Effects of Akidi (*Vigna unguiculata* sub spp. *Sesquipedalis*) Planting Density on Growth, Yields and Land Use Efficiency of Akidi/Cassava Intercrop

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Abstract: Field experiment was conducted at the Teaching and Research Farm, College of Education, Afaha Nsit, Akwa Ibom State, Nigeria to determine the effects of *akidi* (vegetable cowpea) planting density on growth, yields and productivity of akidi /cassava intercropping system in 2008 and 2009 planting seasons. The experiment was laid out in randomized complete block design with three replicates. Treatments were seven akidi populations of 20,000, 30,000, 40,000, 50,000, 60,000, 70,000 plants/ha and a sole cassava. Akidi was also planted sole and in intercropped with cassava. Results indicated that the average plant height of 180.66 and 180.74 cm obtained from the akidi plots at 60,000 and 70,000 plants/ha was significantly (P<0.05) higher than the average of 170.12cm obtained from sole cassava. Similar trend was also observed in cassava leaf area index. A significantly (P<0.05) lowest number of pods/plant (7.37) was obtained from the intercropped plots of akidi (70,000 plants/ha). Dry seed yield of 313.00 kg/ha obtained from the sole plots of akidi (60,000 plants/ha) was significantly higher than 284.97 kg/ha obtained from intercropping akidi at the same planting density. Akidi plots at 60,000 and 70,000 plants/ha produced significantly higher cassava tuberous root yields than the yields obtained from sole cassava and from the plots of other akidi densities in the intercrop. Although akidi at 70,000 plants/ha produced the highest cassava tuberous root yield advantage by 30.1 % over sole cassava; the highest land equivalent ratio (2.34) was however obtained from akidi plots at 60,000 plants/ha. From this study, it appears that integration of optimum akidi density (60,000 plants/ha) in cassava intercrop can enhance cassava growth, tuberous root yield and increased land use efficiency.
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1.   Introduction

Cassava is a popular energy food in most of the tropics and has replaced yam and cocoyam as the number one carbohydrate staple and is said to provide up to 40% of all the calories consumed in Africa (Udoh *et al*., 2005). Nigeria is the largest world producer of cassava with about 34 million metric tonnes. The leading position in Nigeria in cassava root yields is however, attributed to increase in hectarages of production over the years (FAO, 2004). Generally, per hectare crop yield obtained by the small holder farmers in Nigeria is still low compared to those from researcher managed fields (Alimi and Manyong, 2000). This explains why many Nigerians are unable to meet their daily food needs (Benson *et al*, 2003).

Farmers still practice intercropping systems for a number of reasons including yield advantage per hectare among others (Buhler, 2002). The low cassava yield in Nigerian Agriculture has been partly attributed to incompatibility of crop combinations in the intercropping system among other factors. Umanah (2005) and Bassey *et al*. (2001) reported that farmers in the humid zone of Nigeria combined more than three crops among which are maize, melon, pepper and cocoyam with cassava as based crop.

This crop combination results in competitiveness among the growing crops for available limited resources. While cereals are commonly intercropped with legumes for crop yield enhancement in Northern Nigeria; research reports on cassava being intercropped with legumes is scarce in the rainforest zone of Nigeria. However, Njoku and Muoneke (2008) reported that cassava yield in the rainforest zone of Southeastern, Nigeria was found to increase with increase in cowpea density up to 80,000 plants/ha. Though information on akidi intercropped with cassava is limited in Nigeria, it is believed that the crop has great potentials to control weed and increase crop yield. Yield advantages were gained by intercropping maize with akidi in Umudike, Nigeria (Okpara, 2000).

Although cassava can be successfully grown on marginal soils, giving reasonable yields where many other crops have failed (IITA, 1997); it does optimally in fertile soils well endowed with nitrogen and phosphorus (Ibia and Udo, 2009). Akidi like other edible leguminous crops have the potentials to improving physical, chemical and microbiological

properties of the soil and thereby boosting subsequent crop yield (Maccoll, 1990). Such crops have been recommended for fertility enhancement (IITA, 1990) and it has shown to be beneficial to the crop in association (Solubo, 2000). Since intercropping is the dominance cropping system in the country, leguminous crop in intercropping system would serve as a good opportunity to guarantee sustainable soil fertility maintenance in view of soil fertility constraints across Nigeria.

At present, soil amendments in cassava production is low and consequently the yield potentials of various improved varieties of cassava are not often attained (Njoku and Muoneke 2008). Therefore this research was undertaken to examine the optimum akidi density that would enhance growth and yields of cassava/akidi intercrop.

2. Materials and Methods
2.1 Experimental site

The study was conducted at the College of Education Teaching and Research Farm, located at Afaha-Nsit, Akwa Ibom State, Nigeria. The area is located in the lowland rainforest zone of South Eastern Nigeria (04^o50^1 - 05^o20^1 S; 07^o16^1 - 08^o10^1 E) and during the 2008 and 2009 planting seasons it receives about 2500mm rainfall annually during the rainy season (March to November). The rainfall pattern is bimodal, with long (March –July) and short (September-November) rainy seasons separated by a short dry spell of uncertain length, usually in the month of August. The mean relative humidity is 78%, atmospheric temperature 30^oC and mean sunshine hour 12. The soil was acidic coastal plain sands locally grouped under Benin formation. The site was fallowed for five years and the dominant vegetation included *Chromolaena odorata, Pueraria phasioloides* and *Panicum maximum*.

The experimental site was fallowed for four years. Soil analysis of the experimental site revealed that the soil was sandy loam with pH of 6.3 and of ultisol broad group classification. The experiment was carried out in 2008 and 2009.

2.2 Experimental design and treatment

Bush clearing, stumping and tillage were done manually. Each plot measured 6 x 8m and spaced 1.5m apart. The experiment was laid out in a Randomized Complete Block Design with three replicates. The treatments consisted of six Akidi populations: 20,000, 30,000, 40,000, 50,000, 60,000, 70,000 (Plants/ha) planted sole and intercropped with cassava. The was also a cassava as a control.

The akidi used in this study was a creeping type and usually mature within 90 – 100 days. The seeds were planted in the same row with cassava at 1m x 1m apart and the akidi density was maintained according to the treatments after thinning at 10 days

after planting. Cassava (TMS 30572) was planted 1m x 1m apart (10,000 plants/ha). Weeding was done at 4 and 12 weeks after planting (WAP). Fertilizer (NPK - 15: 15: 15) at 150 kg/ha was applied to cassava at 5 WAP.

Assessment of cassava height and number of leaves per plant was done at 4, 6, 8 and 10 WAP. Leaf area index was determined at 2, 3, 4 and 5 months after planting. Cassava tuberous root yield was determined at harvest (12 months after planting). Dry seed yield and yield components of akidi (number of pods/plant, number of seeds/pod, and 100-dry seed weight) were determined at harvest (95 days after planting).

The land use efficiency of cassava/akidi intercrop was evaluated using the land equivalent ratio (LER) as described Udoh and Ndaeyo (2000). Data collected were subjected to analysis of variance and Duncan multiple range test used to compare the treatment means.

3. Results

Table 1 shows height and number of leaves per plant of cassava planted sole and intercrop with Akidi. Plant height and number of leaves per plant were not significantly different at 4-10 WAP. However, at harvest (12 MAP) cassava height (178.00 cm) obtained from the plot planted to akidi at 70,000 plants/ha was significantly (P<0.05) higher than height of 169.90, 170.95, 172.22 and 173.40cm obtained from the plots of sole cassava and akidi at20,000, 30,000 and 40,000 plants/ha, respectively at 12 MAP in 2008. The height of 175.00 cm obtained from the plot of akidi (50,000 plants/ha) was comparable to that obtained from akidi plot at 70,000 plants/ha (178.00 cm) and 173.40 cm obtained from akidi plot (40,000 plants/ha) at 12 MAP in 2008. Similar trend was also observed in 2009. The shortest cassava plant (169.90 and 170.31 cm) were obtained from the sole cassava plots in 2008 and 2009, respectively.

Leaf area index was found to be significantly different at 4 and 5 MAP in both years (Table 2). The leaf area obtained from the 60,000 and 70,000 plants/ha plots were significantly (P<0.05) higher than the leaf area indices obtained from akidi (20,000 and 30,000 plants/ha) plots and sole cassava in 2008 and 2009. The significantly lowest leaf area indices of 1.30 and 1.87 were obtained from the sole cassava plot at 4 and 5 MAP, respectively in 2008. Similar trend was also observed in 2009.

The number of akidi pods per plant was significantly affected in cassava/akidi intercrop than sole akidi in 2008 and 2009 (Table 3). The number of pods per plant obtained from the plots of akidi (20,000, 30,000 and 40,000 plants/ha) were higher than the number obtained from the plants of akidi

(50,000, 60,000 and 70,000 plants/ha) in both sole and intercrop in 2008 and 2009. The sole akidi (50,000, 60,000 and 70,000 plants/ha) plots produced a significantly (P< 0.05) higher number of pods per plant than those obtained from the intercrop plots at the same density. However, the lowest number of pods per plant was obtained from the intercropped plots of akidi (70,000 plants/ha) in 2008 and 2009.

Dry akidi seed yields obtained from sole plots of 20,000, 30,000 and 40,000 plants/ha were not significantly different from the yields obtained from the respective intercrop plots in 2008 and 2009 (Table 4). Seed yields (333.29 and 324.93 kg/ha) obtained from sole akidi plots (70,000 plants/ha) in 2008 and 2009 respectively were significantly higher than the seed yields obtained from the intercrop plots of akidi (40,000 plants/ha) and other akidi densities in sole and intercropped plots. Similarly, the dry seed yield of 313.37 kg/ha obtained from the plots of sole akidi (60,000 plants/ha) was significantly higher than 284.97 kg/ha obtained from the plots of intercrop akidi at the same density over an average of two years planting.

The plots of akidi (60,000 and 70,000 plants/ha) produced significantly higher cassava tuberous root yields of 19.88 and 19.92 t/ha, respectively than sole yield and yields obtained from the plots of other akidi densities on average of two years planting (Table 5). The cassava tuberous root yields of 17.35 and 19.78 t/ha obtained from the plots of akidi (40,000 plants/ha) in 2008 and 2009, respectively were at par with the yields obtained from the plots of akidi (30,000 and 50,000 plants/ha). The lowest average yield (13. 93 t/ha) was obtained from the sole cassava plots on two years average yields. This yield was not significantly different from the average of 13.96 t/ha obtained from the plots of intercropped akidi (20,000 plants/ha) on average of two years planting.

The relative yield (RY) and land equivalent ratio (LER) for cassava increased with increase in akidi density from 20,000 – 60,000 plants/ha (Table 5). The RY and LER for cassava obtained from akidi plots (60,000 plants/ha) were 0.91 and 2.34, respectively. However, the RY and LER for cassava declined to 0.90 and 2.33 respectively with increase in akidi density up to 70,000 plants/ha. The RY obtained for akidi decreased with increase in akidi density. The range was 0.94 from akidi plot 20,000 plants/ha plots to 0.90 obtained from the 70,000 plants/ha.

Table 1. Effects of akidi density on cassava height (cm) and number of leaves per plant in sole and cassava/akidi intercrop in 2008 and 2009

Treatment Akidi (plants/ha)	2008 -----------------------WAP--------------					2009 ------------------WAP----------------				
	4	6	8	10	12	4	6	8	10	12
	Plant height (cm)					**Plant height (cm)**				
Sole Cassava (Control)	12.01_a	23.05_a	60.97_a	99.83_a	169.90d	14.00_a	24.86_a	62.96_a	100.00_a	170.31d
20,000	11.89_a	22.80_a	61.23_a	100.72_a	170.95cd	13.86_a	25.00_a	63.02_a	102.11_a	172.68cd
30,000	12.23_a	23.00_a	61.01_a	101.90_a	172.22c	13.77_a	25.06_a	63.10_a	102.47_a	174.13c
40,000	12.00_a	22.85_a	60.95_a	100.95_a	173.40b	14.10_a	25.11_a	62.89_a	102.76_a	177.86b
50,000	12.11_a	23.01_a	61.05_a	101.75_a	175.00ab	13.89_a	24.95_a	63.00_a	103.21_a	181.77ab
60,000	11.87_a	22.91_a	60.87_a	100.98_a	177.98a	13.92_a	25.08_a	63.30_a	104.00_a	183.98a
70,000	11.91_a	23.05_a	61.00_a	101.79_a	178.00a	14.00_a	25.13_a	63.51_a	104.75_a	184.10a
	Number of leaves/plant (2008)					**Number of leaves/plant (2009)**				
Sole Cassava (Control)	8.00_a	19.19_a	33.10_a	67.67_a	-	9.10_a	22.02_a	37.98_a	68.33_a	-
20,000	7.97_a	19.02_a	34.18_a	70.91_a	-	8.87_a	21.97_a	37.85_a	70.50_a	-
30,000	7.96_a	18.91_a	32.22_a	68.93_a	-	8.11_a	21.88_a	37.76_a	71.11_a	-
40,000	8.01_a	19.12_a	34.02_a	68.66_a	-	8.98_a	21.79_a	38.00_a	70.97_a	-
50,000	8.05_a	19.00_a	34.21_a	70.10_a	-	8.96_a	22.00_a	38.01_a	70.85_a	-
60,000	8.10_a	18.31_a	33.96_a	69.71_a	-	8.92_a	21.60_a	37.95_a	70.90_a	-
70,000	8.02_a	18.49_a	33.89_a	70.00_a	-	9.13_a	22.20_a	38.11_a	71.13_a	-

Means followed by the same letter(s) within each column of the same parameter are not significantly different by DMRT at 5 % probability level.

Table 2. Effects of akidi density on cassava leaf area index in sole and cassava/akidi intercrop in 2008 and 2009 planting seasons

Treatment Akidi (plants/ha)	2008 MAP				2009 MAP			
	2	3	4	5	2	3	4	5
Sole Cassava (Control)	0.48a	0.88a	1.30c	1.87c	0.55a	0.90a	1.43c	1.98c
20,000	0.48a	0.92a	1.36bc	2.03bc	0.53a	0.93a	1.51bc	2.14bc
30,000	0.51a	0.89a	1.40 b	2.10 b	0.66a	0.94a	1.57 b	2.39 b
40,000	0.51a	0.93a	1.48 ab	2.38 ab	0.62a	0.94a	1.63 ab	2.48 ab
50,000	0.49a	0.92a	1.51 ab	2.41 ab	0.63a	0.97a	1.65 ab	2.52 ab
60,000	0.48a	0.91a	1.58 a	2.65 a	0.66a	0.96a	1.76 a	2.67 a
70,000	0.50a	0.90a	1.61 a	2.68 a	0.68a	0.98a	1.77 a	2.69 a

Means followed by the same letter(s) within each column of the same parameter are not significantly different by DMRT at 5 % probability level.

Table 3. Effects of akidi density on akidi yield components in sole and cassava/akidi intercrop at harvest in 2008 and 2009 planting seasons

Treatments Akidi (plants/ha)	Yield components					
	Number of pods/ plant		Number of seeds/ pod		100 – dry seed weight (g)	
	2008	2009	2008	2009	2008	2009
Sole						
20,000	13.10a	11.00 a	9.12a	10.21a	7.04a	7.30a
30,000	13.07a	11.05 a	9.05a	10.17a	7.00a	6.88a
40,000	13.06a	11.03 a	9.02a	9.97a	7.01a	7.11a
50,000	11.28b	9.95 b	8.90a	9.83a	6.90a	6.95a
60,000	10.68 bc	8.59 bc	8.88a	8.99a	6.97a	6.89a
70,000	9.76 bcd	7.98 bcd	8.68a	8.95a	6.87a	6.67a
Intercrop						
20,000	13.00 a	10.94 a	8.96a	9.60a	7.19a	7.00a
30,000	12.98 a	10.91 a	10.85a	9.48a	7.12a	6.92a
40,000	12.96 a	10.88 a	8.88a	9.00a	7.09a	6.88a
50,000	10.17c	8.21c	10.79a	8.94a	6.93a	6.52a
60,000	9.02 d	7.44 d	10.76a	7.98a	6.49a	6.48a
70,000	7.89 e	6.85 e	8.65a	7.87a	6.18a	6.25a

Means followed by the same letter(s) within each column of the same parameter are not significantly different by DMRT at 5 % probability level.

Table 4. Effects of akidi density on dry akidi seed yield (kg/ha) in sole and cassava – akidi intercrop in 2008 and 2009

Treatments Akidi (Plants/ha)	Dry akidi Seed Yield (kg/ha)	
	2008	2009
Sole		
20,000	131.31 h	129.31 h
30,000	200.05 g	200.64 g
40,000	260.62 f	248.91 f
50,000	305.62 d	278.51 d
60,000	320.88 c	305.85 c
70,000	333.29 a	324.93 a
Intercrop		
20,000	125.91 h	120.34 h
30,000	194.73 g	191.83 g
40,000	253.09 f	216.87f
50,000	295.17 de	245.01de
60,000	308.87 d	261.06 d
70,000	317.91 b	276.98 b

Means followed by the same letter(s) within each column of the same parameter are not significantly different by DMRT at 5 % probability level.

Table 5. Effects of akidi density on cassava tuberous root yield and land equivalent ratio (LER) in 2008 and 2009

Treatments Akidi (Plants/ha)	Cassava tuberous root yield (t/ha)		Relative yield Cassava Akidi		LER
	2008	2009			
20,000	14.00 d	13.92 d	1.00	0.94	1.94
30,000	16.78 c	18.10c	1.24	0.96	2.20
40,000	17.35 bc	19.78 bc	1.33	0.92	2.25
50,000	18.79 b	20.12 b	1.40	0.92	2.32
60,000	19.10 a	20.66 a	1.43	0.91	2.34
70,000	19.13 a	20.70 a	1.43	0.90	2.33
Sole Cassava (Control)	13.97 d	13.89 d	-	-	-

Means in the same column followed by the same letters are not significantly different by DMRT at 5 % probability level.

4. Discussion

Cassava height and leaf area index were significantly affected by the variation in akidi densities at the later growth stage and cropping system probably due to the slow establishment of the component crops. Leaf area index is an important photosynthetic apparatus for the synthesis of assimilate leading to the enhancement of cassava growth and yield. This agrees with the findings Njoku and Muoneke (2008) who enhancement of cassava

growth with increase in cowpea density (80,000 plant/ha). Number of seeds/pod and 100-dry seed weight were significantly affected. This could be attributed to the fact that akidi density did not exert enough influent to significantly effect changes in these yield components.

Cassava tuberous yield increased with increase in akidi density. A maximum of 30.1 % relative yield advantage was obtained with akidi (70,000 plants/ha) over sole cassava cropping, while akidi (30,000, 40,000, 50,000 and 60,000 plants/ha) produced tuberous root yield advantage by 20.1, 25.0, 28.4 and 29.9%, respectively. The relatively high cassava tuberous root yield from the plot of akidi (70,000 plants/ha) could be attributed to the integration of legume crop population which might have enhanced soil fertility status (Maccoll, 1990). Such crop when planted together has been known to have beneficial effect on the based crop in association (Sobulo, 2000). The potential to integrate legumes into existing cropping systems in the tropics is high (Kumwenda et al., 1996). In addition, the high population of akidi might reduce the weed pressure at the critical period of cassava growth which is within 3-4 months (Akobundu 1987; Chikoye et al. 2000). Findings from this study agrees with that of Njoku and Muoneke (2008) that the highest cassava tuberous root yield was obtained from the plot of the highest density of cowpea (80,000 plants/ha).

On the other hand, increasing the akidi density in the intercrop to 50,000, 60,000 and 70,000 plants/ha reduced akidi seed yield by 7.5, 9.1 and 9.6 %, respectively compared with the sole yield. This could be attributed to the intra-specific competition due to crop population in the intercrop which reduced the number of Akidi pods/plant. This finding can also be ascribed to competition for limited nutrients, space and light as observed by Fininsa (1997); although not specifically determined in this investigation. The relative low maize yield in maize/sweet potato intercrop was reported by Eneji et al. (1997). Similarly, IITA (1985) reported that melon performed poorly in a cropping system with cassava-maize and yam but improved the yield of other component crops.

The RY and LER in cassava/akidi intercrop increased with increase in akidi density up to 60,000 plants/ha and became constant with increase to 70,000 plants/ha. This demonstrated the productivity of intercrop with increase in akidi density. Fininsa (1997) also reported high LER with bean population of 78,947 and maize intercrop. The LER for akidi decreased in descending order reflecting the decrease in intercrop productivity with increase in akidi population up to 70,000 plants/ha. The plot with the population of akidi (60,000 plants/ha) gave the highest LER (2.34) indicating the advantage of intercropping over sole cropping and other densities (Onwremadu et al., 2008).

5.   Conclusion

Integration of optimum akidi density of 60,000 plants/ha in cassava based cropping improved cassava growth, tuberous root yield and increased land productivity. This system could improve the soils status provide sustainable proteinous food crop and income to farmers.

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