Performance of Cassava Intercropped with Maize, Soybean and Cowpea in the Forest Zone of Ghana

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Résumé
Dapaah, H. K., Ennin, S. A. & Asafu-Agyei, J. N. *La Performance du Manioc Intercultive avec le Maïs, le Soja et le Niebe dans la Zone Forestiere du Ghana.* Des essais ont été entamés dans la zone forestière du Ghana de 1997 à 1999 avec l'objectif de déterminer la performance de deux variétés du manioc intercultivé avec le maïs, le soja et le niébé aux différents arrangements spatiaux. Les variétés du manioc étaient "Gblemoduade" et "Ankra" et les arrangements spatiaux étaient (S1) un rayon de manioc, un rayon de maïs, un rayon de soja, deux rayons de niébé. (S2) un rayon de manioc, un rayon de maïs, deux rayons de soja, trois rayons de niébé et (S3) un rayon de manioc, un rayon de maïs, trois rayons de soja et quatre rayons de niébé. Les rayons de niébé étaient cultivés pendant la saison mineure parmi le manioc comme une culture succédante au maïs et au soja après leur récolte pendant la saison principale. Par rapport aux cultures uniques, l'intercultivation a réduit le rendement racinaire par 22-37% au niveau de "Gblemoduade" et 43-51% au niveau d' "Ankra". En moyenne "Gblemoduade" a produit deux fois et demie plus qu' "Ankra" sous l'intercultivation (24,8 vs 9,1 t ha^{-1} et sous la monoculture (36,9vs 17,4 t ha^{-1}). Ceci est dû au nombre supérieur de racines, ainsi que la présence de racines qui sont plus grandes et plus lourdes que celles d' "Ankra." Le rendement du manioc a diminué au fur et à mesure que le nombre de rayons du soja, du niébé augmentent. Les rendements racinaires étaient similaires dans les cas de S2 et S3 (22,3 et 23,2 t ha^{-1} pour "Gblemoduade" et 8,1 et 8,9 t ha^{-1} pour "Ankra" respectivement) mais moins que les rendements à S1 (28,8 t ha^{-1} et 9,9 t ha^{-1} pour "Gblemoduade" et "Ankra" respectivement). "Gblemoduade" était plus agressif (un concurrent vigoureux) qu' "Ankra" dans le système pendant que les deux variétés du manioc augmentent en agressivité avec une diminution dans le nombre de rayons du soja et niébé dans le mélange (c a d S1=S2>S3). Parmi les cultures, le maïs était plus compétitif au manioc qu'au soja et niébé. Donc on peut améliorer la performance du manioc en cultivant un rayon chacun de manioc, de maïs et de soja suivis de deux rayons de niébé (après la récolte du maïs et du soja) et en cultivant la variété améliorée c a d "Gblemoduade".

Mots clés : Intercultivation, le manioc, le maïs, le soja, le niébé.

Abstract
Experiments were conducted in the forest zone of Ghana from 1997 to 1999 to assess the performance of two cassava varieties intercropped with maize, soybean and cowpea at different spatial arrangements. The cassava varieties were "Gblemoduade" and "Ankra" and spatial arrangements were (S1) one row cassava, one row maize, one row soybean, two

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rows cowpea; (S2) one row cassava, one row maize, two rows soybean, three rows cowpea; and (S3) one row cassava, one row maize, three rows soybean, four rows cowpea. Cowpea rows were planted in the minor season into cassava as a succeeding crop to maize and soybean after their harvest in the major season. Intercropping reduced root yield by 22-37% in "Gblemoduade" and 43-51% in "Ankra" compared to sole crops. "Gblemoduade", on the average, yielded two and half times greater than "Ankra" under intercrop (24.8 vs 9.1 t ha^{-1}) and monocrop (36.9 vs 17.4 t ha^{-1}) as a result of larger number of roots, heavier and bigger roots than "Ankra". Cassava yield decreased as the number of rows of soybean or cowpea increased. Root yields were similar for S2 and S3 (22.3 and 23.2 t ha^{-1} for "Gblemoduade" and 8.6 and 8.9 t ha^{-1} for "Ankra", respectively), but were smaller than yields at S1 (28.8 t ha^{-1} and 9.9 t ha^{-1} for "Gblemoduade" and "Ankra", respectively). "Gblemoduade" was more aggressive (a strong competitor) than "Ankra" in the system while, both cassava varieties increased in aggressivity with decreased number of soybean or cowpea rows in the mixture (i.e. S1=S2 > S3). Among the crops, maize was more competitive to cassava than soybean and cowpea. Thus, the performance of cassava can be improved by planting 1 row each of cassava, maize and soybean followed by 2 rows of cowpea (after maize and soybean harvest) and by growing the improved variety "Gblemoduade".

Keywords: Intercropping, cassava, maize, soybean, cowpea.

Introduction

Cassava is a highly suitable crop for the sub-humid (forest) zone of West Africa. It is no doubt the most important staple food in the forest zone of Ghana. It is mostly intercropped with maize, plantain or cocoyam, with the cassava-maize intercrop the most prominent crop association in the forest zone (Asafu-Agyei *et al.,* 1998). In recent times, however, farmers have attempted to include soybean or cowpea to the cassava-maize association, not only to improve nutrition of their diets but also to improve soil fertility, control erosion and as additional cash crops. When two or more crops are intercropped such that most or part of their life cycles coincide, the factors determining the competition, yield of component crops and the overall productivity of the system include the choice of variety, density of component crop, row spacing and arrangement, relative times of sowing and applied nutrients (Ofori and Stern, 1987; Asafu-Agyei *et al.,* 1998). Farmers in the forest zone sow intercrop component crops randomly without any defined row arrangements. This has resulted in smaller populations of component crop and also made management difficult. Farmers also use low yielding varieties, especially cassava. As the most preferred staple, it is important to assess the performance of cassava and its competitive ability in such associations to better exploit the components of the mixture so as not to cause greater reduction in cassava yield. This study was aimed at determining the response of two cassava varieties when intercropped with maize, soybean and

cowpea at different spatial arrangements.

Materials and methods

The experiment was conducted at the Crops Research Institute research stations at Fumesua (6° 43'N, 1° 36'W) and Kwadaso (6° 43'N, 1° 37'W) in the forest zone of Ghana during the 1997/98 and 1998/99 cropping seasons. The soils at Fumesua belong to the Asuansi series (classified as Ferric Acrisol according to FAO/UNESCO classes; FAO/UNESCO (1988)), with about 5 cm thick top layer of dark grey gritty loam to gritty clay loam and a slope of 2-6 %. The Kwadaso soils belong to the Kumasi series (but also classified as Ferric Acrisol according to FAO/UNESCO classes, FAO/UNESCO (1988)) with about 16-20 cm thick top layer of sandy loam and a slope of 1-5 %. The rainfall pattern is bimodal, and total rainfall averaged 1145 mm at Fumesua and 1299 mm at Kwadaso per year during the study periods.

The land was cleared with a tractor-mounted slasher and Roundup (a.i. glyphosate 360 g l^{-1}) was applied at a rate of 900 g a.i ha^{-1} to the regrowth two weeks later.

A randomized complete block, 2 x 3 factorial design consisting of two cassava varieties ("Gblemoduade") and ("Ankra") and three spatial arrangements was used (Fig. 1). There were three replications. The spatial arrangements were: (S1) one row cassava, one row maize, one row soybean, two rows cowpea, (S2) one row cassava, one row maize, two rows soybean, three rows cowpea and (S3) one row cassava, one row maize, three rows soybean, four rows cowpea. In S1, each row of cassava alternated with one row of maize and one row of soybean. After harvesting the maize and soybean, they were replaced by two rows of cowpea. In S2, the cassava alternated with one row of maize and two rows of soybean, replaced after harvest by three rows of cowpea. In S3, one row of maize and three rows of soybean were replaced by four rows of cowpea. "Gblemoduade" is an improved variety, highly branching with lower placed branches and matures in 12 months, while "Ankra" is a local variety, less branching with higher placed branches which also matures in 12 months. Sole crops of the component crops were also planted as controls. Row length for all plots was 8m. The width of the plots in the intercrops were 4m for S1, 5.5m for S2 and 7m for S3. The spacing between the rows for all intercropped crops and spatial arrangements was 50cm. The spacing within row and number of plants per hill were 50cm, 2 plants per hill for maize; 1m, 1 plant per hill for cassava; and 20cm, 2 plants per hill for soybean and cowpea. The spacing for the sole crops were: 1m x 1m, 1 plant per hill for cassava; 80cm x 40cm, 2 plants per hill for maize; and 50cm x 20cm, 2 plants per hill for soybean and cowpea. There were six rows per plot for each sole crop.

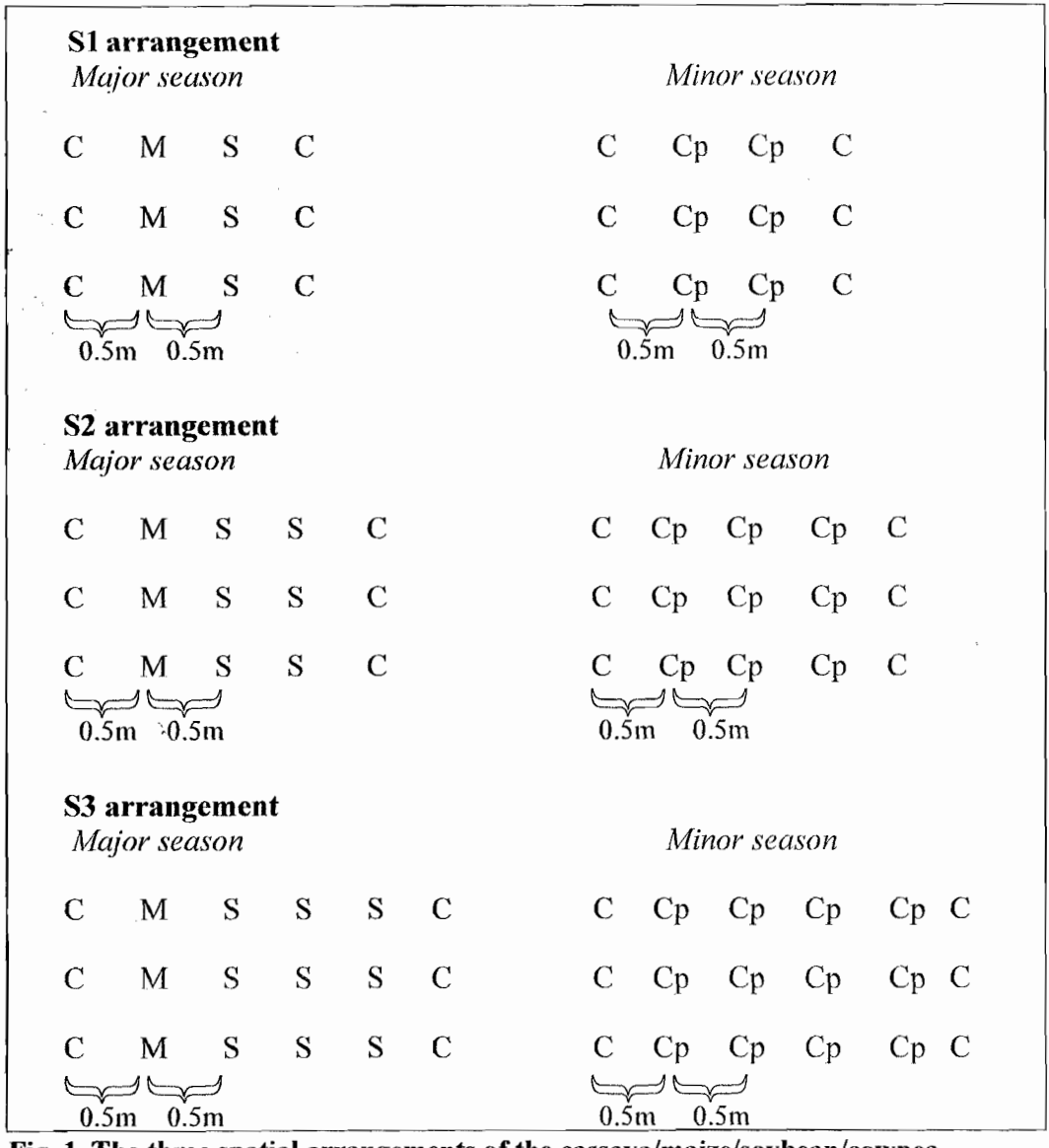

Fig. 1. The three spatial arrangements of the cassava/maize/soybean/cowpea intercropping systems (C = cassava, M = maize, S = soybean and Cp = cowpea).

The maize, soybean and cowpea varieties used were 'Obatanpa' which matures in 110 days, 'Anidaso' 120 days and 'Soronko' 75-80 days. The cassava and soybean were sown simultaneously between 20 and 30 April, and maize intercropped two weeks later. Cowpea was planted between 13 and 22

September into cassava, after maize and soybean were harvested in August. The sole crops of the component crops were planted at the same time as that crop was planted into the intercrop.

Both intercrop and sole maize were fertilized with an equivalent 90:60:0 kg $N:P_2O_5:K_2O$ ha^{-1}. The N was applied in two split doses at 2 and 5 weeks after planting (WAP) the maize. The minor season cowpea was protected against insect pests with Karate 2.5EC (a.i lambda-cyhalothrin 25g l^{-1}) at a rate of 600 ml ha^{-1} and Cymethoate EC (a.i cypermethrin 35g l^{-1} and dimethoate 250g l^{-1}) at a rate of 1000 ml ha^{-1}. Subsequent weed control was by hand weeding.

Cassava varieties were harvested at 12 months after planting from the two middle rows of each plot and used to obtain yield and yield components. Aggressivity (A) was used to measure the competitive ability of cassava related to maize, soybean or cowpea. Aggressivity was determined following Singh *et al.* (1998):

$$A_{ab} = (Y_{ia} / (Y_{ma} \times Z_{ia})) - (Y_{ib} / (Y_{mb} \times Z_{ib})) \quad (1)$$

where Y_{ia} and Y_{ib} are yields of crop a and b when intercropped and Y_{ma} and Y_{mb} are the yields of a and b in monocultures. Z_{ia} and Z_{ib} are sown proportions of crop a and b in intercrops. All data were analysed with the Statistical Analysis Systems package (SAS, 1988). Means were compared using the Standard Error of Difference (SED).

Results and Discussion

Fresh root yield of cassava varied significantly among cropping systems, but did not differ among years and locations. None of the interactions was also significant. Intercropping reduced root yield of "Gblemoduade" by 22-37 % and 43-51 % in "Ankra" (Table 1). Ugbaja and Omaliko (1996) have reported similar findings where intercropping cassava with castor reduced cassava yield by 12-37%. The improved variety ("Gblemoduade") significantly outyielded "Ankra" (local variety) by about two and half times under both intercrop and monocrop. Intercrop and monocrop yields averaged 24.8 and 36.9 t ha^{-1} for "Gblemoduade" and 9.1 and 17.4 t ha^{-1} for "Ankra". Nweke *et al.* (1988), Jalloh and Dahniya (1989) and Jalloh *et al.* (1991) have also reported the superiority in yield of improved cassava varieties over the local ones in intercrops. Generally cassava yield decreased with increased rows (or proportion) of soybean or cowpea, an indication of increased competition from the under-story crops. Root yields did not differ between S2 and S3 under "Gblemoduade" and "Ankra", but were smaller than yields at S1 (Table1). Contrary to the findings of this study, Nitis (1978) and Thomas and Nair (1979) have reported an increase in cassava root yield as a result of intercropping, while Asokan and Sreedharan (1987) found that cassava

Table 1. Fresh root yield, number of roots per plant and weight per root of cassava as affected by cropping system at Fumesua and Kwadaso in 1997/98 and 1998/99.

Cropping system†	*Fresh root yield (t ha^{-1})*		*Number of roots per plant*		*Weight per root (kg)*	
	Kwa‡	*Fum*	*Kwa‡*	*Fum*	*Kwa‡*	*Fum*
S1 with "Gblemoduade"	26.53	31.03	6.9	10.9	0.66	0.39
S2 with "Gblemoduade"	21.82	22.76	7.1	9.8	0.72	0.40
S3 with "Gblemoduade"	22.62	23.83	6.0	7.6	0.58	0.38
S1 with "Ankra"	10.18	9.55	4.1	4.6	0.44	0.29
S2 with "Ankra"	8.93	8.22	4.2	4.5	0.42	0.33
S3 with "Ankra"	10.64	7.17	3.8	3.6	0.38	0.25
Sole "Gblemoduade"	40.94	32.83	7.0	7.8	0.54	0.36
Sole "Ankra"	18.06	16.81	4.4	5.4	0.42	0.23
S.E.D (location)	0.80		0.23		0.012	
S.E.D (cassava variety)	0.88		0.24		0.012	
S.E.D. (spatial arrangement)	1.07		0.29		0.014	
S.E.D. (cropping systems)	1.59		0.46		0.024	

† S1 = 1 row cassava/1 row maize/1 row soybean/2 rows cowpea;
S2 = 1 row cassava/1 row maize/2 rows soybean/3 rows cowpea;
S3 = 1 row cassava/1 row maize/3 rows soybean/4 rows cowpea.
‡ Kwa = Kwadaso, Fum = Fumesua.

yield was not affected by intercropping.

On the average, "Gblemoduade" produced 84% more roots per plant, which were also 34 % heavier than those of "Ankra" in both locations (Table 1). This trend was reflected in root yields showing a significant correlation with number of roots per plant and weight per roots ($r = 0.69$ and 0.40, respectively, both at $p<0.001$) (data not shown). Dahniya *et al.* (1991) also found that the significantly greater number of roots per plant and weight per root strongly accounted for the differences in root yield between an improved and a local cassava variety intercropped with rice in Sierra Leone. The S1 and S2 spatial arrangements had similar number of roots per plant and weight per root, but these were greater and heavier than roots produced under S3 for both varieties (Table 1). Generally, a smaller number of plants m^{-2} was harvested for S2 (0.48-0.56 plants m^{-2}) compared with S1 and S3 (0.62-0.80 plants m^{-2}). Although S1

had similar roots per plant and weight per roots with S2, the smaller number of plants m^{-2} harvested for S2 (data not shown) might have resulted in the smaller root yields produced at S2 compared to S1 in both varieties. The greater plants m^{-2} obtained at S3 for both varieties compensated for the smaller number of roots produced and the lighter root weights, resulting in similar root yields with S2. The inverse relationship between population density and the number of roots and weight per root of cassava intercropped with rice or maize has also been observed (Dahniya *et al.*, 1991; Asafu-Agyei *et al.*, 1998).

Both cassava varieties, on the average, produced bigger roots at Kwadaso than at Fumesua in both years (Table 2). Similarly, "Gblemoduade" had slightly bigger roots than "Ankra" at both locations and years. Among the spatial arrangements, S1 and S2 produced 9-18 % bigger roots than S3 under both varieties, except for "Gblemoduade" at Fumesua, where S3 had similar sized roots as S1 and S2. Intercrop cassava on the average, produced bigger roots than the monocrop for both varieties (Table 2), which may be attributed to the N and non-N effects such as improved soil structure and moisture storage (Copeland *et al.*, 1993) from the legume crops. Table 2 shows that "Gblemoduade" was slightly taller than "Ankra" at the times of maize and cassava harvest. Generally, intercropped cassava grew slightly taller than monocrop cassava, an indication of competition for resources, especially light, in the intercropping system. Also "Ankra" appeared to have recovered faster, after maize and soybeans were harvested, compared with "Gblemoduade".

The aggressivity values of cassava in relation to maize, soybean or cowpea were all positive (Table 2), indicating that cassava was a stronger competitor in the mixture. "Gblemoduade" was more aggressive than "Ankra" in the system with the three crops. It had greater aggressivity values. This might have accounted for "Gblemoduade" yielding two and half times than "Ankra" in the intercrops. The aggresivity of both cassava varieties increased with decreased number of soybean or cowpea rows in the mixture (i.e. S1=S2 > S3). The increase in aggressivity or competitive ability of cassava as the proportion of legumes decreased in the intercrop systems is similar to the findings by Abbas *et al.* (1995). Among the crops, maize was more competitive to cassava than soybean and cowpea, probably because of its ability to grow faster, taller and vegetative thus competing vigorously with cassava for light. However, cassava might have become a stronger competitor as shown by the results, because it was planted earlier giving it a "head-start". The soybean might have competed more with maize than the cassava, hence the positive values obtained for C-M.

Table 2. Diameter (size) per root, plant height and aggressivity of cassava intercropped with maize, soybean and cowpea at Fumesua and Kwadaso in 1997/98 and 1998/99.

Cropping system†	*Diameter (size) per root (cm)*		*Plant height at (cm)*		*Aggressivity#*		
	Kwa‡	*Fum*	*4MAP■*	*12MAP*	*C-M*	*C-S*	*C-Cp*
S1 with "Gblemoduade"	6.77	5.10	185	248	0.91	1.07	1.10
S2 with "Gblemoduade"	7.13	5.32	168	237	0.99	1.11	1.14
S3 with "Gblemoduade"	6.02	5.45	178	251	0.63	0.77	0.80
S1 with "Ankra"	5.93	4.88	135	200	0.62	0.73	0.74
S2 with "Ankra"	6.08	5.12	147	196	0.69	0.82	0.84
S3 with "Ankra"	5.42	4.62	146	210	0.42	0.55	0.57
Sole "Gblemoduade"	6.07	4.92	179	240	-	-	-
Sole "Ankra"	5.45	4.75	134	194	-	-	-
S.E.D (location)		0.063	3.14	2.94			
S.E.D (cassava variety)		0.077	3.56	3.43			
S.E.D. (spatial arrangement)		0.090	4.36	4.20			
S.E.D. (cropping systems)		0.130	6.28	5.88			

† S1 = 1 row cassava/1 row maize/1 row soybean/2 rows cowpea;
S2 = 1 row cassava/1 row maize/2 rows soybean/3 rows cowpea;
S3 = 1 row cassava/1 row maize/3 rows soybean/4 rows cowpea.
‡ Kwa = Kwadaso, Fum = Fumesua.
■ MAP = Months after planting cassava
C = Cassava, M = Maize, S = Soybean, Cp = Cowpea

These findings are contrary to those found by other workers (Osiru and Hahn 1987; Ezumah, 1990; Ezumah *et al.*, 1990; Jalloh *et al.*, 1991; Asafu-Agyei *et al.*, 1998), who observed maize (or cereals) to be the dominant crop when grown with cassava.

In conclusion, the results of this study indicate that for greater cassava yields, 1 row each of cassava, maize and soybean followed by 2 rows of cowpea (after maize and soybean harvest) should be planted; and by growing the improved variety "Gblemoduade". However, where the farmer is interested in poundable roots, which is mostly the case in the forest zone of Ghana, the local variety, "Ankra" can be planted at the same spatial arrangement.

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