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Full Length Research Paper

Evaluation of cassava (*Manihot esculenta* (Crantz) planting methods and soybean [*Glycine max* (L.) Merrill] sowing dates on the yield performance of the component species in cassava/soybean intercrop under the humid tropical lowlands of southeastern Nigeria

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Field study was conducted during 2001/2002 and 2002/2003 cropping seasons to evaluate the effect of cassava planting methods (horizontal or slanting) and soybean sowing dates (4 and 2 weeks before cassava, simultaneous with cassava, 2 and 4 weeks after cassava) on the yield and yield components and biological productivity of the crop species grown in sole and intercrop. The treatments were arranged in a 2 x 5 factorial laid out in randomized complete block design with three replications. Intercropping significantly (P < 0.05) reduced the yield of cassava and soybean compared with their sole crops. Horizontal method of planting cassava (P < 0.05) depressed yield and yield components of the crop species in the mixture. Soybean yields were generally low due to the shading effect of the cassava component in both cropping seasons. In 2001/2002 and 2002/2003, sowing soybean four weeks before cassava increased grain yield than when sown two weeks before, simultaneously, and two or four weeks after cassava planting. There was no interaction effect between cassava planting method and soybean sowing date in the two cropping seasons. Regardless of the cassava planting method used, soybean sown 4 or 2 weeks before cassava gave the highest monetary returns and net profit than soybean sown at any other time in the mixture or by growing the component crops separately.

Key words: Cassava, soybean, intercropping, planting method, sowing date, productivity.

INTRODUCTION

In humid tropical regions, intercropping is the common crop production system. It has been shown to be more efficient in resource utilization (Willey, 1979). Also, it has been found to be ecologically friendly. Yield advantages resulting from intercropping may be due to component crops having different durations or growth patterns, hence, make major demands on resources at different times thereby resulting in better temporal use of growth resources (Ile et al., 1996, Mbah and Muoneke, 2007).

Soybean is a relatively new grain legume and oilseed crop in Nigeria. It provides cheap dietary protein, infant food formulation and vegetable oil for the people (Ogundipe et al., 1989). The crop has the advantage of being able to assimilate large quantities of nitrogen through its symbiotic fixation, hence lowering the total production cost. Cassava is an important staple food crop in Nigeria. It plays a prominent role in alleviating the food

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Table 1. Some physico-chemical properties of the soil (0-20 cm) of the experimental sites.

Year	Soil physical properties				Soil chemical properties								
	Sand (%)	Clay (%)	Silt (%)	pH (H_20)	Org. M (%)	Org. C (%)	Total N (%)	Available P (mg kg^{-1})	Exchangeable bases (mg kg^{-1})				CEC (meq kg^{-1})
									Ca	K	Mg	Na	
2001/2002	78.2	18.5	3.30	5.1	2.15	1.23	0.09	18.65	0.52	0.16	0.70	0.17	4.21
2002/2003	78.6	17.9	3.50	5.2	2.16	1.25	0.10	17.8	0.50	0.15	0.68	0.16	3.89

problem in the country because of its efficient productivity of food energy, tolerance of environmental stress conditions such as drought, year-round-availability and suitability for various farming systems (Hahn and Keyser, 1985). Intercropping legumes, especially soybean with cassava in the humid tropics of southeastern Nigeria is gaining increased attention because soybean fixes atmospheric nitrogen and produces proteins, while cassava depletes the soil nitrogen and produces carbohydrates. Cassava and soybean mixtures improve the diets as well as the soil fertility and productivity.

This study was initiated purposely to evaluate the effects of appropriate cassava planting pattern and relative time of sowing soybean on yield and yield components of the crop species in the mixture as well as to assess the best planting pattern for cassava and soybean sowing time in cassava/soybean mixtures. Documented information is scanty in this regard, whereas farmers in the study area plant cassava stems either in slanting or horizontal position as well as introduce component crops in mixtures at different times. The findings could be used in studies for evaluating nutrient requirements or plant responses in cassava/soybean intercropping, which depends on time of introducing the legume into tuber root crop plots.

MATERIALS AND METHODS

A field experiment was conducted at Michael Okpara University of Agriculture, Teaching and Research Farm, Umudike, Abia State, Nigeria. Umudike is on Latitude 05° 29' N, Longitude 07° 33' E, altitude 122 m in the humid tropical low lands of Southeastern Nigeria. The top soil of the location is a sandy loam characterized as ultisol (Typic Paleustult). Table 1 presents some physical and chemical properties of the soil (0 – 20 cm) of the experimental sites. The rainfall pattern is bimodal, with long and short rainy seasons separated by a short dry spell, usually, during the month of August. During the period of investigation, total annual rainfall was 2,179.5 and 2,069.3 mm while mean monthly temperature ranged from a mean minimum of 25.0ºC to a mean maximum of 28.5 and 20.0ºC to 29.0ºC between July, 2001 and June, 2002 and July, 2002 and June, 2003 cropping seasons, respectively. Mean monthly relative humidity reached a minimum of 36.0 and 50% and maximum of 85.0 and 88.0% in 2001/2002 and 2002/2003 cropping seasons, respectively. The experiment was a 2 x 5 factorial in randomized complete block design with three replications. Treatments were two cassava planting methods (Horizontal at 180° and slanting at 45° positions) and five soybean sowing dates (soybean sown at 2 weeks before cassava (30 July, 2001; 26 July, 2002), 4 weeks before cassava (16 July, 2001; 12 July, 2002), simultaneous sowing with cassava (13 August, 2001; 19 August, 2002), 2 weeks after cassava (27 August, 2001; 23 August, 2002), and 4 weeks after cassava (10 September, 2001; 6 September, 2002). It gave a total of ten (10) intercropped treatment combinations. Sole crop of cassava planting methods and soybean sowing dates were established as controls. Cassava (TMS 30572) and soybean (TGX-1440-IE) varieties were planted at 1 x 1 m (10,000 plants ha^{-1}) and 1 x 0.05 m (133,000 plants ha-1) spacing, respectively. Plot size was 4 x 5 m (20 m^{-2}). Manual hoe weeding was carried out as at when due while fertilizer N:P:K:Mg 12:12:17:2 at the rate of 400 kg ha^{-1} (Enwezor et al., 1989) was applied in two split doses (200 kg ha^{-1}) at 3 weeks after planting (WAP) on soybean and the second half 8 WAP on cassava. The yield and yield components of cassava and soybean taken from three and five component plants, respectively, were randomly sampled from the inner ridges of each plot. Soybean was harvested at 4 months after planting (MAP) when 95 % of the pods had turned brown according to Johnson and Major (1978) by pulling whole dry plants. Harvested soybean pods were sun-dried and threshed. Cassava was harvested at 12 MAP. Data on total number of fresh tubers per plant, weight of tubers per plant and per hectare in cassava and seed weight per plant, 100-seed weight and grain-yield in soybean were collected from the component crops for productivity assessment. All data were subjected to individual years and both years combined analysis of variance for the yield and yield components of the crop species according to the procedure outlined by Gomez and Gomez (1984) for a factorial experiment. Comparison of treatment means were detected by Fisher's least significant difference (F-LSD) at $P < 0.05$ according to Carmer and Swanson (1971). The land equivalent ratio (LER) (Mead and Willey, 1980), which is the sum of the ratio of the yields of the intercrops to those of the sole crops; gross returns and net profit were used as indices to assess the biological and economic productivity of both sole and the intercropping systems.

RESULTS AND DISCUSSION

Cassava

In 2001/2002 and 2002/2003 cropping seasons, fresh tuber yield and yield components of cassava such as total number of tubers per plant, weight of tubers per plant and fresh tuber yield were significantly ($P < 0.05$) affected by cropping system irrespective of the soybean sowing date and cassava planting method in the intercrop (Table 2). Sole cropped cassava gave higher number of tubers per plant but lower tuber weight per plant and fresh tuber yield per hectare in both cropping seasons. Cassava intercropped with soybean out-yielded sole cassava by 11.7% (2001/2002) and 8.5% (2002/2003). Crop species temporal complementarities could be attributed to the high yield obtained under intercropping in the study. Allen and Obura (1983) in their study on corn,

Table 2. Evaluation of cropping system, cassava planting method and soybean sowing date on yield and yield component of cassava in cassava/soybean intercrop in 2001/2002 and 2002/2003 cropping seasons.

Treatment	Total number of tubers per plant			Fresh tuber yield (t ha^{-1})		
	2001/2002	2002/2003	Mean	2001/2002	2002/2003	Mean
Cropping system						
Cassava + soybean	7.76	8.45	8.11	20.6	20.8	20.70
Sole cassava	9.69	10.57	14.98	18.2	19.0	18.60
F-LSD (0.05)	3.456	2.063	1.447	3.456	2.195	1.782
CV (%)	10.10	13.80	14.80	10.10	6.30	7.60
Cassava planting method						
Horizontal (180^{o})	8.09	8.67	8.38	20.0	20.1	20.05
Slanting (45^{o})	7.44	8.23	7.84	21.1	21.4	21.25
F-LSD (0.05)	1.120	0.936	0.687	1.622	0.701	0.851
CV (%)	18.80	14.40	16.40	10.30	4.40	7.90
Soybean sowing date						
4 weeks before cassava	7.18	7.13	7.16	19.30	19.5	19.40
2 weeks before cassava	6.64	7.64	7.14	20.0	20.1	20.05
Simultaneous with cassava	8.02	8.25	8.14	20.6	20.7	20.65
2 weeks after cassava	8.16	8.99	8.58	21.1	21.4	21.25
4 weeks after cassava	8.81	10.24	9.53	21.9	22.3	22.10
F-LSD (0.05)	1.770	1.479	1.086	2.564	1.107	1.346
CV (%)	18.80	14.40	16.40	10.30	4.40	7.90

cowpea and soybean intercropping system observed that the growing of legumes that could fix atmospheric nitrogen previously or in the early stages of the main crop growth could be quite beneficial to the component crops in the cropping system. The results from our study followed similar trend in the two cropping seasons. In 2001/2002, the total number of tubers per plant, weight of tubers per plant and fresh tuber yield of cassava were not significantly ($P > 0.05$) affected by cassava planting method, irrespective of time of sowing the soybean component in the intercropping system. However, the trend was not sustained in 2002/2003. In both cropping seasons, planting cassava slanting (45^{o} position) gave the lowest total number of tubers per plant but increased the weight of tubers per plant and fresh tuber yield per hectare. The reduction in yield when cassava was planted horizontally (180^{o} position) could be attributed to increased number of shoots per plant, resulting in competition for growth resources as well as diversion of photosynthesis into tissues for stem and internodes elongation due to mutual shading by the shoots. Similar findings were reported by Hunt et al. (1977).

In the two cropping seasons, the highest fresh tuber yield and yield components in cassava were obtained when soybean was sown 4 weeks after cassava, irrespective of the cassava planting method adopted; an indication that earlier-planted cassava had greater competition advantage for growth resources than the others in the intercropping situation. Our findings corroborated the observations of Ofori and Stern (1987) who surmised that earlier sown component crops in intercropping often have an initial competitive advantage over the later planted ones.

Averaged over the cropping seasons, weight of tubers per plant and fresh tuber yield per hectare indicated a progressive decline with delayed planting of cassava in the intercropping situation. The findings corroborated the results obtained by Tijani and Akinnifesi (1996) in cassava/soybean mixture.

In 2001/2002 and 2002/2003, the interaction between cassava planting method and soybean sowing time had no significant ($P > 0.05$) effect on total number of tubers per plant, weight of tubers per plant and fresh tuber yield of cassava.

Soybean

Soybean grown sole significantly ($P < 0.05$) increased seed weight per plant, 100-seed weight and grain yield per hectare compared with when in intercrop with cassava (Table 3). The trend was the same in both years. Similar results were obtained by Okpara et al. (1995) in African yam bean (*Sphenostylis stenocarpa*)/yam (*Dioscorea rotunda*) intercrop, where reductions in yields were due to competition in one or all crops in the mixture. Averaged over the two cropping seasons, seed weight per plant, 100-seed weight and grain yield of soybean were not significantly ($P > 0.05$) affected by the cassava planting method used in the study. However, the highest

Table 3. Evaluation of cropping system, cassava planting method and soybean sowing date on yield and yield component of soybean in cassava/soybean intercrop in 2001/2002 and 2002/2003 cropping seasons.

Treatment	Seed weight (g plant^{-1})			†Grain yield (kg ha^{-1})		
	2001/2002	2002/2003	Mean	2001/2002	2002/2003	Mean
Cropping system						
Cassava + soybean	7.02	10.70	8.86	392.04	520.68	456.36
Sole cassava	13.13	23.11	18.12	653.81	793.25	723.53
F-LSD (0.05)	2.549	3.486	3.703	72.201	13.60	21.7
CV (%)	19.80	17.30	33.0	10.2	125.9	121.1
Cassava planting method						
Horizontal (180^{o})	35.22	10.00	22.61	375.33	501.80	438.57
Slanting (45^{o})	40.72	11.40	26.06	408.75	539.58	474.17
F-LSD (0.05)	1.181	1.498	0.719	47.8	59.122	29.09
CV (%)	22.40	18.20	20.0	16.1	14.8	121.1
Soybean sowing date						
4 weeks before cassava	11.81	17.50	14.66	552.57	752.80	652.69
2 weeks before cassava	10.11	15.72	12.92	490.12	700.88	595.50
Simultaneous with cassava	7.98	12.31	10.15	431.73	636.38	535.56
2 weeks after cassava	3.09	4.85	3.97	303.38	363.48	333.43
4 weeks after cassava	2.13	3.16	2.65	182.41	146.86	164.64
F-LSD (0.05)	1.617	2.368	0.985	65.40	93.480	39.840
CV (%)	22.4	18.29	20.0	16.1	14.8	14.4

†Grain yield at 14% moisture content.

yield parameters of soybean were obtained when slanting method of planting cassava was adopted in the intercrop.

In 2001/2002 and 2002/2003, seed weight per plant, 100-seed weight and grain yield of soybean per hectare were significantly ($P < 0.05$) affected by time of sowing soybean. Sowing soybean two or four weeks before cassava resulted in increased grain yield and yield components because the crop component was subjected to less competition for growth resources and had enough time for seed filling, hence, more yield. Conversely, soybean sown two or four weeks after cassava irrespective of the cassava planting method, initiated seed filling late under intense competition for growth resources, hence, had very short seed filling period, which resulted in very poor grain yield. The results obtained corroborated the works of Adeniyan and Ayoola (2007) on soybean/maize/cassava intercrop, in which they were of the view that the performance, quality and quantity of obtainable seed yield of soybean could be seriously affected by both micro-climatic environment of the crop species and macro-climatic conditions from the time of planting to the time of harvesting of the component crops in the mixture. Also, Udealor (2002) in cassava/vegetable cowpea intercropping system noted that the longer the delay in sowing legume species with cassava, the greater was the shading effect of the well established cassava, resulting in poor yield of the legume crop. Similarly, Egli and Yu (1991) demonstrated that shading of soybean plants caused abscission of half the pods leading to reduction in number of seeds and seed yield.

In the two cropping seasons, there was no significant ($P > 0.05$) interaction effect between cassava planting method and time of sowing soybean on soybean yield and yield components in the intercrop.

Biological and economic productivities of the intercropping system

The total land equivalent ratios of cassava and soybean in the intercrop were all above 1.0 ranging from 48 to 91% (2001/2002) and 36 to 98% (2002/2003), an indication that higher productivity per unit area was achieved in intercropped cassava than sole cropping (Tables 4 and 5). However, the highest LER of 1.91 and 1.98 were obtained when soybean was sown 4 weeks before cassava in 2001/2002 and 2002/2003, respectively. Okoli et al. (1996) obtained similar results in cassava/cowpea intercropping. Early sowing of soybean favoured the performance and yield of cassava in the intercropping system by adding organic matter to the soil through its leaves and stems, which were advantageous to the mixture. The highest yield advantage, 82% (2001/2002) and 84% (2002/2003) were obtained when cassava was planted slanting, irrespective of time of sowing the soybean component in the intercrop.

Table 4. Evaluation of cropping system, cassava planting method and soybean sowing date on land equivalent ratio and gross monetary return in sole and cassava + soybean intercrop in 2001/2002 cropping season.

Treatment	Land equivalent ratio			‡Gross monetary return (₦:K)			Net profit (₦:K)		
	Partial		Total	Partial		Total	Partial		Total
	Cassava	Soybean	Cassava + soybean	Cassava	Soybean	Cassava + soybean	Cassava	Soybean	Cassava + soybean
Sole cassava	1.00	-	1.00	109,200.00	-	109,200.00	43,900.00	-	43,900.00
Sole Soybean	-	1.00	1.00	-	52,304.80	52,304.80	-	4,064.80	4,064.80
Sole cassava	1.00	-	1.00	106,800.00	-	106,800.00	41,500.00	-	41,500.00
Sole cassava	1.00	-	1.00	111,000.00	-	111,000.00	45,700.00	-	45,700.00
Cassava planting method									
Horizontal (180 ^{o})	1.08	0.57	1.65	120,000.00	30,026.40	150,026.40	72,150.00	-730.60	71,419.40
Slanting (45 ^{o})	1.19	0.63	1.82	126,600.00	32,700.00	159,300.00	78,750.00	1,975.00	80,725.00
Soybean sowing date									
4 weeks before cassava	1.06	0.85	1.91	115,800.00	44,205.60	160,005.60	65,950.00	3,480.60	79,430.60
2 weeks before cassava	1.10	.075	1.85	120,000.00	39,209.60	159,209.60	72,150.00	8,484.60	80,634.60
Simultaneous with cassava	1.13	.066	1.79	123,600.00	34,538.40	158,138.40	75,750.00	3,813.40	79,563.40
2 weeks after cassava	1.16	.046	1.62	126,600.00	24,270.40	150,870.40	78,750.00	-6,454.60	72,295.40
4 weeks after cassava	1.20	.028	1.48	131,400.00	14,592.80	145,992.80	83,550.00	-16,132.20	67,417.80

‡Yield of the component crops (cassava and soybean) were sold at the prevailing market prices of ₦6 kg^{-1} and ₦80 kg^{-1}, respectively in 2001/2002.
1 US Dollar = ₦120.50 (Nigerian Naira) in 2001/2002.

Table 5. Evaluation of cropping system, cassava planting method and soybean sowing date on land equivalent ratio and gross monetary return in sole and cassava + soybean intercrop in 2002/2003 cropping season.

Treatment	Land equivalent ratio			‡Gross monetary return (₦:K)			Net profit (₦:K)		
	Partial		Total	Partial		Total	Partial		Total
	Cassava	Soybean	Cassava + soybean	Cassava	Soybean	Cassava + soybean	Cassava	Soybean	Cassava + soybean
Sole cassava	1.00	-	1.00	152,200.00	-	152,200.00	61,800.00	-	61,800.00
Sole Soybean	-	1.00	1.00	-	71,392.50	71,392.50	-	8,642.50	8,640.50
Sole cassava	1.00	-	1.00	156,800.00	-	156,800.00	66,600.00	-	66,600.00
Sole cassava	1.00	-	1.00	147,200.00	-	147,200.00	57,000.00	-	57,000.00
Cassava planting method									
Horizontal (180 ^{o})	1.03	0.63	1.66	160,800.00	45,162.00	205,962.00	102,950.00	11,262.00	114,212.00
Slanting (45 ^{o})	1.16	0.68	1.84	171,200.00	53,422.20	224,622.20	113,350.00	19,522.20	132,872.20

Table 5. Contd.

Soybean sowing date									
4 weeks before cassava	1.03	0.95	1.98	156,000.00	65,752.00	223,752.00	98,150.00	31,852.00	130,002.00
2 weeks before cassava	1.06	0.88	1.94	160,800.00	63,079.20	223,879.20	102,950.00	29,179.20	132,129.20
Simultaneous with cassava	1.09	0.81	1.90	165,600.00	57,544.20	223,144.20	107,750.00	23,644.20	131,394.20
2 weeks after cassava	1.13	0.46	1.59	171,200.00	32,713.20	203,912.20	113,350.00	-1,186.80	112,163.20
4 weeks after cassava	1.17	0.19	1.36	178,400.00	13,217.40	191,617.40	120,550.00	-20,682.60	99,867.40

‡Yield of the component crops (cassava and soybean) were sold at the prevailing market prices of ₦8 kg^{-1} and ₦90 kg^{-1}, respectively in 2002/2003.
1 US Dollar = ₦128.50 (Nigerian Naira) in 2002/2003.

In 2001/2002 and 2002/2003, gross monetary returns in the intercrop had higher values than the component crops planted sole. Planting cassava slanting gave higher monetary returns (₦159, 300. 00) in 2001/2002 and (₦224, 622. 20) in 2002/2003, irrespective of soybean sowing date in the intercrop.

Conclusion

In the cropping seasons, regardless of the cassava planting method used, soybean sown 2 or 4 weeks before cassava gave the highest monetary returns and net profit, which showed that it is more profitable to grow soybean with cassava by sowing the legume 2 or 4 weeks before cassava than at any other time or by growing the component crops separately.

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