} X intercrop Sam Soy-2 with TMS 30572 (163.98 kg ha^{-1}) and intercrop TGX 1448-2F and TMS 30572 (159.68 kg ha^{-1}).

The most obvious benefit of including grain legumes in the cropping systems is the grain output and increased efficiency of resource use by the crop mixtures. Results obtained from the performance of the cropping systems and varieties of Soybean in this study agrees with the result of Danshiell et al. (1990) who screened 15 soybean varieties in the lowland valley near Bida in Central Nigeria. There was a significant yield difference among varieties and maturing classes of soybean. Grain yield ranged from 19 to 241 kg.ha^{-1}, with only one variety yielding over 200 kg.ha^{-1}. An important distinction between sole and intercrop was observed. Sole crops yielded higher than intercrop except TGX 1805-31F.

Cassava tuber yield

At 12MAP N_0K_{50} out-yielded all other fertilizer rates (30.7 t.ha^{-1}) which was 204% higher than the yield at no fertilizer (12.6 t.ha^{-1}), 108% higher than at $N_{45}K_0$, (28.40 t.ha^{-1}) and at $N_{45}K_{50}$ (28.03 t.ha^{-1}) (Table 5). At intercrop systems with potassium application, the grain yield was above 120 kg.ha^{-1}. This observation showed that the main constraint to soybean grain production in the South East ecological zone was related to nutrient balance. At intercrop NR 8230 intercropped with TGX 1894-3E gave significantly the highest tuber yield (30.8 t.ha^{-1}) which was 97% higher than the sole crops (19.03 t.ha^{-1}). Sole cassava X all fertilizer rates was lower than their yields at intercrops. The yield of N_oK_{50} X NR 8230 intercropped with TGX 1894-3E (medium maturing variety) gave significantly the highest cassava tuber yield of 42.03 t.ha^{-1}. Similarly, medium maturing varieties, TGX 1894-3E and TGX 1805-31F, intercropped with the two varieties of cassava gave very close and consistent tuber yield at N_0K_{50}: 42.0, 38.9, 38.2 and 38.7 t.ha^{-1}, and are higher than all other soybean varieties X fertilizer rates both at sole and at intercrop.

Table 5. Effects of fertilizer rates and cropping systems on cassava tuber yield ($t.ha^{-1}$) at 12MAP.

Cropping systems	Fertilizer rates				
	N_oK_o	N_oK_{50}	$N_{45}K_o$	$N_{45}K_{50}$	Mean
NR 8230 Sole	4.2	22.1	24.2	25.6	19.03
TMS 30572 Sole	6.8	20.0	21.4	26.1	18.6
NR 8230/TG X1448-2E	7.1	24.2	17.8	12.4	17.9
TMS 30572/TGX 1448-2E	13.1	23.5	36.5	35.6	27.2
NR 8230/Sam Soy-2	10.5	33.8	30.1	40.5	28.7
TMS 30572/Sam Soy-2	12.0	31.5	32.9	16.7	23.3
NR 8230/TGX 1894-3E	15.7	42.0	30.6	34.7	30.8
TMS 30572/TGX 1894-3E	11.5	38.9	32.6	22.0	26.3
NR 8230/TGX 1805-31F	9.7	38.2	30.4	32.8	27.8
TMS 30572/TGX 1805-31F	11.8	38.7	27.8	27.3	26.4
NR 8230/TGX 1889-12F	14.6	35.5	32.6	32.6	28.8
TMS 30572/TGX 1889-12F	21.8	32.4	31.6	23.5	27.3
NR 8230/TGX 1864-17F	18.2	25.8	25.8	27.4	24.3
TMS 30572/TGX 1864-17F	19.6	23.6	23.6	25.3	21.7
Mean	12.6	30.7	28.4	28.03	

$LSD_{0.05}$ fertilizer = 0.51; cropping system = 0.58; interaction = 1.14.

Conclusion

The results showed that the probable intensification of agriculture in the derived Savannah Zone can be sustained only if nitrogen input is assured from non-chemical fertilizer input and good selection of legume for the mixture. This study also agrees with the report of Sanginga (2003) who made primary observations in the Savannah of Northern Guinea (Nigeria) which showed that legumes require fertilizer application for growth and that soils of Savannah cannot supply the quantities of N required for its growth without sustainable crop management methods. Chemical fertilizer input (urea) is not a sustainable way for agricultural production. The green manure from soybean offered tremendous potential in terms of contribution to sustainable agriculture.

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