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Evaluation of Maize, Cowpea, Cassava and Sweet Potato Intercrop Systems

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ABSTRACT

Various intercrop systems involving maize, cowpea, cassava and sweet potato grown in the field in the semideciduous forest zone of Ghana were evaluated based on the monetary returns (net incomes) from yields using the 1987 farmgate prices of the crop products. Even though farmgate prices could change with time, the evaluation of the systems in this study would still be valid for as long as the relative importance of the crops (status of the crops with respect to each other) remained unchanged. Maize spaced at 1.0 x 1.0m three plants per hill and intercropped with cassava also spaced at 1.0 x 1.0m in the maize rows was adjudged the best system. It was suggested that this system, commonly practised by peasant farmers in the semideciduous forest zone of Ghana, be encouraged and assisted with the use of fertilizers, so that the same pieces of land can be continuously cropped.

Keywords: cassava, cowpea, intercropping, maize, peasant farmer, sweet potato.

INTRODUCTION

Intercropping (simultaneous polyculture of crops) is a widely practised cropping system in Africa [19] and Latin America [5]. It is a traditional cropping system that is rooted in the socioeconomic life of the peasant farmer, and it derives its sustenance from results of centuries of trial and error [10]. The system has some important advantages: it is a way of insuring against total crop failure; it has been suggested as a way of reducing soil and nutrient losses and of maintaining good physical properties of the soil [2]; the results of the work of Ofori and co-workers [15, 16, 17] demonstrated consistent advantages of intercropping in terms of the land-equivalent ratios (LER), ie. the total land area required under sole cropping to give yields equalling those in intercropping [13]; according to Kissiedu [11], research undertakings tend to indicate that in traditional cropping systems, mixtures achieve higher total productivity than pure stands of the component crops.

The adverse comments usually made against intercropping inadvertently come as a result of its traditional connection with shifting cultivation which has been widely recognized as a wasteful and inefficient system where demand on land is high. Crop rotation, which has monocropping as an integral feature, and is usually suggested as an alternative to shifting cultivation, is alien to most traditional peasant farmers in the tropics and the pace of its acceptance by them would be slow, if at all. A farming system that would make continuous use of the land, for example through organic and inorganic fertilization and incorporates intercropping, would be readily accepted by the peasant farmer.

In intercrop systems in many tropical regions, cassava is generally grown in mixtures with other crops, including yam, maize, cocoyam, plantain, sugarcane, bean, groundnut, melon, sweet potato, and assorted vegetables [2, 4, 7, 8, 14, 19]. With selection from such a wide range of crops, various crop combinations are possible. In the semideciduous forest zone of Ghana, cassava, maize and cowpea are, respectively, the major root, cereal and leguminous crops grown by farmers, and these crops are commonly intercropped. The cultivation of sweet potato is also becoming increasingly important in this area. There is an urgent need to evaluate the productivity and efficiency of various crop combination systems. Various procedures could be used to make such evaluations. For example, Ofori and co-workers evaluated the relative efficiencies of maize/cowpea intercropping versus sole cropping on the basis of the land-equivalent ratios [15, 16], and also on the basis of the contribution of fixed N_2 by cowpea to the total N balance in the cropping system as assessed in terms of soil, harvested seed and crop residues [17].

The objective of this study was to compare various

intercrop systems involving cassava, maize, cowpea and sweet potato in the semideciduous forest zone of Ghana on the basis of yields and monetary returns for one year of cropping.

MATERIALS AND METHODS

The study was conducted at the experimental field of the Arable Crops Section of the Crop Science Department, University of Science and Technology, Kumasi, Ghana, during the 1986/87 cropping season. The site is located geographically at latitude 06° 43' N and longitude 01° 31' W in the semideciduous forest zone with mean day/night temperatures of 30/22°C and relative humidity of 60/95%, and a mean annual rainfall of 1375 - 1625mm. The soil is Akroso series (Typic Haplustult, coarse loamy, kaolinitic, thermic) with a sandy loam texture, pH($H_2$0) 4.9, cation exchange capacity of 90 mEq kg^{-1}, available P (Bray P1) of 2.5 mg kg^{-1} soil, and carbon and total nitrogen contents of 9.3 and 0.84 g kg^{-1} soil, respectively. The crops used in the study, which are commonly grown by farmers in the locality, were maize (La Posta), cassava (Ankra), cowpea (Vita 5, white, brown-eyed) and sweet potato (white, local).

The experiment consisted of seven treatments, which were the following crop combination and spacing systems:

MNS (maize, narrow-spaced, sole crop): Maize, sole crop, planted at a spacing of 0.75 x 0.25m, one plant per hill; followed by cowpea;

MWS (maize, wide-spaced, sole crop): Maize, sole crop, planted at a spacing of 1.0 x 1.0m, three plants per hill; followed by cowpea;

MMC (maize, medium-spaced, intercropped with cassava): Maize planted at a spacing of 1.0 x 0.25m, one plant per hill, with cassava at a spacing of 1.0 x 1.0m;

MWC (maize, wide-spaced, intercropped with cassava): Maize planted at a spacing of 1.0 x 1.0m, three plants per hill, with cassava at a spacing of 1.0 x 1.0m;

MWP (maize, wide-spaced, intercropped with sweet potato): Maize planted at a spacing of 1.0 x 1.0m, three plants per hill, with sweet potato at a spacing of 1.0 x 1.0m;

PS (sweet potato, sole crop): Sweet potato, sole crop, planted at a spacing of 1.0 x 1.0m; and

CS (cassava, sole crop): Cassava, sole crop, planted at a spacing of 1.0 x 1.0m.

The treatments were each replicated four times on plots measuring 11.0 x 11.0m, arranged in a randomized complete block design. The land was ploughed and harrowed, and mixed fertilizer 15-15-15 was applied by broadcasting at a rate of 200 kg ha^{-1} at harrowing. Maize was planted in the first week of May 1986. Cassava was planted as 25-cm cuttings in the slanting position three weeks after maize had been planted, and in the same row as the maize in the case of the maize/cassava intercrop systems. Sweet potato was planted by vine cuttings on ridges in the maize rows (in the case of maize/potato system) at the silking stage of maize. In treatments MNS and MWS cowpea was planted at a spacing of 1.0 x 0.30m in the second season after the maize had been harvested. The land was not reploughed prior to the planting of the cowpea in the second season.

At planting, the cassava received, by pocket application, additional N, P and K at rates of 45, 7 and 46 kg ha^{-1} as sulphate of ammonia, single superphosphate and muriate of potash, respectively, and the sweet potato also received additional P and K at rates of 26 and 58 kg ha^{-1}, respectively. At a height of about 40cm all maize plants received a sidedressing of additional 40 kg N ha^{-1} as sulphate of ammonia. In treatments MNS and MWS, since the land under maize had been fertilized in the first season, the following cowpea was not further fertilized. In cowpea, preflowering insect pests were sprayed twice with Ripcord and postflowering pests twice with Perfecthion. Weeds were controlled by handhoeing.

The maize was harvested 132 days after planting (DAP) when the plants had turned completely brown, by collecting the cobs from the inner 10 x 10m area of plots. The sweet potato was harvested 134 DAP when most of the foliage had turned brown, by carefully digging out the tubers with a mattock. The cowpea was harvested 80 DAP by handpicking the dry brown pods. The cassava was harvested 303 DAP by both uprooting by hand and digging with a mattock. Maize grains and cowpea seeds were sun-dried and weighed. Sweet potato and cassava tubers were weighed fresh soon after harvest.

Gross monetary returns from yields were estimated using the farmgate prices paid to farmers as at January 1987 (information furnished by the Food Distribution Corporation and the Ministry of Agriculture, both in Kumasi), which were ¢55 kg^{-1} for cowpea, ¢33 kg^{-1} for maize, ¢11 kg^{-1} for cassava and ¢10 kg^{-1} for sweet potato. The net income on which the evaluation of the cropping systems was based was obtained by subtracting from the gross monetary returns the cost of production for each system which was based on only the cost of planting

materials and insecticides. The cost of production was based on only the cost of planting materials and insecticides because these varied among treatments, but the cost of other inputs, such as land preparation, fertilizers and labour remained essentially similar for all treatments. Statistical analyses were done on the yield and monetary data using Duncan's Multiple Range Test for means separation.

RESULTS AND DISCUSSION

Maize yields were generally low, due to the late planting (in May). Long before the silking stage of the maize the dry spell set in, causing poor growth and pod-filling in the crop. The highest maize yield (obtained in treatment MNS - sole maize crop at a spacing of 0.75 x 0.25 one plant per hill in the first season) was 2.64 t ha^{-1} (Table 1), which was lower than the yield of 3 - 5 t ha^{-1} for La Posta in similar ecological zone (Crops Research Institute, Ghana, Private Communication, 1987). Low maize yields resulting from late planting, later than the end of April in the forest zone of Ghana, have been reported by many workers [1, 12]. This yield (2.64 t ha^{-1}) was, however, significantly higher than the maize yields in the other cropping systems in this study, and this might be explained by the high plant population (53,000 plants ha^{-1}) and the absence of competition from other crops. There were, however, no significant differences in yields of maize (1.48, 1.62 and 1.86 t ha^{-1} for treatments MWS, MWP and MWC, respectively) planted at a spacing of 1.0 x 1.0m three plants per hill (ie. at a density of 30,000 plants ha^{-1}).

Yield of cowpea following maize planted at 0.75 x 0.25m (treatment MNS) was 1.68 t ha^{-1} and that following maize at 1.0 x 1.0m three plants per hill (MWS) was 1.08 t ha^{-1}. There were no significant differences in these cowpea yields (Table 1). The cowpea yields achieved in this study were comparable to the range (0.9 - 1.5 t ha^{-1}) usually obtained in the forest zone of Ghana [6, Crops Research Institute, Ghana, Private Communication, 1987].

Table 1 Yield of maize, cowpea, cassava and sweet potato in intercrop systems

Cropping System			Yield (tha^{-1})			
Treatment Code	Crops	Planting Distance (m)	Maize	Cowpea	Cassava	S. potato
MNS	Maize fb Cowpea	(0.75 x 0.25) (1.0 x 0.30)	2.64 b	1.68 a	--	--
MWS	Maize fb Cowpea	(1.0 x 1.0) (1.0 x 0.30)	1.48 a	1.08 a	--	--
MMC	Maize iw Cassava	(1.0 x 0.25) (1.0 x 1.0)	2.06 ab	--	8.45 a	--
MWC	Maize iw Cassava	(1.0 x 1.0) (1.0 x 1.0)	1.86 a	--	9.28 a	--
MWP	Maize iw S. potato	(1.0 x 1.0) (1.0 x 1.0)	1.62 a	--	--	2.21 a
PS	S. potato, Sole	(1.0 x 1.0)	--	--	--	5.35 b
CS	Cassava, Sole	(1.0 x 1.0)	--	--	13.46 b	--
	LSD (P = 0.05):		0.67	NS	2.41	1.66

fb = followed by; iw = intercropped with.
Yields of a crop followed by the same letter are not significantly different at P = 0.05.

The sole cassava crop (treatment CS) yielded 13.46 t ha^{-1}. The cassava intercropped with maize spaced at 1.0 x 0.25m (MMC) yielded 8.45 t ha^{-1}, and that intercropped with maize spaced at 1.0 x 1.0m three plants per hill (MWC) yielded 9.28 t ha^{-1}. The differences in the yield of the sole cassava on the one hand and those of the intercropped cassava on the other were highly significant (P = 0.01). However, the difference between the intercropped cassava yields (8.45 and 9.28 t ha^{-1}) at the two different maize planting densities was not significant (Table 1). Cassava intercropped with maize initially showed poorer growth (thinner and shorter stems) than the sole cassava crop. This poor growth might have resulted from shading and competition for nutrients and water by the maize intercrop. After the maize harvest, however, the intercropped cassava resumed a more rapid growth. Similar poor growth situation of cassava intercropped with maize have been reported by other workers [10, 11]. Hahn [10] reported a yield of 12.1 t ha^{-1} for sole cassava and 10.0 t ha^{-1} for cassava intercropped with maize at a density of 10,000 plants ha^{-1}. By comparison, cassava yields obtained in this study were lower than those (20 - 25 t ha^{-1}) obtained by Wargiono [20] in fertilizer trials in Indonesia.

Sweet potato yield was 5.36 t ha^{-1} in pure stand (treatment PS) and 2.22 t ha^{-1} when intercropped with maize (MWP). The difference between these sweet potato yields was highly significant (P = 0.01). The lower yield of intercropped sweet potato might have resulted from the shading and competition for nutrients and water by the maize crop. The intercropped sweet potato produced thinner and smaller tubers than the sole crop. The yields of sweet potato obtained in this study were lower than the Africa average of 6.5 t ha^{-1} listed by Hahn [10].

The cropping systems have been evaluated in terms of monetry returns based upon the January 1987 farmgate prices of the products (Table 2). In all the treatments, except PS (sole sweet potato crop), the land was made to be under crop for two seasons. Thus, the monetary returns were estimated for total products obtained from two seasons. Since in treatment PS the sweet potato was grown for only one season, this was not included in the evaluation. Even though the farmgate prices of these crops have increased in 1990 about fourfold over their 1987 prices, the status (importance) of the crops with respect to each other has not changed; the degree of price change was similar and would remain so for quite some time for all the four crops

Table 2 Comparison of monetary returns (income) from yields of maize, cowpea, cassava and sweet potato in intercrop systems

Cropping System			Individual Crop Income (C ha^{-1})					
Treatment code	Crop	Planting distance (m)	Maize	Cowpea	Cassava	S. potato	Total gross income (C ha^{-1})	Total net income (C ha^{-1})
MNS	Maize fb Cowpea	(0.75 x 0.25) (1.0 x 0.30)	87021	92180	–	–	179201	171201 f
MWS	Maize fb Cowpea	(1.0 x 1.0) (1.0 x 0.30)	48708	59510	–	–	108218	100618 c
MMC	Maize iw Cassava	(1.0 x 0.25) (1.0 x 1.0)	67815	–		–	160743	156543 de
MWC	Maize iw Cassava	(1.0 x 1.0) (1.0 x 1.0)	61347	–	102102	–	163449	159449 ef
MWP	Maize iw S. potato	(1.0 x 1.0) (1.0 x 1.0)	53328	–	22110		75438	74938 b
PS	S. potato	(1.0 x 1.0)	–	–		53530	53530	53530 a
CS	Cassava	(1.0 x 1.0)	–	–		148038	– 148038	144538 d
	LSD (P = 0.05):							13537

fb = followed by; iw = intercropped with.
Net incomes followed by the same letter are not significantly different at P = 0.05.

studied. It was therefore valid to use the 1987 farmgate prices to evaluate the cropping systems for as long as the relative status of the crops, as was in 1987, remained unchanged. The highest net income was obtained from treatment MNS (sole maize crop spaced at 0.75 x 0.25m in the main season followed by a cowpea crop in the minor season). However, a maize spacing of 0.75 x 0.25m is not a common practice in peasant farming; it is more a feature of mechanized planting. The second most profitable cropping system was one most commonly practised by the peasant farmer; it is the intercropping of maize spaced at 1.0 x 1.0m three plants per hill, with cassava also at 1.0 x 1.0m in the same row as the maize (treatment MWC). There was no significant difference in the net incomes of the two cropping systems (MNS and MWC). Therefore, on the basis of convenience and ease of manual cultivation, cropping system MWC would be preferable to MNS. The cropping system with the lowest net income was MWP (maize intercropped with sweet potato).

It is worth noting that the evaluation in this study was based on the most direct effect that is most easily measured and compared - yield, and that some indirect and long-term effects were not directly considered. It would be more informative to have the systems modelled and evaluated on the basis of such composite effects as restoration of soil fertility (eg. through N_2-fixation and return of crop residue) and control of soil erosion (eg. by such cover crops as sweet potato). However, yield of a crop represents the final expression of the interaction of all these effects, and therefore could still be relied upon for making such evaluations as were done in this study.

CONCLUSION

Of the various cropping systems studied, the system MWC (maize spaced at 1.0 x 1.0m three plants per hill with cassava also at 1.0 x 1.0m in the same row as the maize) was assessed the best on the basis of net monetary returns and convenience of manual planting. Since a high maize density could potentially reduce cassava yield, the maize population in the maize/cassava system should not exceed 30,000 plants ha^{-1} (as in the spacing of 1.0 x 1.0m, three plants per hill) in order to obtain good cassava yields. It is anticipated that still better total yields and monetary returns per hectare could be obtained by the cropping system MWC when both cassava and maize are planted at the same time as recommended by Kissiedu [11] and Hahn [10], at the right time (from mid-March to mid-April) and with the right application of fertilizers. It is suggested that this traditional maize/cassava intercrop system (MWC in this study using fertilizers be encouraged in the forest zone of Ghana and similar ecological situations.

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