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INFLUENCE OF CASSAVA POPULATION DENSITY ON THE GROWTH AND YIELD PERFORMANCE OF CASSAVA - MAIZE INTERCROP WITH A RELAYED COWPEA.

[INFLUENCIA DE LA DENSIDAD DE YUCA SOBRE EL CRECIMIENTO Y PRODUCCIÓN DE CULTIVO YUCA-MAIZ CON SUCESIÓN DE VIGNA]

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SUMMARY

Experiments were conducted during the growing seasons of 1996, 1997 and 1998 at the Institute of Agricultural Research and Training, Ibadan on latitude 7° 30'N and longitude 3°54'E in the degraded rain forest vegetation zone of Nigeria to assess the effects of cassava population densities on the growth and yield of Maize – Cassava intercrop with a relayed Cowpea. The treatments were four cassava population densities (CPD) viz.: CPD 1 = 12,300 Cassava plants / ha (0.9 m x 0.9m); CPD 2 = 10,000 Cassava plants / ha (1m x 1m): CPD 3 = 8,888 cassava plants / ha (1.5 x 0.75m) CPD 4 = 6,666 cassava plants / ha (1.5m x 1.0m). The controls were: Sole Cassava, Sole Maize and Sole Cowpea. Results showed that cassava population density (CPD) had significant effects on maize plant height and average leaf area at tasselling. It also significantly reduced yield and yield components of maize. Cowpea yield was also reduced with increasing cassava population densities. Cassava root yield decreased by 15%,25%, 40% and 44% at CPDs 12,300,10,000, 8,888, and 6,666 plants/ha respectively relative to yield obtained under sole cassava. The marginal rate of return (MRR) for the intercrops also increased with decreased cassava population densities. The highest average MRR of 81% was got with cassava intercropping at 6,666 plants/ha. The lowest return of 49% was got from 12,300 cassava plants/ha. Total productivity per unit land and total income was highest at cassava population density of 6,666 plants/ha followed by 8,888 plants/ha. It was concluded that, although higher yields could be obtained by planting cassava, maize and cowpea in monoculture, the benefits derivable in terms of shared labour costs could not make sole cropping sustainable

Key Words: Cassava/ Maize/Cowpea Intercropping; Cassava Population; Growth; Yield

RESUMEN

Se realizaron experimentos durante los ciclos 1996-1998 en el “Institute of Agricultural Research and Training”, Ibadan, Nigeria, (Lat 7° 30’N y Longitud 3° 54’E) localizado en una selva lluviosa degradada, para evaluar el efecto de la densidad de Yuca en el crecimiento y producción de un cultivo intercalado de Maize-Yuca con sucesión de Vigna. Los tratamientos fueron cuatro densidades de yuca (CPD) 1= 12,300 plantas/ha, CPD 2= 10,000 p/ha, CPD 3:8,888 p/ha y CPD 4= 6,666 p/ha. Tratamientos control fueron Yuca, Maíz y Vigna no intercalados. Se encontró que CPD tuvo efecto significativo en la altura de la planta y área de hoja del maíz al momento de espigar. También redujo la producción de grano y sus componentes. La producción de Vigna se redujó también con el incremento en la densidad. La producción de raíz de Yuca se redujo 15, 25, 40 y 44% en los CPD 1, 2, 3 y 4 respectivamente, en relación a la producción del cultivo de Yuca sola. La tasa marginal de retorno (MRR) para los cultivos intercalados incremento con la reducción en la densidad. La mayor MRR (81%) se obtuvo con la densidad 6,666 p/ha. La menor MRR fue para la densidad 12,300p/ha. La productividad total por unidad de tierra fue mayor para la densidad de 6,666 p/ha. Se concluyó que aún cuando se pueden obtener mayores producciones en los monocultivos (maíz, yuca y vigna), los costos asociados no hace el monocultivo una práctica sustentable.

Palabras clave: Yuca/Maíz/Vigna intercalado, densidad yuca, crecimiento, producción.

INTRODUCTION

The need to maximize land productivity is becoming more evident in the humid tropics because of high population pressure and other human activities competing with agriculture for the limited available land (Steiner, 1991). This has not been achievable with monoculture with single harvests per season, as gains in production per unit area under this system have not been impressive in the tropical environment (IITA, 1990). Development and application of new technologies for multiple cropping systems should prove more promising to increase food output (Papendick *et al*., 1976). Multiple cropping systems are particularly prevalent in small farms in the tropics where they are means of increasing the efficiency or utilization of resources, which include land, water and solar radiation (Palaniappan, 1985).The efficiency, is measured by the quantity of produce obtained per unit resource in a unit time. The need to create security against potential risk of monoculture has been one of the driving forces behind intercropping, especially among small holder farmers who depend to a large extent on the vagaries of nature and are as such, exposed to a diverse level of risk in their production (Muhammad *et al*., 2003; Tsubo *et al*., 2003).Intercropping can be beneficial in increasing crop yield and land use efficiency (Amanullah *et al*., 2006b).

Cassava - based cropping systems are more prevalent because cassava (*Manihot esculenta* Crantz) is one of the most important food crops widely grown in several countries in sub-Saharan Africa. It is the most important root crop in Nigeria in terms of food security, employment creation and income generation for farm families (Ugwu and Ukpabi, 2002). It is well suited to intercropping with short-duration crops such as maize, cowpea, melon, okra and several leafy vegetables. The crops are selected on the basis of differences in growth habits and can be combined in either simple or complex mixtures. Maize is the principal cereal associated with cassava in the humid tropics probably due to efficient utilization of resources by the crops as a result of morphological differences in mixture components though cassava growth could be initially retarded. It is however, possible to get a high relative yield of the sole crop (Amanullah *et al*., 2006a).

Cassava is often left to continue growing after the other short duration crops, such as maize have been harvested in the early season. Some farmers however, plant a few stands of okra and other vegetables in the cassava farm in the late season when the canopy has not closed. A leguminous crop like cowpea (*Vigna unguiculata* L. Walp*)* could also be cultivated in the late season because of their inherent advantages such as short growth period; low canopy plant structure; drought tolerance; as well as ability to fix atmospheric N in their root nodules, which make it highly advantageous to grow in relay or mixed cropping systems (Nangju, 1975).This could be achieved by modifying plant arrangements and crop populations. This paper therefore assessed the effects of cassava population densities on the growth and yield of Maize – Cassava intercrop with a relayed Cowpea.

MATERIALS AND METHODS

Experimental site

The experiments were conducted during the growing seasons of 1996, 1997 and 1998 at the Institute of Agricultural Research and Training, Ibadan on latitude 7^o 30'N and longitude 3^o54'E in the degraded rain forest vegetation zone of Nigeria. Annual rainfall during the period ranged between 1000 and 1,600mm The mean annual temperature ranged between 19.1^{o}C and 35.3^{o}C while the average relative humidity was about 74%. The soil of the experimental site was a Plinthic Tropudalf (USDA, 1975). It is strongly leached with low to medium humus content, deep red-clayed profile with top sandy texture. The site had been cultivated to crops such as maize, cassava and legumes with little fertilizer application. It was covered by both annual and perennial weeds such as *Boerhavia difusa; Euphorbia heterophylla*; *Chromolaena odorata* and *Mucuna mucunoides* before it was cleared for these experiments.

Experimental design

The experiment was laid out in a randomized complete block design (RCBD) with three replications. Plot size was 5 x 4m with a 2m margin round each plot. Cassava (TMS 30555) and maize (TZSR-W) were planted at the same time in each year of experimentation. Cowpea (IT 84E-2246) was relayed into cassava, 16 weeks after planting when maize had been harvested fresh. Sole cowpea was planted in the harvested sole maize plots. Sole cassava was planted at 0.9 m x 0.9 m (12,345 plants/ha) while sole maize was planted at 0.9 m x 0.45 m (2 plants / stand) to give a maize population density of 49,383plants / ha. Cowpea was planted at 0.6m x 0.6 m (2plants /stand) to give a population of 55,555 plants/ha. Same population densities were maintained for maize and cowpea under sole cropping and intercropping. There were four intercrop treatments with three controls:

CPD 1 = Maize intercropped with cassava at 12,300 plants / ha (0.9 m x 0.9m)

CPD 2 = Maize intercropped with cassava at 10,000 plants / ha (1m x 1m)

CPD 3 = Maize intercropped with cassava at 8,888 plants / ha (1.5 x 0.75m)

CPD 4 = Maize intercropped with cassava at 6,666 plants / ha (1.5m x 1.0m)

The control treatments were: Sole Cassava; Sole Maize; Sole Cowpea

Cultural practices:

The experimental site was ploughed and harrowed. Planting was done on the flat. Inorganic fertilizer was applied, according to the recommendation of IAR&T (1991). 60 kg N, 30 kg P_2O_5 and 30 kg K_2O per hectare, supplied as NPK 20 – 10 – 10 was applied. It was applied 3 weeks after planting cassava and maize by ringing around maize plant while it was drilled in holes (6cm deep) between two rows of cassava planted sole at 6 weeks after planting. The plots were weeded manually whenever necessary throughout the, experimental period. Cowpea insects pests were controlled with Karate[R] (lambda-cyhalothrin 2.5 EC) at the rate of 625ml/ha as from the 5th week of planting until full pod formation. Maize was harvested fresh at 14 weeks after planting and it was sun - dried to 14% moisture content to get the dry grain weight. Ripe and dry cowpea pods were picked as from the 10th week of planting to avoid pod shattering and weevil infestation. Cassava roots were harvested 12 months after planting.

Data Collection

Maize plant height and leaf area at tasselling were taken. Plant height was measured from the ground level to the base of the tassel. The leaf area was determined from the fully- expanded leaves. The stover weight; grain yield and average cob length were also taken. The grain yield; average number of pods / plant and weight of 1000 seeds were taken for Cowpea while the root weight; average weight of tubers and average number of tubers / plant were assessed for cassava.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) procedure and means were compared using the Least Significant Difference (LSD) at 0.05 level of probability when the F-ratio was significant.

Economic analysis: The economic assessment was carried out using the partial budget technique to estimate the gross value of the component crops at 2006 market prices for the crops and inputs. The prevailing rates paid to farm labourers were used to estimate the labour costs that vary. The accruing net benefit and the cost that vary were then compared. The marginal rate of return (MRR) (%) for each treatment was calculated thus:

$$MRR = \frac{\text{Net Benefit for each treatment}}{\text{Costs that vary for each treatment}} * 100$$

RESULTS AND DISCUSSION

Cassava population density (CPD) had significant ($P \leq 0.05$) effects on maize plant height at tasselling. The tallest plants of 2.24 and 2.28m were observed in the first and second croppings, respectively with sole cropping (Table 1). These were not significantly taller than the 2.16 and 2.17m tall plants observed with intercropping with 6,666 cassava plans/ha, in the first and second plantings. Higher cassava populations had significantly ($P \leq 0.05$) shorter plants as cassava population increased (Table 1). The average leaf area expansion followed the same trend as plant height, with leaf area getting significantly wider, with decreasing cassava population. However, by the second year, the average leaf area expansion with 8,888 6,666 cassava plants /ha were statistically similar to leaves from sole maize cropping (Table 1). The highest stover weight of 7.85 t/ha, among the intercrops was comparable to the sole crop that gave a stover yield of 8.05 t/ha, in the first year.

Yields from higher densities were significantly ($P \leq 0.05$) lower. In the second year, stover yields from all the intercrops were significantly lower than yield from sole maize (Table 1). Maize grain yield reduced by 38%, 16% 17% and 8% under CPD of 12,300, 10,000, 8,888 and 6,666 respectively when compared with sole maize yield of 2.62 t/ha in the first season. The dry grain yield was highest from the sole cropping. 2.62 and 2.77 t/ha were observed in first and second cropping, respectively. Intercropping with 6,666 cassava plants / ha gave a significantly ($P \leq 0.05$) lower yield of 2.41 t/ha in the first year but a comparable yield of 2.49 t/ha in the second cropping (Table 2). Increasing the cassava population to 8,888 plants/ha gave a further significantly lower yield of 2.17 t/ha in the first year but a comparable yield of 2.40 t/ha in the second year. Such reduction in maize yield when intercropped with cassava has been earlier reported (Amanullah *et al*., 2006a). Cob weight in the first year was also highest from the sole cropping (116.4g) but was not significantly ($P \leq 0.05$) higher than cobs from the intercrops. In the second year, cob weights from intercropping with cassava at 10,000 and 8,888 plants/ha were comparable with either the 92.8g from 12,3000 plant/ha or 107.7g from 6,666 plants/ha. They were however all significantly ($P \leq 0.05$) lower than 119.9g that was obtained with sole maize cropping (Table 2).

The growth and yield performances of maize under sole cropping was much better than at CPDs of 12,300, 10,000 and 8,888 generally due to lack of competition for soil resources (water and nutrient). Plant populations were higher under these treatments compared to sole maize and 6,666 which did not show much difference in growth and parameters. Various research studies on intercropping have shown that performance of crops within a mixture depend on the plant populations and planting patterns used (Harwood and Banta, 1974; Trenbath, 1976; Adeyemi, 1991). Others have found that competition exists among crops planted in mixtures for soil resources (Iwueke, 1991; Ikeorgu, 1984).

Table 1. Effects of Cassava population density on average plant height, average maize leaf area at Tasselling and Stover weight.

	Plant Height(m)		Leaf area (m^2)		Stover wt (t/ha)	
*Treatments	1st cropping	2nd cropping	1st cropping	2nd cropping	1st cropping	2nd cropping
CPD 1	1.69	1.59	0.67	0.75	5.77	6.77
CPD 2	2.00	1.99	0.73	0.78	6.62	6.94
CPD 3	2.05	2.06	0.76	0.88	6.31	7.17
CPD 4	2.16	2.17	0.91	0.97	7.85	7.23
Sole maize	2.24	2.28	1.01	0.99	8.05	8.67
LSD (0.05)	0.1452	0.1205	0.0766	0.1262	0.8895	0.7269
SED	0.04	0.03	0.04	0.07	0.47	0.39

*CPD 1 = 12,300 Cassava plants / ha (0.9 m x 0.9m), CPD 2 = 10,000 Cassava plants / ha (1m x 1m)
CPD 3 = 8,888 Cassava plants / ha (1.5 x 0.75m), CPD 4 = 6,666 Cassava plants / ha (1.5m x 1.0m)

Table 2. Effects of cassava population density on Maize grain yield and average cob weight.

*Treatments	Grain yield (t/ha)		Cob wt (g)	
	1st cropping	2nd cropping	1st cropping	2nd cropping
CPD 1	1.62	1.93	94.2	92.8
CPD 2	2.19	1.90	102.4	96.7
CPD 3	2.17	2.40	99.6	106.1
CPD 4	2.42	2.49	72.2	107.7
Sole maize	2.62	2.77	116.4	119.9
LSD (0.05)	0.1212	0.3655	48.38	11.321
SED	0.06	0.19	25.70	6.01

*CPD 1 = 12,300 Cassava plants / ha (0.9 m x 0.9m), CPD 2 = 10,000 Cassava plants / ha (1m x 1m)
CPD 3 = 8,888 Cassava plants / ha (1.5 x 0.75m), CPD 4 = 6,666 Cassava plants / ha (1.5m x 1.0m)

Cassava root yield decreased by 15%,25%, 40% and 44% at CPDs 12,300,10,000, 8,888, and 6,666 plants/ha respectively relative to yield obtained under sole cassava at both seasons. The differences in cassava yields under the various treatments were due to differences in population densities where highest cassava population density had the highest yield. In the first year, cassava root yield decreased significantly ($P \leq 0.05$) with intercropping, with the sole cassava, yielding 15.1 t/ha compared to 12.86 t/ha observed with the same population intercropped with maize. Intercropping with a reduced cassava population gave even significantly ($P \leq 0.05$) lower yields (Table 3). By the second year, yields from sole cropping (15.33 t/ha) and intercropping (12.53 t/ha) at the same population were comparable. Other intercrops still gave significantly lower yields relative to the sole crop (Table 3). Average tuber weight was favoured with intercropping at lower densities of 8,888 and 6,666 plants/ha. Intercropping at 10,000 plants/ha had comparable tubers in the first year, but significantly ($P \leq 0.05$) bigger tubers than from sole crops in the second year. Average number of tubers/ plant from 12,300 plants/ha was comparable with sole crops. Lower populations gave lower number of tubers/plant (Table 3).

The quality of tuber produced at lower CPDs (8,888 and 6,666 plants/ha) was higher than obtained from high CPDs (12,300 and 10,000 plants /ha). This could be attributed to availability of more space at lower population densities for development of bigger sized tubers which is more desirable by West African farmers (IITA, 1985). It has been observed that farmers are more interested in bigger- sized tubers because they could be peeled faster than smaller ones.

Table 3. Effects of cassava population density on cassava root yield (t/ha); tuber weight (g) and average number of tubers / plant.

*Treatment	Root yield(t/ha)		Av. Tuber wt. (g)		Av.No.of Tubers/Plant	
	1st cropping	2nd cropping	1st Cropping	2nd cropping	1st cropping	2nd cropping
CPD 1	12.86	12.53	347.5	355.3	6.90	6.20
CPD 2	11.30	11.10	469.2	526.6	5.57	5.73
CPD 3	9.13	9.26	520.2	609.1	4.43	4.96
CPD 4	8.47	9.20	630.5	673.4	4.47	5.13
Sole cassava	15.10	15.33	472.5	454.8	6.50	6.80
LSD (0.05)	1.1318	3.4114	122.67	51.603	1.5306	0.6311
SED	0.60	1.81	65.15	27.41	0.81	0.33

*CPD 1 = 12,300 Cassava plants / ha (0.9 m x 0.9m), CPD 2 = 10,000 Cassava plants / ha (1m x 1m)
CPD 3 = 8,888 Cassava plants / ha (1.5 x 0.75m), CPD 4 = 6,666 Cassava plants / ha (1.5m x 1.0m)

Diversion of assimilates from the roots to the stem has been reported at high cassava population which may lead to decrease in yield of commercially acceptable tubers (Odurukwe, 1986). It has also been observed that total dry weight was greater for the larger tubers produced at low population than the smaller tubers produced at high population (Williams, 1972).

Cowpea yield was significantly ($P \leq 0.05$) reduced with cassava intercropping (Table 4). It was reduced to an average of 81% and 73% with cassava population of 6,666 and 8,888 plants/ha respectively (Table 4). Higher cassava densities further reduced cowpea yield. The number of pods /plant ranged between 19 and 23 in the first year. They were not significantly different. In the second year, the range of 21 to 23 pods/plant from 8,888 and 6,666 plants/ha were similar to the sole crop but were significantly more than from 12,300 and 10,000 plants/ha. The weight of 1,000 seeds from 6,666 cassava plants/ha was comparable with the sole crop. Higher densities gave significantly lower weights.

Cowpea yields and yield components which were better at CPD 6,666 could be attributed to lesser competition and low shading effect of cassava plants on cowpea. The canopy of cassava plants had started closing up after maize harvest at the other CPDs. The performance of cowpea associated with cassava was reported to depend on the time and system of planting (Muleba and Ezumah, 1985).

The benefit and cost analysis for the various treatments (Table 5) shows that the marginal rate of return (MRR) for the intercrops increased with decreased cassava population densities. It was averagely highest with cassava intercropping at 6,666 plants/ha. It returned averagely 86 % for every naira invested while intercropping at 8,888 plants/ha returned 70%. The lowest return of 49% was got from intercropping with 12,300 cassava plants/ha. The highest cost of ₦141, 605 was expended at CPD of 12,300 plants/ha while the lowest cost (₦ 49, 720) was incurred for sole cowpea. The low cost incurred for sole cowpea was because it was planted after harvesting sole maize and some of the expenses such as cost of fertilizer as well as labour for land preparation and fertilizer application were not incurred separately for sole cowpea. The marginal rate of returns (MRR) were highest (76.2%) at CPD of 6,666 plants /ha for first cropping season.

Table 4. Effects of cassava population density on cowpea yield, No. of pods per plant and seed weight.

*Treatment	Cowpea yield (t/ha)		No of pods / plant		1000 seeds wt (g)	
	1st cropping	2nd cropping	1st cropping	2nd cropping	1st cropping	2nd cropping
CPD 1	0.43	0.42	19.8	19.6	66.5	68.3
CPD 2	0.49	0.53	20.6	19.8	72.1	74.9
CPD 3	0.59	0.63	20.9	21.7	86.2	93.4
CPD 4	0.68	0.69	21.6	21.6	96.1	97.8
Sole cowpea	0.83	0.88	23.3	23.1	99.5	105.6
LSD (0.05)	0.0791	0.1096	3.5129	2.6474	6.4253	7.8828
SED	0.04	0.06	1.86	1.40	3.41	4.19

*CPD 1 = 12,300 Cassava plants / ha (0.9 m x 0.9m), CPD 2 = 10,000 Cassava plants / ha (1m x 1m)
CPD 3 = 8,888 Cassava plants / ha (1.5 x 0.75m), CPD 4 = 6,666 Cassava plants / ha (1.5m x 1.0m)

Table 5. Benefit and cost analysis for crops under different cassava plant population densities in a cassava – based cropping system.

*Treatments	1st cropping				2nd cropping			
	Total Benefit (₦ /ha)	Total Variable cost (₦/ha)	Net Benefit (₦ /ha)	MRR (%)	Total Benefit (₦ /ha)	Total Variable cost (₦/ha)	Net Benefit (₦ /ha)	MRR (%)
CPD 1	204,672	141,605	63,067	44.5	215,061	139,605	75,456	54.1
CPD 2	228,900	140,570	88,330	62.8	219,476	138,570	80,906	58.4
CPD 3	222,799	136,570	86,229	63.1	238,986	134,570	104,416	77.6
CPD 4	238,819	135,570	103,249	76.2	248530	133,570	114,960	86.1
Sole Cassava	98,150	83,885	18,265	22.9	99,645	77,885	21,760	27.9
Sole maize	133,096	76,850	76,850	73.2	140,716	74,850	65,866	88.0
Sole cowpea	74,866	49720	49,720	50.6	79,376	49720	29,656	59.6

*CPD 1 = 12,300 Cassava plants / ha (0.9 m x 0.9m), CPD 2 = 10,000 Cassava plants / ha (1m x 1m)
CPD 3 = 8,888 Cassava plants / ha (1.5 x 0.75m), CPD 4 = 6,666 Cassava plants / ha (1.5m x 1.0m)
$1USA is an equivalent of ₦126.00

The highest MRR (88.0%) was obtained from sole maize in the second year because the yield of maize was high since there was no competition from other crops and inputs supplied were those needed for maize production only. The least MRR was obtained from sole cassava in both cropping seasons in spite of high cassava yield recorded since there were no component crops to share in the cost of production.

CONCLUSION

In this study, it has been found that though higher yields could be obtained by planting cassava, maize and cowpea in monoculture, the benefits derivable in terms of shared labour costs could not make sole cropping sustainable. The total productivity per unit land and total income were highest at cassava population density of 6,666 plants/ha, followed by 8,888 plants/ha. Cassava, maize and cowpea, when grown in intercrop, could better utilize environmental resources (light, nutrients and moisture) at different periods of the growing season. This cropping system could also improve the nutrient intake of the farm family by providing adequate protein levels needed in their diets with the inclusion of grain legume.

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