PRODUCTIVITY OF COCOYAM/ COWPEA INTERCROP AS INFLUENCED BY COWPEA GROWTH HABIT

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ABSTRACT
Cocoyam was grown with vegetable cowpea in sole cropping and in intercropping to examine the effects of four contrasting vegetable cowpea growth habits on the productivity of the component crops in Umudike, southeastern Nigeria. The experiment was laid out in a randomized complete block design with three replications. Treatments comprised all combinations of cocoyam and four cowpea cultivars (spreading Akidi ani, climbing Akidi enu, semi erect IT81D-128-14 and erect IT86F-2014-1) and sole crops of each crop. On average, intercropping reduced cocoyam corm yield by 22% in spreading Akidi ani, 25% in semi erect IT81D-128-14 and 41% in erect IT86F-2014-1. Similarly, intercropping reduced cowpea pod yield by 21% in erect IT86F-2014-1, 22% in climbing Akidi enu and 27% in semi erect IT81D-128-14. The climbing Akidi enu had the least adverse effect on corm yield and gave high pod yield, with a high combined average land equivalent ratio (LER) of 1.8.

KEY WORDS: Cocoyam, vegetable cowpea, growth habit, productivity

INTRODUCTION
Cocoyams (*Colocasia esculenta* (L.) Schott and *Xanthosoma sagittifolium* Schott) are important crops in West and Central Africa, ranking third after cassava and yam in Nigeria (NRCRI, 2008). In Cameroon, cocoyams rank second after cassava while in Ghana, the crop ranks first (Karikari, 1971). In the rainforest agro-ecosystem of eastern Nigeria where tuber crops are major crops, intercropping is the dominant cropping practice (Unamma *et al.,* 1985). With intercropping, soil erosion may be reduced as the ground is more thoroughly covered (Burgos, 1980). The reduction in soil erosion would minimize nutrient loss and hence prevent rapid decline of soil fertility, particularly if a legume is used in intercropping. Where tuber crops are grown in wide rows with a companion crop of short duration, intercropping may be more productive than sole cropping (Udealor and Asiegbu, 2005; Njoku and Muoneke, 2008). In this case, the associated crop can mature before severe competition occurs between the two species, such that the effect of the main crop on growth and yield of the associated crop is generally small (Tsay *et al.,* 1988)

Cowpeas are short duration crops, whose inclusion as intercrop or in rotation has been found to improve both physical and chemical properties of the soil (Carsky *et al.,* 2001). Consequently, cowpeas are used as under storey crops in systems based on cereals or tuber crops for pods or grains and for sustainable maintenance of soil nutrients through incorporation into the soil as green manure or as litter fall (Karl and Kotschi, 1997). However, cowpea types suitable for intercropping may depend on growth habit, so that competition is minimized and complementary effects optimized (Willey, 1979). Vegetable cowpea shows better adaptation and performance than cowpea grown for grain in southeastern Nigeria (Uguru, 1996; Okpara, 2000), where the soils are highly weathered and heavy rainfall causes leaching of basic cations and nitrates (Asiegbu, 1989). An adequate level of soil organic matter in the top soil is vital for the sustainability of the cropping systems where no fallow or only a short fallow period is practiced. Recycling of legume crop residues could, therefore, improve the soil organic matter and nitrogen content besides providing pod or grain for the farmer. The present study examined the effects of cowpea with contrasting growth habits on cocoyam/ cowpea intercropping.

MATERIALS AND METHODS

The field experiment was conducted in 2004 and repeated in 2005 cropping season at the Michael Okpara University of Agriculture Research Farm at Umudike, Southeastern Nigeria. The site characterized by a sandy loam tropical ultisol soil is situated on latitude 05^0 29^1N, longitude 7^o 33^1E and altitude 122m above sea level. At the start of the experiment the land was cleared on 12 April, disc ploughed on 15 April, harrowed once on 17 April and ridged 1m apart on 20 April, 2004. In 2005, the land was slashed on 25 April, ploughed on 29 April, harrowed in on 2 May and ridged on 4 May. The experiment was laid out in randomized complete block design with three replications. There were 9 treatments comprising crop combinations of cocoyam and four contrasting cowpea cultivars (spreading *Akidi ani,* climbing *Akidi enu,* semi erect IT81D-128-14 and erect IT86F-2014-1) and sole crops of each component cocoyam and cowpea cultivars.

The cocoyam used was *Colocasia esculenta*, cultivar cocoindia obtained from the National Root Crops Research Institute, Umudike, Southeastern Nigeria. The cowpea cultivars IT81D-128-14 and IT86F-2014-1 were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The plots measured 4m x 3m ($12m^2$) each. The sole crops of the cocoyam and cowpeas were included as treatments to ensure computation of land equivalent ratio (LER).

Soil sampling was done before planting and at harvest of the cocoyam. The first composite soil samples were obtained before planting to a depth of 20cm from 6 representative locations in the field. The second composite soil samples, from 3 locations per plot, were obtained after harvest of the cocoyam and used for study of treatment effects (contrasting vegetable cultivars) on pH, organic matter, %N, P. and K. Cocoyam cormels weighing 26-45g and dual purpose cowpea seeds were planted on 23 April, 2004 and 7 May, 2005. Planting of both crops were done the same day. The cocoyam cormels were planted at one per hole on the crest of the ridges while the dual purpose cowpea was sown at two seeds per hole and later thinned to one seedling per stand at 2 weeks after planting (WAP). Cocoyam was planted at a spacing of 1m x 1m giving a density of 10,000 plants/ha while cowpea was seeded at a spacing of 1m x 0.25m resulting in a density of 40,000 plants/ha. The plots were weeded manually three times at a regular interval of 3 WAP. Compound fertilizer (NPK Mg 12:12:17:2) was applied at the rate of 400 kg/ha to the cocoyam by banding 7 WAP. The cowpea was protected against insect pests by spraying twice with cypermethrin at 200ml in 15L water at 3 weeks interval after planting.

Measurements were taken on shoot dry weight (g/plant) at 7 WAP for cowpea and 14 WAP for cocoyam in 2004 only. Four cowpea and two cocoyam plants from the border rows of each plots were sampled for dry matter while cowpea plant was harvested for pods from 8 WAP to 14 WAP. Cocoyam was harvested for corm yield and yield components at 27 WAP. Observations were taken on number of pods per plant, pod weight (g/plant), pod yield (t/ha), number of seeds per pod, 100-seed weight (g), seed yield, number of corms/plant, fresh corm weight (kg/plant), and corm yield (t/ha) in both years. Soil pH was measured in 1:2.5 soil: water ratio. Organic carbon was determined by Nelson and Sommers (1982) method. The organic carbon was converted to organic matter (O.M) by multiplying by 1.724. Total soil N was analysed by the Kjeldahl method (Pearson 1976). Total P content was determined by the Bray 1 method and K by flame photometry (Black 1965). The data were statistically analysed using the procedures of Steele and Torrie (1980) for randomized complete block design (RCBD). Land equivalent ratio (LER) and competition coefficient (C) were calculated using the formulae of Fisher (1977) and Okigbo (1979) respectively.

RESULTS

The soils of the experimental site were sandy loam and acidic, with organic matter, nitrogen, phosphorus and potassium contents being higher in the soil used for 2004 experiment (Table 1).

Table 1: Initial soil properties of the experimental site and monthly rainfall for the experimental periods, 2004 and 2005

	2004	2005
Physical characteristics		
Sand (%)	69.8	78.1
Clay (%)	10.8	13.9
Silt (%)	19.4	8.0
Texture class	Sandy loam	Sandy loam
Chemical characteristics		
0.M (%)	2.66	0.913
N (%)	0.15	0.056
P (mg/kg)	74.0	15.46
K (Cmol/kg)	1.3	0.481
pH (H_20)	5.45	5.48
Monthly rainfall (mm)		
April	134.5	141.3
May	217.6	222.4
June	279.4	264.4
July	309.5	277.0
August	304.3	225.0
September	324.9	339.7
October	249.1	323.0
Total for the period	1819.3	1792.8

Rainfalls for the experimental period of April to October were 1819.3 mm in 2004 and 1792.8 mm in 2005.

Post harvest soil properties showed significantly higher organic matter content where cocoyam was intercropped with erect IT86F-2014-1 than where cocoyam was combined with spreading *Akidi ani*, which also gave higher organic matter value than other treatments (Table 2).

Table 2: Effect of contrasting vegetable cowpea growth habits on post harvest soil chemical properties in 2004

.	**OM (%)**	**N (%)**	**P (mg/kg)**	**K (Cmol/kg**	**pH (H_20)**
Sole cocoyam	2.1	0.13	70	0.19	5.3
Cocoyam + Spreading *Akidi ani*	2.3	0.13	71	0.16	5.1
Cocoyam + Climbing *Akidi enu*	2.1	0.12	53	0.19	5.3
Cocoyam + Semi erect IT81D-128-14	2.1	0.10	114	0.17	5.3
Cocoyam + erect IT86F-2014-1	2.8	0.17	82	0.17	5.1
LSD(0.05)	0.1	0.02	33.7	0.02	0.08

The nitrogen content of the soil where cocoyam was intercropped with erect IT86F-2014-1 was also higher while potassium content was higher where cocoyam was sole or combined with the climbing *Akidi enu* compared to other treatments. Soil pH was higher where cocoyam was combined with semi erect IT81D-128-14 or climbing *Akidi enu* or sole cocoyam than with erect IT86-2014-1.

Shoot dry matter of cocoyam at 14 WAP among the treatments did not differ but corm yield varied significantly between the monocrop and intercrops, except where cocoyam was intercropped with climbing *Akidi enu* in 2004 (Table 3).

Table 3: Shoot dry weight (14 WAP), corm yield and yield components of cocoyam in sole crop and intercropping with contrasting cowpea cultivars

Crop Combination	Shoot dry weight (g/plant)	Number of corm/plant		Corm weight (kg)		Corm yield (t/ha)		
	2004	2004	2005	2004	2005	2004	2005	Mean
Sole Cocoyam	38.1	25.0	8.2	0.062	0.073	16.2	6.0	11.1
Cocoyam + Spreading *Akidi ani*	47.5	19.8	5.8	0.069	0.063	13.7	3.7	8.7
Cocoyam + Climbing *Akidi enu*	53.1	24.0	6.7	0.064	0.067	16.3	4.4	10.4
Cocoyam + Semi erect IT81D-128-14	32.8	20.4	7.4	0.058	0.060	12.2	4.3	8.3
Cocoyam + Erect IT86F-2014-1	40.2	16.0	5.7	0.060	0.057	9.8	3.2	6.5
LSD (0.05)	NS	6.5	NS	NS	NS	4.1	1.4	1.8

Under intercropping, cocoyam produced significantly more corms per plant and higher corm yield with climbing *Akidi enu* than the rest of the intercrop treatments. Corm yield reductions due to intercropping were on average 6, 22, 25 and 41% for climbing *Akidi enu,* spreading *Akidi ani*, semi erect IT81D-128-14 and erect IT86F-2014-1, respectively.

Under sole cropping, the spreading Akidi ani gave significantly higher shoot dry matter than the erect IT86F-2014-1. However, under intercropping, the erect IT86F-2014-1 produced significantly higher dry matter than semi erect IT81D-128-14 but not other cultivars. Except for semi erect IT81D-128-14, all cultivars gave higher drymatter under intercropping, although statistically significant difference existed only with the erect IT86F-2014-1 intercrop compared with monocrop.

Under sole cropping, fresh pod yield was significantly higher with semi erect IT81D-128-14 than with other cultivars. Similarly, under intercropping, the semi erect IT81D-128-14 gave higher pod yield than the spreading Akidi ani but not other cultivars. Except for the spreading Akidi ani, intercropping depressed pod yield by 22, 27 and 21% in climbing Akidi enu, semi erect IT81D-128-14 and erect IT86F-2014-1, respectively. On the other hand, seed yields obtained in both cropping systems in climbing Akidi enu, semi erect IT81D-128-14 and erect IT86F-2014-1 were statistically similar but significantly higher than that in spreading Akidi ani, especially under sole cropping. Year differences were significant for cocoyam corm yield but not for cowpea pod yield (Table 5).

Crop growth and yield data of cowpea are shown in (Table 4).

Table 4: Growth (7 WAP), yield and yield components of cowpea cultivars in sole crop and intercropping with cocoyam

	Shoot dry weight (g/plant)	Number of Pods/plant		Pod weight (g)		Fresh pod yield (t/ha)			Number of seeds/pod		100-seed weight (g)		Seed yield (t/ha)		
	2004	2004	2005	2004	2005	2004	2005	Mean	2004	2005	2004	2005	2004	2005	Mean
Sole Spreading *Akidi ani*	49.5	16.6	16.2	2.6	2.9	1.8	1.9	1.9	11.9	14.2	6.3	6.9	0.5	0.7	0.6
Sole Climbing *Akidi enu*	37.2	23.9	34.8	3.0	3.5	2.9	4.9	4.0	9.4	15.7	9.1	8.3	0.8	1.8	1.3
Sole Semi erect IT86F-2014-1	38.9	25.7	32.7	4.8	5.3	4.9	7.0	6.0	9.6	12.8	7.7	8.9	0.8	1.5	1.2
Sole erect IT86F-2014-1	24.2	37.1	26.6	2.5	4.2	3.8	4.5	4.2	8.8	10.7	10.4	10.2	1.4	1.2	1.3
Cocoyam + *Akidi ani* (Spreading)	53.2	20.3	17.4	3.1	2.1	2.5	1.4	1.9	13.8	15.5	5.1	7.3	0.7	0.8	0.8
Cocoyam + *Akidi enu* (Climbing)	45.6	25.4	25.5	2.8	3.2	2.9	3.2	3.1	12.4	16.2	6.7	7.9	0.8	1.4	1.1
Cocoyam + IT81D-128-14 (Semi erect)	38.3	19.6	30.4	4.1	4.6	3.3	5.6	4.4	8.5	12.0	8.6	9.3	0.6	1.4	1.0
Cocoyam + IT86F-2014-1 (erect)	62.4	21.4	25.8	3.4	3.6	2.9	3.7	3.3	9.9	11.9	9.3	12.2	0.8	1.5	1.2
LSD (0.05)	18.4	12.0	7.7	NS	1.0	NS	1.9	1.2	4.1	4.4	2.2	1.8	0.4	0.7	0.4

Table 5: Effect of year on corm and fresh pod yields of cocoyam and cowpea

Year	Number of corms per plant	Corm yield (t/ha)	Number of pods per plant	Fresh Pod yield (t/ha)
2004	21.0	13.7	23.8	3.1
2005	6.7	4.3	26.2	4.0
LSD (0.05)	3.6	3.2	NS	NS

However, while corm yield was higher in 2004 in which the soil was of higher fertility, pod yield was slightly higher in 2005. Land equivalent ratios were 1.52 to 2.48 in 2004 and 1.37 to 1.60 in 2005 (Table 6).

Table 6: Land equivalent ratio and competition coefficient of cocoyam and cowpea in mixture

	Cocoyam		Vegetable Cowpea		Total LER		Competition coefficient			
							Cocoyam		Vegetable Cowpea	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Cocoyam + Spreading *Akidi ani*	0.93	0.62	1.55	0.84	2.48	1.46	0.38	0.45	0.62	0.55
Cocoyam + Climbing *Akidi enu*	1.01	0.71	1.24	0.66	2.25	1.37	0.51	0.51	0.49	0.49
Cocoyam + Semi erect IT81D-128-14	0.84	0.72	0.68	0.88	1.52	1.60	0.55	0.46	0.45	0.54
Cocoyam + Erect IT86F - 2014-1	0.60	0.54	1.09	0.84	1.69	1.37	0.44	0.39	0.56	0.61

The competition coefficient was above 0.5 and in favour of cocoyam in climbing *Akidi enu*. However, the competition coefficient was in favour of cowpea in spreading *Akidi ani,* erect IT86F-2014-1 and semi-erect IT81D-128-14 in that order.

DISCUSSION

Corm yields obtained from cocoyam intercropped with climbing *Akidi enu* were high compared to the yields obtained from cocoyam combined with other cowpea types, due probably to the greater shade provided by the climbing cowpea. According to Knispscheer and Wilson (1987), cocoyam is shade tolerant and associated crop has a moderation effect, with cocoyam producing a reasonable yield when grown under shade. Yield depression in cocoyam due to intercropping was, therefore, slight at 6% in climbing *Akidi enu* and high at 22% in spreading *Akidi ani*, 25% in semi erect IT81D-128-14 and 41% in erect IT86F-2014-1, on average. The highest corm yield reduction obtained when cocoyam was intercropped with erect IT86F-2014-1 could be attributed to the similar growth habit of the component crops, which encouraged stiffer competition. Irrespective of growth habit, intercropping induced greater vegetable cowpea growth, essentially due to competition. The highest increase in growth in the intercrop occurred in the erect IT86F-2014-1, apparently in an effort to reduce shading by the candidate cocoyam. The semi erect IT81D-128-14 gave high pod yields in both cropping systems, followed by erect IT86F-2014-1 or climbing *Akidi enu* and spreading *Akidi ani* in that order. This confirms the results of Cenpukdee and Fukai (1992) that cultivar performance in sole cropping is important in determining yield in intercropping. However, intercropping reduced pod yield in the vegetable cowpea cultivars by 22% for climbing *Akidi enu,* 27% for semi erect IT81D-128-14 and 21% for erect IT86F-2014-1 on average. The reductions in vegetable cowpea pod yields of intercrops relative to sole stands in this study was due mainly to shading or reduction in light intensity that was imposed on the cowpea by cocoyam, which reduces the rate of photosynthesis (Mpairwe *et al.,* 2002). Yield reductions arising from competition for growth resources have been reported (Ndukwe and Muoneke, 2008; Muoneke and Asiegbu, 1997; Okpara, 2000). While the yield of cocoyam was higher by 216% in 2004, pod yield of vegetable cowpea was slightly higher in 2005. The poor yields obtained from cocoyam in 2005 were due probably to the lower fertility of the soil used for the 2005 experiment. Nitrogen and potassium were higher in the soil of 2004 than 2005 by 168% and 170% respectively. Nitrogen is usually credited with the building up of leaf tissues while potassium is essential for increased photosynthetic activity (Tsuno, and Fujise, 1964). However, despite the low soil nitrogen content in 2005, the associated vegetable cowpea performed well that year, owing to nitrogen fixation by the legume.

The general trend in most intercropping experiments is that yields of a given crop in the mixture are less than the yields of the same crop grown alone, but the total productivity per unit of land is usually greater for mixtures than for sole crops (Willey, 1979; Natarajan and Willey, 1980; Mpairwe *et al.,* 2002; Okpara *et al.,* 2004). The LERs for all treatments were above unity, indicating a clear advantage of intercropping over sole cropping. While the LER productivity estimate in mixture involving cocoyam with spreading *Akidi ani* was high at 1.97 on average, pod yield of the vegetable cowpea cultivar was very poor. The important implication for subsistence farmers is that intercropping fields with legumes and non-legumes can produce the elements of a nutritionally balanced diet (May, 1982). The base crop cocoyam was more productive in the climbing *Akidi enu,* and the system gave a high combined LER of 1.8, on average.

CONCLUSION

Overall, the results of this study indicate that cocoyam and vegetable cowpea could be successfully intercropped. For optimum performance of the base crop and high productivity of the system, cocoyam should be intercropped with the climbing *Akidi enu.* On average, corm yield obtained when cocoyam was intercropped with climbing *Akidi enu* was significantly higher than the yield obtained when cocoyam was intercropped with other cowpea types.

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