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ORIGINAL RESEARCH

Evaluation of the agronomic characters of three sweet potato varieties for intercropping with soybean in Makurdi, Southern Guinea Savannah, Nigeria

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ABSTRACT

Field experiment was conducted under rain-fed conditions at the teaching and research farm of the University of Agriculture, Makurdi (7.14^{0}N and 31^{0}E) Nigeria during the 2011 and 2012 cropping seasons, to investigate the effect of intercropping three varieties of sweet potato and soybeans on the performance of sweet potato and soybeans. The experiment was a 2x3 split plot laid out in a randomized complete block designed in three replications. Main plot consisted of cropping systems. (sole sweet potato), sole soybeans and intercrops of sweet potato with soybeans. Sub plot consisted of varieties of sweet potato (CIP440037, CIP44014 and NRSP/05/007C). Growth, yield and yield components were determined for sweet potato and soybeans. There was significant ($p<0.05$) reduction in number of branches and vine lengths of sweet potato across varieties as a result of intercropping in both years of the experiment. Similar reductions were observed in number of roots per plant and marketable roots due to intercropping. Sweet potato variety NRSP/05/007C recorded the highest yield (15 tons/ha), number of roots/plant (4.67) and number of marketable roots when intercropped with soybeans. Intercropping significantly reduced the number of pods (30%) of soybean per plant and the grain yield (44%). All intercropping combinations of sweet potato varieties with soybeans had land equivalent ratio (LER) greater than unity (LER>1.00) indicating yield advantages. Highest percentage land saved (23.05 and 32.57) were obtained when soybeans was intercropped with sweet potato variety NRSP/05/007C in both seasons.

Keywords: Sweet potato, soybean, variety, intercropping.

Introduction

Sweet potato (*Ipomoea batatas* L.) is an extremely important staple food crop worldwide due to its high yield and wide spread adaptation, (Bouwkamp 1985). Among food crops, sweet potato ranked seventh in both economic importance and contribution to the calorie and protein intake in developing countries which produce the major portion of this crop. It is the second most important root tuber crop in the world after Irish potato (Dantata 2010) and ranked third in production area among the root and tuber crops following cassava and yam in Nigeria (Anyaebunam et al. *2008*). The wide spread cultivation of sweet potato in small farms in different regions of the world shows its potential for inclusion in cropping systems suited to the agronomic and socio-economic condition of resource poor farmers.

Soybean (*Glycine max* L.) is an integral component of the traditional cropping system of the Southern Guinea Savanna agro- ecological zone due to its beneficial effect on sustainability and as a source of nutritious food (Henriet et al. *1997).* The importance of soybean is predicated on its high nutritious quality with respect to its protein and oil. From the nutritional standpoint, it ranks high in the protein quality index as ascertained by Food and Agricultural Organization (Langer and Hill 1991). Soybean ranks below fish, beef muscle and whole egg, but above other legumes and cereal proteins. In developing countries, it is an important industrial crop especially in the manufacture of non-food and as a food crop in the making of confectionaries and main dishes is currently being extensively exploited *(*Atteh et al. *1990*). Oil from soybean is of high quality, being 85 percent unsaturated and cholesterol free and hence is suitable for heart disease patients (Onochei 1975).

The productive efficiency of a plant is determined by the genotype and the environment. Selection for system yield under intercropping revealed some adaptation to the intercrop environment that differed from crop yield under monoculture (Oleary and Smith 2004). Therefore, evaluation of the agronomic performance under monoculture maybe insufficient to identify suitable characters for intercropping (Francis and Smith 1985). Plant characteristics that are considered to be useful in monoculture may not be so under intercropping. According to Davis and Wooley (1993) the traits required for intercropping are those which enhanced the complimentary effect between species and minimized the intercrop competition, it is therefore important to identify sweet potato varieties that are associated with adaptation to intercropping, such variety may prove useful in selecting for high dry matter production and root yield. Egbe and Idoko (2009) observed that sweet potato varieties commonly cultivated by farmers in Southern Guinea Savannah zone of Nigeria often result in low yield (3-9 t/ha) compared to the average world yield of 14.9 t/ha (FAO,2001). Though, yield advantages occur in sweet potato intercropped such other crops as maize, okra and pigeon pea (Ossom 2010, Ijoyah and Jimba 2011, Egbe and Idoko 2009) and soybean intercropped with such other crops as maize, sorghum and castor *(*Ennin et al. *2002*; Akunda 2001, Evans and Streedharran 1982). There is not much documented information on yield advantages derived from sweet potato / soybean intercropping. Therefore, the objective of this experiment was to determine the suitability of sweet potato varieties for intercropping with soybean and to assess the yield advantages from growing both sweet potato and soybean so as to enhance food production in the Southern Guinea Savannah zone of Nigeria.

Materials and methods

Field trials were conducted during 2011 and 2012 cropping seasons at the Teaching and Research Farm of the University of Agriculture Makurdi to evaluate the response of three sweet potato varieties to intercropping. The study location (7^o 14^1 N and 8^o 37^1 E) is at an altitude of 228m above sea level in the Southern Guinea Savannah Agro-ecological zone of Nigeria. The texture of the top soil (30 cm) of the experimental site was sandy loam (table 8).

The experiment was a 2 x 3 split plot laid out in a randomized complete block design replicated three times. Main plot consisted of cropping systems (sole sweet potato, sole soybean and intercropped of sweet potato with soybean), Sub plot consisted of varieties (CIP440037, NRSP/05/007c and CIP440141). Sweet potato varieties were obtained from National Root Crop Research Institute sub- station Otobi while soybean variety TGX 1448-2E was obtained from National Cereal Research Institute sub – station Yandev, Gboko. The land was manually cleared and ploughed, the gross plot consist of 4 ridges 3m long ($12m^2$) while the net plot had 2 ridges 3m long. Planting was done on the 7^{th} and 9^{th} of July 2011 and 2012 respectively. Sweet potato vines of 30cm with at least 4 nodes were planted by the side of the ridge while soybean was sown on top of the ridge with seeds drilled which were later thinned to one plant per stand in sole and intercrop at a spacing of 100cm x 5cm (200,000plants/ha). Fertilizer was applied based on recommendation of Benue state (Makurdi), soybean – 10kg N/ha; 36kg p_2o_5/ha and 20kg k_2o/ha. Sweet potato – 34kg N/ha; 50kg p_2o_5/ha and 80kg k_2o/ha (Kalu, 1993).Weeding was carried out manually twice before the crops matured; soybean was harvested when it was fully matured and the leaves have turned brown and sweet potato when the leaves were turning yellowish.

The following parameters were taken: sweet potato – number of branches, vine girth, leaf area, vine length, fodder weight per plant, fodder weight per tonne, number of roots per stand, root length, root girth, marketable root number (comprised of tuberous roots > 150g which are not infested or disease attacked), unmarketable root number (comprised of roots < 150g) and net yield. Soybean – plant height, number of days to 50% flowering, number of branches per plant, number of pods per plant, number of empty pods per plant, number of seeds per pod, biomass weight tonne per hectare, weight of 100 seeds, harvest index and net yield tone per hectare.

All data were statistically analyzed using GENSTAT Release (Rothamsted Experimental Station) copy right 2011. Least Significant Difference (LSD) at $P<0.05$ was used for means separation when ever difference between means were significant following the procedure of Obi (1990). Land Equivalent Ratio (LER) as described by Willey (1985), Competitive Ratio (CR) as proposed by Willey and Rao (1980) and percentage (%) land saved as calculated by Willey (1985) were used to determine the productivity of the intercropping system.

Results and discussion

Sweet potato

Number of branches

Result on sweet potato number of branches (Table 1) showed that there was significant ($P< 0.05$) difference in number of branches from six weeks after planting among the various varieties tested and across the two seasons of planting. V_3 (CIP440141) produces the highest number of branches and lowest by V_1 (CIP440037). Branching of the sweet potato is said to be cultivar dependent varying not only in the number but also in the distance the branches grow outward from the crown of the plant (Yen 1974). There was significant reduction in number of branches when sweet potato was intercropped, this could have come as a result of the shading effect of soybean on the sweet potato crop. This result conformed to Chipungahello et al. *(2005)* who reported that sub- optimal light conditions reduce growth of sweet potato.

Table 1. Effect of variety and cropping system on the vegetative component of sweet potato.

	No of branches				Vine length				leaf area				fodder wt /plant	
	2011		2012		2011		2012		2011		2012		2011	2012
	Wks		Wks		Wks		Wks		Wks		Wks		Wks	Wks
	6	8	6	8	6	8	6	8	6	8	6	8		
Cs 1	4.28	4.73	2.89	4.30	2.73	3.52	2.53	3.18	66.09	97.50	78.3	83.8	0.59	0.59
Cs 2	2.36	2.30	0.70	0.97	1.96	2.57	1.25	1.57	46.06	47.50	64.6	55.3	0.35	0.35
LSD_{05}	1.34*	0.82*	1.93*	2.54*	NS	0.91*	NS	1.05*	NS	12.53*	NS	26.10*	NS	NS
Var.														
V_1	1.89	2.00	1.28	1.85	1.67	2.18	1.16	1.48	68.54	70.70	72.50	70.70	0.39	0.37
V_2	2.38	2.58	1.57	2.06	1.92	2.72	1.64	2.06	53.7	59.30	77.4	72.20	0.40	0.43
V_3	5.69	5.94	2.53	4.01	3.46	4.23	2.87	3.59	45.98	60.60	45.87	66.00	0.62	0.79
LSD_{05}	0.92*	0.47**	0.76*	0.73**	0.92*	0.94**	0.51*	0.45*	7.93*	NS	NS	NS	0.17*	0.14*

CS=cropping system, Var. = variety, LSD_{05} = Least significant difference at 5%, *=significant, **= highly significant.

Vine length (cm)

The result obtained in this study showed that vine length was strongly influence by intercropping at eight weeks after planting (Table 1), there was significant ($P< 0.05$) difference between sole cropping and intercropping. There was decreased in Vine length as sweet potato was intercropped. This could be as a result of reduce solar radiation received by the sweet potato crop, Chipungahello et al. *(2007)* observed increased in main vine length, stem and leaf weight as shading was reduced and light intensity increased and Robert et al. (1986) reported restricted growth when light transmission was reduced in sweet potato intercrop. There was significant ($P< 0.05$) difference in vine length among the varieties. Vine length was highest in V_3 (CIP440141) and least in V_1 (CIP440037*),* Hossain *et al. (1994)* on effect of vine parts on growth of sweet potato discovered that vine length was cultivar dependent.

Vine girth

Result on vine girth showed that there was decreased in vine girth as sweet potato was intercropped, however, the effect was not significant. Similarly, Variety did not significantly influenced vine girth, furthermore, there were differences between the various Varieties used but their differences had no consistent trend.

Fodder weight

The result showed that cropping system did not significantly influenced fodder weight per plant or per hectare. However, there was decrease in fodder weight in intercropping. (Table 1). Fodder weight responded significantly (P< 0.05) to varietal influence, V_3 (CIP440141) showed higher fodder weight than the other varieties while V_1 (CIP 440037) showed lowest fodder weight per plant and per hectare.

Table 2. Effect of variety and cropping system on the yield and yield component of sweet potato.

	No of root.plt		root girth		root length		unmarketable rt no		marketable rt no		harvest index		net yield t/ha	
CS	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Cs_1	3.8a	4.02	3.38	4.08	9.99	11.00	19.04	23.11	6.93a	4.11	0.54	0.57	18.39	17.34
Cs_2	1.96b	1.98	2.62	2.80	7.26	7.26	9.48	9.63	0.74b	1.15	0.50	0.53	9.47	7.55
LSD_{05}	0.2**	0.75*	0.59*	1.18*	NS	NS	4.54*	8.38*	3.59*	3.10*	NS	NS	5.63*	3.30*
Var.														
V_1	2.54	2.78	2.11	2.32	6.88	8.41	10.11	11.17	2.94b	1.56	0.46b	0.51	8.32	9.21
V_2	3.66	3.66	3.62	4.38	8.72	10.02	21.56	23.17	5.17	4.39	0.75a	0.73	23.91	16.26
V_3	2.40	2.57	3.26	3.62	10.2	12.23	11.11	14.22	3.39	1.94	0.41	0.40	9 96	11.88
LSD_0	0.26**	0.31**	0.61**	0.71**	1.26**	1.12*	3.85**	6.36*	1.33*	1.05**	0.06**	0.12**	3.30*	3.82*

CS=cropping system, Var. = variety, LSD_{05} = Least significant difference at 5%, *=significant, **= highly significant.

These differences in fodder weight among the varieties could have resulted from their genetic characteristics which must have been modified by the environment. This finding is in agreement with the work of Belehu (2003) who revealed that genotype by environment interaction often determines the vegetative characteristics of the different sweet potato varieties and Siddique (1985) also found that fodder weight varied across sweet potato varieties.

Table 3 present the interaction effects of cropping systems x variety on the fodder weight produced by sweet potatoes in Makurdi in both experimental years. Sole cropping produced higher fodder weight than intercropping in all the sweet potato varieties tested, and this was particularly significant in 2012. CIP440141 (V_3) gave the highest fodder weight, while CIP440037 (V_1) produced the lowest fodder weight in both years of the study.

Number of roots per plant

Number of fresh storage roots were significantly (P< 0.05) influenced by cropping system. Lower numbers of roots were obtained in intercropping than in sole cropping (Table 2). The decrease in fresh storage roots per plant in intercrop could be attributed to competition between sweet potato and soybean for natural resources in intercrop. This in line with the findings of Belehu (2003) who reported that environmental factors such as solar radiation and nutrient had profound influence in the formation of preformed root primordial in sweet potato. Number of roots was significantly (P< 0.05) influenced by variety, V_2 (NRSP/05/007c) produced significantly different root number from the other varieties, Hossain *et al. (1994)* and Siddique *et al. (1988)* also found that the number of fresh storage root per plant varied from one variety to another.

Root length

A wide variation was observed in root length among the varieties, V_3 (CIP440141) had the longest roots (10.26 and 12.23 cm) and V_1 (CIP440037) produced the shortest roots (6.88 and 8.41 cm) for the two cropping seasons (Table 2). There was significant ($P< 0.05$) difference among the varieties tested. These differences in root length could be varietal differences. Lowe and Wilson (1974) reported that differences in root length are as a result of meristem activity of the primary and secondary meristematic strips in which the rate of development differed in many cultivars. Cropping system had no significant effect on root length. However, there was 27.33% and 18.18% reduction in intercrop sweet potato in the two seasons.

Table 3. Influence of cropping systems x variety on the fodder weight (t/ha) of sweet potato in makurdi in 2011 and 2012.

Cropping Systems	Fodder Weihgt (t/ha)							
	2011				2012			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
Sole	15.30	10.18	19.05	14.84	22.48	16.20	12.37	17.02
Intercrop	7.92	7.71	10.22	8.62	11.15	7.81	5.84	8.27
Mean	11.61	8.94	14.63	11.73	8.90	10.25	18.77	12.64
FLSD(0.05)								
CS	6.37					11.00		
VAR	5.03					3.78		
CS X VAR	6.53					8.49		

V1= CIP440037; V2 = NRSP/05/007C; V3 = CIP440141

CS = Cropping systems; VAR = Variety.

Root girth

Root girth varied markedly among the cropping systems (Table 2), root girth in sole cropping significantly ($P< 0.05$) differed from intercropping system, the decreased in root girth in intercropping could be due to reduction in photosynthate as a result of shading effect of soybean, Van De Fliert and Braun (1999) revealed that bulking and root enlargement is the final phase in sweet potato growth that any interference in partitioning of assimilates during this period will affect their development. Root girth was significantly ($P< 0.01$) influenced by variety, root girth was highest in V_2 (NRSP/05/007c) 3.66cm and 3.63cm and lowest in V_1 (CIP440037) 2.11cm and 2.32cm in the two cropping seasons. These differences could be attributed to varietal characteristics in line with the work of Goswami (1991) and Li and Kao (1985) who observed differences in dry mass production and partitioning of assimilate between sweet potato cultivars.

Marketable and unmarketable root number

As shown on Table 2, marketable and unmarketable root numbers were depressed by intercropping. There was significant ($P< 0.05$) difference in the number of marketable and unmarketable roots, intercropping significantly lowered the number of marketable (89.32% and

72.02%) and unmarketable (51.21% and 58.33%) roots in 2011 and 2012. The reduction could be due to inter plant competition for natural growth resources such as soil nutrient, water and space by both intercrop components, Similar findings were reported by Basuca *et al* (1990), Hossain and Mondol (1994) and Tahan and Saddique (2001). The superior performance of V_2 (NRSP/05/007c) over the other varieties in marketable and unmarketable root number showed the cultivar ability to initiate preform root primordial and partitioning of much assimilate to the storage root, this agreed with the work of Belehu (2003) and Jahan and Saddique (2001) who found that the rate of partitioning of assimilate to the sink to vary from one cultivar to another. Sulaiman and Sasaki worked on some sweet potato cultivars and observed variation in marketable and unmarketable root number formed.

Table 4. Effect of cropping systems x variety on the number of marketable roots per plant of sweet potato intercropped with soybean in makurdi in 2011 and 2012.

Cropping Systems	Number of Marketable roots							
	2011				2012			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
Sole	1.67	4.67	2.44	2.93	2.67	6.67	3.00	4.11
Intercrop	0.33	1.56	0.33	0.74.	0.44	2.11	0.89	1.15
Mean	1.00	3.11	1.39	1.83	1.56	4.39	1.94	2.63
FLSD (0.05)								
CS	2.65				3.10			
VAR	1.20				1.05			
CS X VAR	2.09				2.39			

V_1= CIP440037; V_2 = NRSP/05/007C; V_3 = CIP440141

CS = Cropping systems; VAR = Variety.

Net root yield

The yield of storage roots varies significantly ($P< 0.05$) among the varieties.V_2 (NRSP/05/007c) gave the highest yield, whereas the lowest yield was from V_1 (CIP440037). The differences in yield among the varieties could be due to their different rate of partitioning assimilates as reported by Lowe and Wilson (1975), Goswami (1991) and LI and Kao (1985).

Data on sweet potato net root yield (Table 2) showed that sole sweet potato yielded significantly ($P< 0.05$) higher than that of intercropped. This is consistent with several previous reports, (Sullivan 2000, Ossom and Phykerd 2008, Egbe and Idoko 2009, Ossom 2010, Ijoyah and Jimba 2011).

Table 4 presents the results of the influence of cropping systems x variety on the number of roots produced per plant of sweet potato intercropped with soybean in Makurdi in both 2011 and 2012,although the influence was not significant in 2011. The number of marketable roots/plant of sweet potato had a mean of 1.83 and 2.63 in 2011 and 2012 respectively. Intercropping depressed the number of roots/plant of all the sweet potato varieties used in the study. The depression was particularly significant in V_2 in 2012. In both years, V_2 consistently had the highest number of roots/plant of sweet potato in Makurdi.

Soybean

Vegetative and flowering parameters of soybean were not significantly influenced by intercropping system or variety (Table 5). Similarly, yield and yield component were not significantly influenced by variety. However, cropping systems only affected number of pods and net grain yield.

Table 5. Main effect of variety and cropping system on soybean vegetative component in the year 2011 and 2012.

	Plant height (cm)				leaf area				no of branches		fodder weight (t/ha)	
	4Wk		8Wk		4Wk		8Wk					
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Cs 1	44.30	38.52	62.22	57.5	38.81	33.45	52.08	47.33	8.25	3.92	3.86	3.63
Cs 2	42.04	38.84	60.98	58.8	40.44	31.64	50.99	48.78	7.70	3.68	3.55	3.19
LSD_{05}	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
						Var.						
V_1	43.41	38.24	60.17	57.3	40.00	33.8	51.01	47.07	8.32	3.69	3.70	3.26
V_2	42.04	38.84	60.98	58.80	40.44	31.64	50.99	48.78	7.70	3.68	3.55	3.19
V_3	43.57	38.59	62.06	59.60	42.50	32.22	51.37	48.59	7.60	4.00	3.80	3.75
LSD_{05}	ns	ns	ns	ns	ns	ns	ns	ns	ns ns	ns ns	ns	ns

$LSD_{0.05}$ = Least significant difference at 5% level, CS = Cropping system, V = Variety, ns = Non significant.

Number of pods

Table 5 Shows number of pods per plant, there was significant (P< 0.05) influence of cropping systems on number of pods per plant. Number of pods was higher in sole cropping than intercropping by 34.88% in 2011 and 27.02% in 2012. Pod yield attained in this experiment was consistent with previous findings (Babatunde et al. 2011; Njoku et al. 2007, Ijoyah and Jimba 2011, Nkambule and Ossom 2010) who reported generally that intercropping with sweet potato reduces number of pods per plant.

Table 6. Main effect of variety and cropping system on soybean yield and yield component in the year 2011 and 2012.

	50% flowering		No of pod/plant		No empty pod/plt		No of seed/pod		100 seed wt		H.I		Net yield (t/ha)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
1	41.30	42.02	86.30	74.40	10.18	2.86	2.12	2.15	12.96	12.89	0.28	0.28	1.57	1.33
Cs ii	41.69	43.22	56.2	51.30	11.50	2.96	2.09	2.12	12.93	12.06	0.28	0.27	0.94	0.69
LSD_{05}	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1	42.06	42.39	64.1	55.40	11.83	3.04	2.11	2.15	12.89	12.56	0.27	0.26	1.27	0.92
Var ii	42.00	42.17	81.00	63.30	10.15	2.68	2.08	2.22	13.00	12.83	0.27	0.27	1.19	1.00
Var iii	41.00	43.33	68.70	69.80	10.53	3.04	2.13	2.14	12.94	13.06	0.28	0.26	1.31	1.12
LSD_{05}	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns		ns	ns	ns

$LSD_{0.05}$ = Least significant difference at 5% level, CS = Cropping system, V = Variety, * = significant, ns = Non significant.

Grain yield

Grain yield in soybean was significantly influenced by cropping systems (Table 6). Net yield was significantly ($P< 0.05$) higher in sole crop than in intercrop. Increase in grain yield in sole crop in this study could be due to increase in number of pods in sole crop as number of pods is said to significantly influence yield (Adeniyan and Ayoola 2006). The decrease in net yield in intercrop could be as a result of competition between component crops and this agreed with the work of Alhassan (1995) and Babatunde et al. (2011) who reported significantly higher grain yield in sole crop over intercrop. A percentage reduction of 40.13% and 48.12% grain yield was observed in intercropping in 2011 and 2012 respectively.

Table 7. Land equivalent ratio (ler) competitive ratio (cr) and percentage land save of sweet potato varieties intercropped with soybean in the year 2011 and 2012.

	LER No of pod/plant			CR				% LAND SAVE	
				Sweet potato		Soybean			
CS/Var	2011	2012	mean	2011	2012	2011	2012	2011	2012
Variety 1/ soybean	1.40	1.43	1.42	0.52	0.57	1.92	1.75	28.57	30.07
Variety 2/ soybean	1.46	1.48	1.47	0.74	0.51	1.36	1.96	31.51	32.43
Variety 3/ soybean	soybean 1.23	1.37	1.30	0.35	0.40	2.84	2.51	23.08	27.01

CS = Cropping system. Var. = Variety.

Land Equivalent Ratio (LER), Competitive Ratio (CR) and Percentage of Land Save

Land Equivalent Ratio (LER), Competitive Ratio and Percentage of Land Save are as presented in Table 7. The result showed that all the intercrop combinations had LER values greater than unity (LER>1) under all the sweet potato varieties tested, signifying yield advantage in intercropping various varieties of sweet potato with soybean. However, higher yield advantages were obtained (1.46 and 1.48) when NRSP/05/007c (V_2) was intercropped with soybean in the two cropping seasons. This result showed that genetic compatibility might exist between sweet potato varieties and soybean. Oleary and smith (2004) investigated the variability to intercrop adaptation and observed suitable genotypic traits that are necessary for compatibility. This genotypic compatibility was also observed by Egbe and Idoko (2009) on sweet potato and pigeon pea and Njoku et al. (2007) on sweet potato and okra.

The competitive ratio values of intercrop soybean were higher than its associated crop, indicating that soybean was more competitive than sweet potato and this could be as a result of the soybean being the taller crop. This view agreed with Palaniappan (1985) who stated that taller component crops intercept major share of the solar radiation thereby reducing the competitive ability of the other crop.

Percentage of land save is an indicator of the percentage of land a farmer saved from intercrop if the same yield were to be obtained in sole plot. This work indicated that it is advantageous to have the crops in mixture since the farmer would need as much as 1.46 to 1.48 hectare of land when crops are grown sole in order to achieve the same yield level from one hectare of land when crops are grown in mixture, thereby saving 31.51% to 32.43% of land. Ijoyah and Jimba (2011) also observed 49.2% to 50% of land saved in intercrop.

Table 8. Physical and chemical properties of the soil of the experimental site in 2011 and 2012.

Soil parameters	Method of analysis	2011	2012
% sand	Hydrometer	84.4	85.02
% silt	Hydrometer	8.45	7.88
% clay	Hydrometer	7.15	7.10
Textural class		Sandy loam	Sandy loam
pH (1:1 soil/H_20)	pH meter	6.2	6.3
pH (1:1soil/kcl)	pH meter	4.6	4.8
Organic matter	Walkley	2.62	2.44
Exchangeable catio	A. A. S	3.46	2.92
Available P mg/kg	Bray-1	6.5	5.8
Total Nitrogen g/kg	Kieldahl	0.96	0.88
Exchangeable Mg	Flame photometer	1.00	1.02
Exchangeable K	Flame photometer	0.32	0.30

Conclusion

Generally the result obtained showed yield advantages of intercropping compared to sole cropping. The LER values indicated that higher advantages were obtained when the sweet potato variety NRSP/05/007c was intercrop with soybean. However, it can be concluded that in Makurdi, a location in southern Guinea Savannah agro ecological zone of Nigeria, for higher yield among the three varieties of sweet potato tested, soybean should be intercrop with sweet potato variety NRSP/05/007c. It is however recommended that further investigation be conducted with more varieties across different locations in the guinea Savannah agro ecological zone of Nigeria.

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