Intercropping maize with cassava or cowpea in Ghana

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SUMMARY

Maize/cassava and maize/cowpea intercrops were evaluated in southern Ghana, over a 5-year period to determine the optimum combination of component crop varieties and component plant population densities to optimize productivity of maize-based intercropping systems. Results indicated that some cowpea varieties which perform well under sole cropping tend to climb under intercropping and may not be adapted for intercropping. Selection of improved cowpea lines under intercropping might, therefore, be necessary. Full-season maize intercropped with short-duration cassava (LER=1.5), and medium-maturing cowpea intercropped with early-maturing or full-season maize (LER=1.4-1.53) resulted in high productivity of the intercrops. The optimum plant population density of the intercropped maize (50,000 to 58,000 plants ha^{-1}) was similar to the recommended optimum sole crop maize plant population density. It is recommended that intercropped cassava population density should not exceed 15,000 plants ha^{-1} to obtain marketable sizes of cassava roots. Planting double rows of cowpea between two rows of maize was a better alternative (LER=1.60-1.62) to sole cropping.

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RÉSUMÉ

ENNIN, S. A., ASAFO-AGYEI, J. & DAPAAH, H. K.: *Semailles de maïs en lignes alternantes avec le manioc ou la dolique au Ghana.* Les cultures de maïs/manioc et de maïs/dolique semées en lignes alternantes étaient évaluées au sud du Ghana au cours d'une période de 5 ans, pour déterminer la combinaison optimum des variétés des cultures constituantes et les densités de la population des plantes constituantes pour optimiser la productivité des systémes de semailles en lignes alternantes basés sur le maïs. Les résultats indiquaient que quelques variétés de dolique qui croissent bien sous le système de monoculture ont la tendance de grimper sous le système de semailles en lignes alternantes et ne doivent pas être adaptées pour les semailles en lignes alternantes. La sélection des lignes de dolique améliorée sous les semailles en lignes alternantes pourrait être, par conséquent, nécessaire. Le maïs de maturation tardive semé entre les lignes de manioc de la maturation tôt sur la Proportion d'Equivalent de Terre (PET = 1.5) et la dolique de la maturation moyenne semée entre les lignes de maïs de la maturation tôt ou de maïs de la maturation tardive (PET = 1.4 - 1.53) donnaient les résultats d'une productivité élevée des cultures semées en lignes alternantes. La densité optimum de la population de plante du maïs semé entre les lignes d'une autre culture (50,000 - 58,000 plantes ha^{-1}) était semblable à la densité optimum recommandée pour la seule culture de maïs. Nous recommandons que la densité de la population du manioc semé entre les lignes d'une autre culture ne doit pas dépasser 15,000 plantes ha^{-1} afin d'obtenir les racines de manioc ayant des grosseurs commercialisables. La plantation de deux lignes de dolique entre deux lignes de maïs était un choix meilleur (PET = 1.60 - 1.62) à la monoculture.

Introduction

Intercropping is a crop intensification practice, whereby two or more crops are interplanted on the same field (Ofori & Stern, 1987). It is a popular practice in the tropics and is the predominant cropping system for maize and cowpea production in Ghana.

The main intercropping systems in Ghana have involved cowpea and sorghum, cowpea and millet, and maize and sorghum intercrops in the Guinea savanna zone; maize and cassava intercrop of the forest and coastal savanna zones, and the maize or cassava and cowpea systems found in the coastal savanna zones. A maize technology diffusion study conducted throughout the major maize-producing areas in Ghana in 1990 showed that about 63 per cent of maize farmers in the country intercropped (GGDP, 1990). In the Guinea savanna zone, 88 per cent of farmers intercropped cowpea with sorghum or millet. In the forest-savanna transition zone, about 40 per cent of cowpea farmers practised intercropping (GGDP, 1991).

Intercropping is popular because of acclaimed advantages of higher productivity compared to sole cropping, higher gross returns, and higher protein yield. Intercropping also serves as an insurance against total crop failure (Moss & Hartwig 1980; Mugabe, Sinije & Sibuge, 1982; Allen & Obura, 1983; Natarajan & Willey, 1986; Russell & Caldwell, 1989; Allen, 1990; Cardona, 1990; Sharma & Mehta, 1991). In Ghana, these advantages include the farmer's ability to satisfy his domestic dietary and commercial interest under uncertain rainfall conditions, poor soil fertility, and limited financial resources. The Ghanaian farmer has traditionally practised mixed intercropping by growing two to five component crops with no distinct row arrangements and low component crop population densities. The varieties used are local varieties with potentially low yields.

These studies aimed at evaluating the yields of improved maize and cowpea varieties in different varietal combinations under maize/cassava and maize/cowpea intercropping, and at determining optimum plant population densities of component crops needed for maximum intercrop productivity and economic benefits.

Materials and methods

The experiments were located on the Crops Research Institute's research stations at Ejura, Fumesua, Kwadaso, and Pokuase of southern Ghana from 1984 to 1988. The Ejura site (7° 28' N, 1° 28' W) is in the forest-savanna transition zone on Akroso soil series, classifield by USDA as Dystrochrepts and by FAO/UNESCO Legend as Dystric Cambisol. Fumesua and Kwadaso (6° 43' N', 1° 36 W) are in the forest zone, with Asuansi soil series, classified by USDA as Paleustult and as Ferric Acrisol by FAO/UNESCO Legend. The Pokuase site (5° 36' N, 00° 10' W) in the coastal savanna zone is also on Akroso soil series.

Rainfall in southern Ghana follows a bimodal pattern with the peak of the major rainy season in May-June and the peak of the minor rainy season in September-October (Table 1).

Table 2 describes the crops and varieties studied under intercropping and sole cropping. The improved varieties of maize were bred at the Crops Research Institute, and the improved cowpea varieties were introduced from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Maize/cassava intercrops

In 1984/85, two improved maize varieties ('Seleccion Precoz' and 'Laposta') at two population

TABLE 1

Mean Monthly Rainfall (mm) during the Study Period (1984-1988) in Southern Ghana

Location	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Pokuase	9	20	69	65	146	147	107	78	132	101	103	21
†Kwadaso	15	53	162	175	145	230	207	97	222	149	37	15
Ejura	9	16	122	122	167	198	212	128	235	151	12	14

†Fumesa is near Kwadaso

TABLE 2

Characteristics of Crop Varieties Investigated in the Intercropping Studies

Crop	Variety Name	Habit	Maturity
Maize	Seleccion Precoz	Open pollinated, improved	Short duration, 90 days
	Laposta	Open pollinated, improved	Long duration, 120 days
	Dorke	Open pollinated, improved	Short season, 90 days
	Pool 16	Open pollinated, improved	Short duration, 90 days
	Dobidi	Open pollinated, improved	Long duration, 120 days
	Aburotia	Open pollinated, improved	Medium duration, 105 days
Cassava	Bosome Nsia	Late branching, local	Short duration, 9 months
	Ankra	Late branching, local	Long duration, 15 months
Cowpea	Asontem	Erect improved	Early maturing, 65 days
	Soronko	Semi-erect improved	Medium duration, 75 days
	IT82D-716	Erect improved	Early maturing, 65 days

densities (20,000 and 40,000 plants ha^{-1}) were studied under intercrop with local cassava, 'Ankra'; at two cassava population densities (10,000 and 20,000 plants ha^{-1}) and two maize fertilizer rates (0 and 90-60-60 kg ha^{-1} NPK) (Table 2) at Kwadaso. The experimental design was a randomized complete block in a 2^4 factorial arrangement. In 1986/87, at Fumesua, two newly released maize varieties ('Dorke' and 'Dobidi') at two population densities (20,000 and 40,000 plants ha^{-1}) were evaluated in intercrop with two cassava varieties ('Bosome Nsia' and 'Ankra') and two maize fertilizer levels (45 and 180 kg N ha^{-1}), with a randomized complete block design in a 2^4 factorial arrangement. At Fumesua in 1987/88, 'Pool 16' maize variety was substituted for 'Dorke' and evaluated alongside 'Dobidi', under intercropping with two cassava varieties ('Bosome Nsia' and 'Ankra'). There were two maize population densities (20,000 and 40,000 plants ha^{-1}) and two cassava population densities (10,000 and 20,000 plants ha^{-1}). The experimental design was a randomized complete block in a 2^4 factorial arrangement.

In a study of cassava/maize intercropping systems by population density initiated in 1986/1987 at Fumesua and Pokuase, eight maize plant population densities increasing from 0, 10 000, 20 000, 30 000, 40 000, 50 000, 60 000 to 70 000 plants ha^{-1} were tested under intercropping with eight cassava population densities decreasing from 21 000, 18 000, 15 000, 12 000, 9 000, 6 000, 3 000 to 0 plants ha^{-1} with two cassava/maize intercropping systems ('Dobidi'/'Ankra' and Pool 16/ 'Bosome Nsia'). The study was repeated in 1987/1988 at Kwadaso and Pokuase. The experimental design was split plot with two intercropping systems as the main plots and eight plant population densities as subplots.

In all the studies, plot sizes were 8 m long and 8 m wide; cassava and maize were planted at the same time in alternate rows. Fresh cassava stem cuttings, 20 cm long, were used for planting. Fertilizer applied to maize, unless otherwise stated, was equivalent to 90-60-60 kg ha^{-1} N-P_2O_5-K_2O. The nitrogen was applied in a split 2 and 5 weeks after planting. Weeds were controlled by pre-emergent application of [1]Primagram 500 FW (metolachlor +atrazine) at 2.0 kg ai ha^{-1} and a follow-up with hand-weeding.

Cowpea/maize intercrops

Two improved cowpea varieties, 'Asontem' and 'Soronko', which are high yielding in sole crop systems, were evaluated under intercropping with two improved maize varieties ('Dobidi' and 'Aburotia') by three spatial arrangements (planting maize and cowpea in alternate rows, double cowpea rows within two maize rows, and sole cropping of cowpea and maize) at Ejura in 1986 and Fumesua in 1987. Maize and cowpea populations were 62 000 and 125 000 plants ha^{-1}, respectively, for intercrops and sole crops. The experimental design was randomized complete block design with a 2 × 2 × 3 factorial arrangement of maize variety cowpea variety, and spatial arrangements. In 1988, due to the climbing nature of 'Asontem' when intercropped in 1987, it was replaced by 'IT82D-716' and the study repeated at Fumesua in the major season with a double row cowpea between two rows maize spatial arrangement. The experimental design was a randomized complete block design with a 2 × 2 factorial arrangement of maize and cowpea varieties. Plot sizes were 5 m long, 3.6 m wide. Maize and cowpea plant populations were 62,500 and 125,000 plants ha^{-1}, respectively. Maize was fertilized at a rate of 90-60-0 kg ha^{-1} N-P_2O_5-K_2O with split application of N, 2 and 5 weeks after planting. Cowpea was protected against pre-flowering insects with [1]Cymbush 2.5 EC (cypermethrin) at 50 g. a. i. ha^{-1} once at budding and once at flowering stages. Post-flowering insects were controlled with two applications of [1]Roxion (dimethoate) at 400 g. a. i. ha^{-1}; the first was applied at early-podding stage, and the second at the pod-filling stage.

Intercrop productivity was measured by the land equivalent ratio (LER) (Balaaubramanian & Sekayange, 1991) which was calculated as follows:

$$LER = \sum_{i}^{n} (Y_i^I / Y_i^M)$$

where

Y_i^I = Yield of crop i in intercropping

Y_i^M = Yield of crop i in sole cropping

n = Total number of crops in association

Results and discussion

Maize/cassava intercrop

This paper deals with the effect of crop variety and plant population density on intercrop yields and productivity. There was a significant ($P \leq 0.05$) interaction among maize and cassava varieties on maize grain yield. Long-duration maize variety significantly out-yielded the early-maturing maize variety when intercropped with cassava (Fig. 1); however, the yield differences between the maize varieties accentuated as the maturity of the cassava increased. The yield of both maize varieties were higher under 'Bosome Nsia', the 9-month cassava, than under 'Ankra',

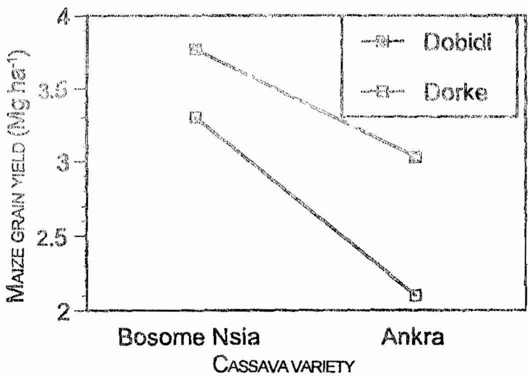

Fig. 1. Maize grain yield as influenced by maize and cassava varieties, 1986/87. ('Dobidi' is a 120-day maize; 'Dorke', a 90-day maize; 'Bosome Nsia', a 9-month cassava; and 'Ankra', a 15-month cassava.)

the 15-month cassava. The 15-month cassava variety which had more vigorous growth competed with maize for growth resources and depressed long-duration maize yields by 11 per cent, with a greater yield reduction of 32 per cent in the short-season maize. The sole crop maize yields of 3.07 and 3.4 Mg ha^{-1} for 'Dorke' and 'Dobidi', respectively, were similar to maize yields when intercropped with the short-season cassava. Compared to the 9-month cassava, the 15-month cassava caused a greater maize yield reduction. The reduction was 36 per cent for 'Dorke', the short-duration maize, and 18 per cent for 'Dobidi', the full-duration maize. These results indicate that in a maize/cassava intercropping, a farmer would maximize maize yields when long-duration maize is intercropped with short-duration cassava.

The results of intercropped cassava yields in the 1986/87 and 1987/88 studies are similar to trends in intercropped maize yields. The late-maturing varieties caused a greater yield depression of the component maize crop than the early-maturing varieties (Fig. 2). Thus, a cassava farmer would maximize cassava yields under

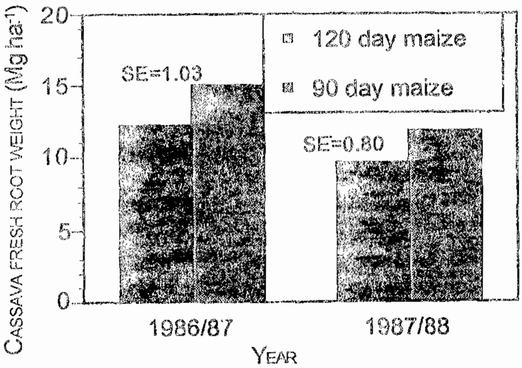

Fig. 2. Effect of maize variety on intercropped cassava root yield. (The 120-day maize was 'Dobidi' and the 90-day maize was 'Dorke' in 1986/87 and Pool 16' in 1987/88.)

intercropping by growing cassava with a short-duration maize. The average productivity of the intercrops estimated by the LER was 1.5 at Fumesua in 1986/87. Intercropping of maize and cassava is a productive system. It will require 50 per cent more land to be planted to the sole crops to produce the same quantities of maize and cassava as were produced in the intercrops. Similarly, yield advantages of 58-77 per cent were reported for maize/cassava intercrop over their sole crops in southern Nigeria (IITA, 1982).

When intercropped with cassava, maize plant population density of 40 000 plants ha^{-1} significantly out-yielded plant population density of 20 000 plants ha^{-1}. However, increasing cassava plant population density from 10 000 to 20 000 plants ha^{-1} did not affect maize yields (Table 3). In 1986/87, more intercropped maize populations were tested at two locations (Fig. 3 and 4). There were quadratic responses of intercropped-maize to varying maize plant population densities, and of intercropped cassava to varying cassava plant population densities. There were quadratic responses of intercropped maize grain yield (Mg ha^{-1}) to plant population density (plants ha^{-1}) in Kwadaso and Fumesua. The optimum intercropped maize plant population densities were

TABLE 3

Grain Yield of Intercropped Maize as Influenced by Maize and Cassava Population Densities

Season	*Factor*	*Plant density (× 1000 ha^{-1})*	*Maize grain yield (kg ha^{-1})* 1984/85	*Maize grain yield (kg ha^{-1})* 1987/88
Major rainy season	Maize density	20	2.62*	1.7*
		40	3.73	2.2
Minor rainy season	Maize density	20	0.59*	3.5
		40	1.11	4.6
Major rainy season	Cassava density	10	3.27 ns	1.9 ns
		20	3.07	1.9
Minor rainy season	Cassava density	10	0.90 ns	4.6 ns
		20	0.81	4.1

* = significant at $P = 0.05$

ns = non-significant

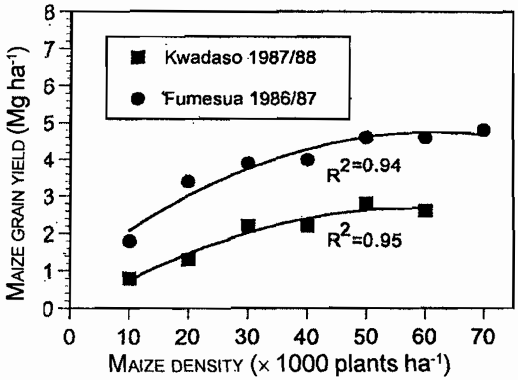

Fig. 3. Response of intercropped maize to maize plant population density.

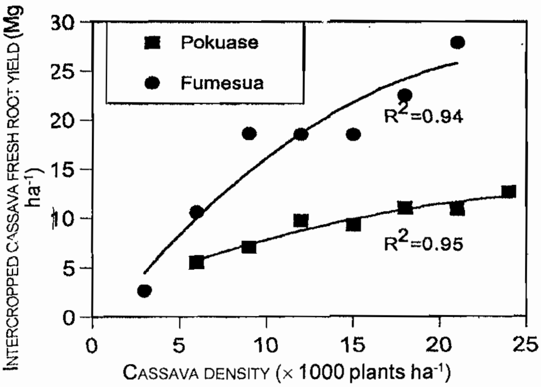

Fig. 4. Response of intercropped cassava to cassava plant density, 1986/87.

50 000 plants ha^{-1} at Fumesua, and 58 000 plants ha^{-1} at Kwadaso. These population densities are similar to the 56 000 plants ha^{-1} recommended optimum plant population density for sole crop 'Dobidi' maize in Ghana (Anonymous, 1996). The response of intercropped cassava root yields (Mg ha^{-1}) to cassava plant population density (plants ha^{-1}) was quadratic. The optimum cassava plant population density was 22 000 plants ha^{-1} in Pokuase and 26 000 plants ha^{-1} in Fumesua. However, it was observed that significant increases in yield beyond 15 000 plants ha^{-1} could be attributed to the proliferation of small unmarketable tubers. This suggests that for all practical purposes, intercropped cassava plant density must be similar to sole cropping, and should not exceed 15 000 plants ha^{-1}. These results indicate that intercropped maize and cassava population densities should be kept at the sole crop population densities to maximize yields of the component crops.

Maize/cowpea intercrop

The 80-day semi-erect cowpea, 'Soronko', was found to out-yield the 65-day erect cowpea variety, IT82D-716, by 34 per cent when intercropped with maize. However, in sole cropping, the early-erect variety out-yielded the late-maturing variety by 10 per cent (Table 3). It was observed that the incidence of Brown blotch (*Colletotricum truncatum*) was higher in intercropped IT82D-716 than its sole crop, and this could have contributed to the reduction in yield of intercropped IT82D-716 cowpea. Terao *et al.* (1997) also found IT82D-716 to have the higher yield in sole cropping but the lowest yield under intercropping with millet. These findings indicate that some cowpea varieties which perform well under sole cropping may not be adapted for intercropping. The early-maize variety, 'Aburotia', and the late-maturing cowpea variety, 'Soronko', had the higher LER of 1.53. Partial budget analysis (Table 4) showed that although the highest net benefit of ¢102,803 was realized for the full maize/late-maturing cowpea variety, the early-maturing maize intercropped with the late-maturing cowpea which had the higher LER values had a similar net benefit (Table 4).

Maize grain yield was significantly reduced by both spatial arrangements at Fumesua and Ejura compared with sole crops (Table 5). There were no significant differences between spatial arrangements in maize yields. However, cowpea yield was significanly higher under the double row spatial arrangements. This resulted in the double rows of cowpea between two maize rows being more productive, with higher LERs than the alternate row arrangement. The greater productivity of double row legumes in cereal/legume intercrops have also been reported by Ofori & Stern (1987).

TABLE 4

Varietal Influence on Intercropped Maize and Cowpea, Fumesua, 1988

Variety		Grain yield				
Maize	Cowpea	Maize	Cowpea	LER	Net benefit	Net benefit
		Mg ha^{-1}			¢ ha^{-1}	$ ha^{-1}
Aburotia	IT82D - 716	1.87	0.80	1.04	52,282	227
Dobidi	IT82D - 716	2.99	0.74	1.20	85,744	373
Aburotia	Soronko	2.30	1.23	1.53	102,265	445
Dobidi	Soronko	2.82	1.11	1.40	102,803	447
	IT82D - 716	-	1.98	1.00	110,176	479
	Soronko	-	1.79	1.00	93,200	405
Aburotia		2.92	-	1.00	65,970	287
Dobidi		3.61	-	1.00	89,511	389
LSD$_{(0.05)}$		ns	0.134			

TABLE 5

Effect of Spatial Arrangement on Intercropped Maize and Cowpea at Two Locations in 1986 and 1987

Location	Spatial arrangement	Grain yield Cowpea	Maize	LER
		Mg ha^{-1}		
Ejura 1986	Alternate 1 row maize, 1 row cowpea	1.00b†	3.27b	1.40
	Double rows cowpea between 2 rows maize	1.25b	4.07b	1.60
	Sole crop	1.37a	5.94a	1.00
Fumesua 1987	Alternate 1 row maize, 1 row cowpea	0.79	2.83	1.26
	Double rows cowpea between 2 rows maize	1.22	2.87	1.62
	Sole crop	1.48	3.85	1.00

† Means in a column followed by the same letters are not significantly different at $P = 0.05$ (DMRT).

Conclusion

These studies have shown that intercropping is a productive cropping system, and its productivity and monetary benefits can be enhanced through proper management practices. In the maize/cassava intercrop, late-maturing varieties caused a greater yield depression of the component crop than the early-maturing varieties. In the maize/cowpea intercrop, the early-maturing maize variety, 'Aburotia', and the late-maturing cowpea variety, 'Soronko', had the highest LER of 1.53. The optimum intercropped plant population density was similar to the 56 000 plants ha^{-1} recommended optimum plant population density for sole crop 'Dobidi' maize in Ghana. The studies also found that some cowpea varieties which perform well under sole cropping may not be adapted for intercropping. Double row cowpea was a more productive spatial arrangement than alternating one row of maize and cowpea.

There is need for future maize intercropping and cowpea intercropping research to focus on developing systems which will maintain or enhance the quality of the crops' environment.

The development of intercrop row arrangements that will facilitate mechanization and the development of simple machinery for intercrops will contribute to the sustainable production of maize and cowpea in Ghana.

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