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PERFORMANCE OF SWEET POTATO (*IPOMOEA BATATAS* L.) AS INFLUENCED BY CROP MIXTURE AND PLANT POPULATION DENSITY IN A TROPICAL FOREST ZONE

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INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is a root crop more commonly grown in the savannah zones of Nigeria than in the forest zones. In recent years, efforts have been made to introduce this crop into the forested southern parts of Nigeria, where cassava (*Manihot esculenta* Crantz) is the staple root crop, and corn (*Zea mays* L.) is the major cereal crop. In the humid tropics, mixed cropping of cereals with low canopy crops which tend to control erosion and reduce soil temperature has a number of advantages (Norman, 1974). Cassava planted with two successive crops of sweet potato was lower than two successive cassava crops in net income and gross margin but relatively higher than two successive cassava crops in family income (CATIE, 1978). In Nigeria, the economic value of sweet potato depends on its ability to contribute to total yield from the farm, to bring about a sugary taste in foods, and to help in weed control. The effect of intercropping with corn or cassava on tuber yield, leaf size, petiole length, and weed control ability in sweet potato is discussed in this paper.

MATERIALS AND METHODS

Two experiments were conducted in the 1985/86 and 1987/88 rainy seasons on a sandy loam (typic paleudult) soil at the Research and Teaching Farm of the University of Science and Technology, Port Harcourt (4°46′N, 7°01′ E). The initial fertility of the soil was as follows: pH in water, 5.43; N, 600 ppm; P, 33.0 ppm (measured by the Bray and Kurtz No. 1 method); and exchangeable K, 35.9 ppm.

Experiment 1. Monocrop and intercrop populations of sweet potato, cassava, and corn were sown simultaneously on 25 April 1985. The variety of sweet potato grown was "TIS 146/3092", obtained from the National Root Crops Research Institute, Umudike, Nigeria. The corn and cassava varieties used were "FARZ 34" and "30211", respectively. The experimental design was a randomized complete block (RCB) with four replications in plots 4 m × 6 m with a 0.5 m space between plots and a 1 m space between replicates. Treatments (T) in experiment 1 were: T_1, monocropped corn (70 cm × 100 cm); T_2, monocropped sweet potato

(100 cm × 100 cm); T_3, monocropped cassava (100 cm × 100 cm); T_4, corn (70 cm × 100 cm) + cassava (100 cm × 100 cm); T_5, corn (70 cm × 100 cm) + cassava (100 cm × 100 cm); T_6, sweet potato (100 cm × 100 cm) + cassava (100 cm × 100 cm); and T_7, corn (70 cm × 100 cm) + cassava (100 cm × 100 cm) + sweet potato (100 cm × 100 cm). Cassava and sweet potato were planted at the top of the ridge, while corn was planted on one side of the ridge. Corn was sown at the rate of three kernels per hill. Two weeks after planting (WAP), the crop was thinned to two plants per hill, giving a population of about 30,000 plants/ha in both pure and mixed stands. Cassava and sweet potato were planted at the same time, using one stem cutting/stand in each case.

NPK (15:15:15) was applied to the monocrops at the following rates: corn only, 150 kg/ha at 4 WAP followed by 50 kg/ha at 10% flowering; sweet potato only, 400 kg/ha at 4 WAP; cassava only, 200 kg/ha at 4 WAP and another 200 kg/ha at 20 WAP. For the intercrops, the following rates were used: corn + sweet potato, 150 kg/ha at 4 WAP followed by 150 kg/ha at 10% corn flowering; corn + cassava, 150 kg/ha at WAP and repeated at 10% flowering; sweet potato + cassava, 400 kg/ha at 4 WAP; corn + cassava + sweet potato, 150 kg/ha at 4 WAP followed by 50 kg/ha at 10% corn flowering. No fertilizer was applied to any treatment at planting, in keeping with local farming practices. The crops were harvested after the following periods: corn, 16 WAP; sweet potato, 24 WAP; and cassava, 54 WAP. At each harvest, gross plot yields were taken. For both cassava and sweet potato, only tubers were harvested and weighed, whereas for corn, only grain-weight was considered at 15.5% moisture content.

Weed infestation in plots was estimated by means of a 100 cm × 100 cm quadrat at 24 WAP to enable the effective weed suppression ability of the sweet potato to be evaluated just before its harvest. Four random samples/plot were taken. To estimate weed infestation, a scale of 0 to 5 was used. On this scale, 0 (zero weeds in the quadrat) represented the minimum weed density, while 5 (entire ground space covered by weeds) represented the maximum weed density. This method had been used before by Ossom (1986) and Orluchukwu and Ossom (1988). Leaf area measurements were made on sweet potato at harvest. Thirty fresh leaves/plot were randomly obtained from harvested vines. The leaves were laid flat on paper and their outlines were traced. A transparent centimeter grid was superimposed on the traced outlines, and the area/leaf was measured to obtain the average leaf size. Francis, *et al.* (1969) had suggested using of 5-10 leaves in one replicate. The same method was used by Ramanujam and Indira (1978), who found it to be in agreement with planimeter readings. In this experiment, the average leaf size was the average of the thirty randomly picked leaves/plot. Linear measurements were used in determining petiole lengths.

Experiment 2. Based on the observations in experiment 1, experiment 2 was designed to investigate the performance and compatibility of sweet potato in a sweet potato-cassava association with a fixed cassava population density but with a varying sweet potato population density. The relationship between the two tuber crops was more closely monitored in the absence of the cereal crop. The crops were planted on April 7, 1987, after the start of the rainy season. Experiment 2 consisted of seven treatments in an RCB design replicated 4 times. Treatments were as follows: T_1, sweet potato only at 25 cm × 100 cm; T_2, sweet potato only at 50 cm × 100 cm; T_3, sweet potato only at 100 cm × 100 cm; T_4, sweet potato (25 cm × 100 cm) + cassava (100 cm × 100 cm); T_5, sweet potato (50 cm × 100 cm) +

TABLE 1. Influence of crop mixture on the yield of sweet potato, 1985-1986.

Crop Mixture	Number of Plants/ha			Single Crop Yield/Yr (mt/ha)			Total Yield/Yr (mt/ha)
	Sweet Potato	Cassava	Corn	Sweet Potato	Cassava	Corn	
Corn	0	0	30,000	0	0	2.46	2.46
Sweet Potato	10,000	0	0	5.66	0	0	5.66
Cassava	0	10,000	0	0	8.33	0	8.33
Corn + Sweet Potato	10,000	0	30,000	1.38	0	1.88	3.26
Corn + Cassava	0	10,000	30,000	0	4.48	1.96	6.44
Sweet Potato + Cassava	10,000	10,000	0	2.85	4.29	0	7.14
Corn + Cassava + Sweet Potato	10,000	10,000	30,000	1.41	4.06	1.63	7.10
L S D	—	—	—	0.51	0.34	0.51	2.91

Values are means of 4 replications.

TABLE 2. Effect of crop density on performance of sweet potato, 1987-1988.

Crop Combination	Population/ha		Petiole Length (cm)		Leaf Size (cm_2)		Weed Score (0-5)	Single Crop Yield (mt/ha)		Total Crop Yield/Year (mt/ha)
	Sweet Potato	Cassava	Sweet Potato	Cassava	Sweet Potato	Cassava		Sweet Potato	Cassava	
Sweet Potato	40,000	0	16.40	0.0	64.00	0.0	0.0	1.33	0.0	1.33
Sweet Potato	20,000	0	14.70	0.0	52.60	0.0	1.30	1.37	0.0	1.37
Sweet Potato	10,00	0	16.60	0.0	69.90	0.0	1.90	1.18	0.0	1.18
Sweet Potato + Cassava	40,000	10,000	13.13	16.56	55.00	n.a.	2.50	0.58	17.42	18.00
Sweet Potato + Cassava	20,000	10,000	15.05	18.88	67.70	n.a.	4.00	0.88	9.08	9.96
Sweet Potato + Cassava	10,000	10,000	14.80	14.52	63.50	n.a.	4.50	0.48	23.25	23.73
Cassava only	0	10,000	0.0	17.14	0.0	n.a.	4.80	0.0	20.42	20.42

Values are means of 4 replications.
n.a. = data not available.

TABLE 3. Influence of sweet potato density on weed suppression in mixed cropping.

Cropping System (with density)	Name of Weed	Sub-Class	Relative Abundance (%)	Weed Score (0-5)
Sweet Potato (40,000 plants/ha)	(No Weeds)	—	0	0
Sweet Potato (20,000 plants/ha)	*Talinum triangulare* Jacq.	Dicot	95)	1.3
	Corchorus olitorius L.	Dicot	5)	
Sweet Potato (10,000 plants/ha)	*Ipomoea involucrata* Beauv.	Dicot	60)	1.9
	Calopogoniun mucunoides Desv.	Dicot	40)	

Sweet Potato (40,000 plants/ha)	*Aspilia africana* (Pers.) C.D.	Dicot	5)	
	Ipomoea involucrata Beauv.	Dicot	75)	
			)	2.5
+ Cassava (10,000 plants/ha)	*Amaranthus spinosus* L.	Dicot	3)	
	Commelina nudiflora L.	Moncot	17)	
Sweet Potato (20,000 plants/ha)	*Ipomoea involucrata* Beauv.	Dicot	50)	
	Centrosema pubescence Benth	Dicot	20)	
			)	4.0
+ Cassava (10,000 plants/ha)	*Aspilia africana* (Pers.). C.D.	Dicot	15)	
	Triumfetta rhomboidea L.	Dicot	15)	
Sweet Potato (10,000 plants/ha)	*Commelina nudiflora* L.	Monocot	15)	
	Digitaria horizontalis Willd.	Monocot	30)	
			)	
+ Cassava (10,000 plants/ha)	*Ageratum conyzoides* L.	Dicot	25)	
	Talinum triangulare Jacq.	Dicot	18)	4.5
			)	
	Centrosema pubescence Benth.	Dicot	10)	
	Hibiscus meeusual Excell.	Dicot	2)	
Cassava (10,000 plants/ha)	*Aspilia africana* (Pers.) D.C.	Dicot	65)	
	Triumfetta rhomboidea L.	Dicot	15)	
	Amaranthus viridis L.	Dicot	5)	
	Ageratum conyzoides L.	Dicot	5)	
			)	4.8
	Digitaria horizontalis Willd.	Monocot	5)	
	Commelina nudiflora L.	Moncot	3)	
	Panicum maximum L.	Monocot	2)	

Values are means of 4 replications.

cassava (100 cm × 100 cm); T_6, sweet potato (100 cm × 100 cm) + cassava (100 cm × 100 cm); and T_7, cassava only at 100 cm × 100 cm. Fertilizer rates consisted of 400 kg/ha of NPK (15:15:15) applied at 4 WAP to sweet potato, while monocropped cassava received 200 ka/ha at 4 WAP and at 20 WAP (Ethirveerasingam, *et al.*, 1985). All intercropping mixtures received 400 kg/ha of NPK at 4 WAP. Weed infestation, leaf size, and petiole measurements were made as described in Experiment 1.

RESULTS: EXPERIMENT 1, 1985-86

Fresh weight yield. Results of this experiment suggested that sweet potato was more compatible (than corn) with cassava in intercropping. While sweet potato alone yielded 5.66 mt/ha in mixture, it yielded 1.38 mt/ha, when grown in association with corn, 2.85 mt/ha, when grown with cassava, and 1.41 mt/ha, when intercropped with both cassava and corn (Table 1). Highest total tuber yield per land area among the mixed crops was obtained, when sweet potato was grown together with cassava. The lowest yield (kernel + tuber) per land area was obtained, when corn was intercropped with sweet potato. Cassava tuber yields were depressed, when intercropped with sweet potato alone and were further reduced, when all three crops (corn, sweet potato, and cassava) were grown together. These results were in agreement with earlier results obtained in sweet potato intercropping studies with cassava and other crops (Soria, 1976; CATIE, 1978). Reduction in cassava tuber yield, when all crops were sown together, was also in agreement with findings of Ossom (1976), who observed that the larger the number of crops in a mixed cropping system, the greater the competition among component crops.

Leaf size. The area/leaf of monocropped sweet potato was the highest (63.15 cm^2). Among mixed crops, sweet potato grown in association with corn had the highest area/leaf (59.45 cm^2), while that grown with cassava was the lowest (58.36 cm^2). However, these differences were not statistically significant. There was a positive linear correlation ($r = 0.88$) between area/leaf and tuber yield, which was significant at $P = 0.05$.

Petiole length. The petiole length of sweet potato was greatest (20.10 cm), when the crop was planted with cassava. Petiole length was shortest (16.90 cm), when grown in association with both corn and cassava. There was a positive, nonsignificant correlation ($r = 0.63$) between petiole length and tuber yield. Petiole length plays an important role in leaf display for efficient photosynthesis, and it is likely that any factors which cause stress may also adversely influence petiole length as well as leaf area. The interspecies competition among crops in this experiment was apparently responsible for decreased petiole length in sweet potato.

RESULTS: EXPERIMENT 2, 1987-88

Fresh weight yield. Table 2 shows the effect of crop density on the performance of sweet potato. Total tuber yield per land area was greatest, when sweet potato was intercropped with cassava at a population of 10,000 plants/ha for each crop in the mixture. There was a reduction in cassava yield, when intercropped with sweet potato, as was also observed in Experiment 1. These results agreed with those of CATIE (1978), which observed that a reduction in cassava yields resulted from competition with sweet potato. The yield of sweet potato in

TABLE 4. Monthly rainfall (mm) in the years when the sweet potato was grown.

Period		Rainfall	Period		Rainfall	Period		Rainfall	Period		Rainfall
Jan.	1985	17.2	Jan.	1986	50.7	Jan.	1987	8.4	Jan.	1988	16.1
Feb.	1985	6.0	Feb.	1986	71.5	Feb.	1987	85.4	Feb.	1988	52.3
March	1985	82.9	March	1986	71.5	March	1987	192.9	March	1988	118.5
April	1985	256.3	April	1986	224.0	April	1987	72.5	April	1988	186.0
May	1985	390.8	May	1986	240.3	May	1987	234.5	May	1988	232.7
June	1985	282.0	June	1986	171.0	June	1987	269.4	June	1988	203.5
July	1985	265.1	July	1986	371.5	July	1987	477.3	July	1988	258.8
August	1985	348.0	August	1986	257.9	August	1987	427.5	August	1988	319.8
Sept.	1985	278.9	Sept.	1986	286.1	Sept.	1987	189.6	Sept.	1988	397.9
Oct.	1985	153.7	Oct.	1986	184.0	Oct.	1987	189.6	Oct.	1988	258.9
Nov.	1985	61.8	Nov.	1986	161.2	Nov.	1987	50.2	Nov.	1988	106.8
Dec.	1985	0.0	Dec.	1986	0.0	Dec.	1987	4.2	Dec.	1988	30.2
Totals		2232.7			2199.4			2201.5			2181.5

mixture was lower than in monocrop, but there was an increase in total crop yield obtained per unit of land under intercropping. This result agreed with the criteria of Willey (1979) for assessing yield advantages in intercropping. There was a highly significant ($P = 0.01$) correlation ($r = 0.99$) between number of sweet potato tubers/plot and tuber yield/plot. These results indicate the need for a reasonably high total population, a conclusion which had also been reached by other workers (IRRI, 1974; Kassam, 1973).

Leaf size. As shown in Table 2, area/leaf of monocropped sweet potato at 10,000 plants/ha was greatest, while that at 20,000 plants/ha was lowest. Intercropping resulted in reduced area/leaf of the crop, as had been observed by Ossom (1976). The degree of reduction appeared to be proportional to the total number of plants/plot. No relationship was found between area/leaf and tuber yield ($r = 0.01$). For a tuber crop, there should be a correlation between leaf area and tuber yield, if pests and diseases do not reduce leaf size and photosynthetic efficiency. It is unlikely that the attack on sweet potato leaves by sweet potato weevil (*Cylas puncticollis*) and sweet potato butterfly (*Acraea acerata*) during this experiment interfered with the leaf area development of the plant.

Petiole length. When planted as a monocrop at 40,000 plants/ha, sweet potato had an average petiole length of 16.40 cm, whereas when intercropped (40,000 plants/ha of sweet potato and 10,000 plants/ha of cassava), petiole length was reduced to 13.13 cm. The correlation between petiole length and tuber yield was low ($r = 0.21$) and not significant, indicating that petiole length may not contribute much to tuber yield. Cassava had the lowest petiole length, when intercropped with sweet potato (10,000 plants/ha for each crop species), whereas monocropped cassava had a petiole length of 17.14 cm (Table 2). As in Experiment 1, intercropping resulted in reduced petiole length of sweet potato, but this reduction was more noticeable, when the crop was interplanted at 10,000 and 40,000 plants/ha through cassava at 10,000 plants/ha. This seems to indicate that interspecies competition may have a greater influence than intraspecies competition in reduction of petiole length.

Weed infestation. The influence of plant density on weed suppression is shown in Table 3. Broadleaf weeds infested all plots more than grassy weeds. Sweet potato at 40,000 plants/ha suppressed weeds most effectively, while monocropped cassava had the lowest weed suppression. Among mixed crops, sweet potato at 40,000 plants/ha + cassava at 10,000 plants/ha gave the best weed suppression. Light is one of the factors affecting weed-crop balance. Results from this study confirm earlier findings (Shetty, *et al.*, 1982) that the differential shading ability of a crop canopy was one of the factors which determined crop-weed competition balance and thus contributed to the differential crop productivity observed in intercropping systems. Leihner (1983) observed that one of the advantages of intercropping is better soil coverage obtained from the beginning with the association. Such a coverage diminishes light penetration to the soil and reduces weed growth. Peasant farmers do not usually keep their farms completely weed-free as at experimental stations. Rather, they intercrop as a form of weed control and remove those weeds they know to be aggressive. A judicious choice of crop combination and plant population density can help the small farmer in cultural weed control.

CONCLUSIONS

Sweet potato is compatible with cassava in intercropping. Increased total yield and effective weed control are the two major advantages derived from the use of sweet potato in intercropping at a suitable crop density. The lower yields of sweet potato in Experiment 2 may have resulted from reduced rainfall and its poor distribution, particularly during the growing period of April to October (Table 4). The sweet potato appeared to be at a disadvantage, while cassava seemed to have benefitted from intercropping. Also, the amount of rainfall during the three months prior to planting favored a better soil moisture condition for sweet potato in Experiment 1 than in Experiment 2 (Purseglove, 1977). Sweet potato is not adapted to this locality (cassava is), but research efforts are continuing in the identification of cultivars and varieties which are promising in their performance. The results of this work indicate that the density at which sweet potato quickly covers the soil would make an important contribution to tuber yield and cultural weed control for the peasant farmer, who often lacks capital to purchase agricultural chemicals.

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