Evaluation of maize intercrops (Canavalia, Mucuna, and Dolichos) in Central Honduras

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Abstract: Factors limiting subsistence maize production in Honduras include low soil fertility and the lack of resources for adequate fertilization. Crop rotation with leguminous plants to improve N nutrition in maize is known and practised successfully in some parts of Honduras. Because of the lack of available land for rotation, intercropping legumes has been proposed by development organizations. Intercrops of Mucuna (*Mucuna pruriens* (L.) DC. var. *utilis*), Canavalia (*Canavalia ensiformis* (L.) DC.) and Dolichos (*Lablab purpureus* (L.)) were intercropped with maize (*Zea mays* L.) on a Typic Ustifluvent in Honduras (14 00' N, 87 05'W). Intercrops did not improve maize production when compared with monocropping. The year with least intercrop biomass production resulted in the highest maize yield. An increase in the incidence of maize ear rot (*Stenocarpella maydis* (Berk.) Sutton) was noticed with the Dolichos and Canavalia intercrops in different years. Lack of yield response to intercropping may result from nutrient release from the biomass not being synchronous with critical stages of maize growth. In the absence of rotation, intensification of maize systems with edible legumes should be evaluated and promoted in terms of total crop production.

Keywords: Maize-legume intercropping, subsistence farming, yield and disease effects.

Resumen: Entre los factores que limitan la producción de maíz de subsistencia en Honduras están la baja fertilidad del suelo y la falta de recursos para una fertilización adecuada. La rotación de cultivos con plantas leguminosas para mejorar la nutrición del maíz con nitrógeno es conocida y practicada con éxito en algunas partes de Honduras. Debido a la falta de tierra disponible para rotación de cultivos, la siembra de leguminosas intercaladas con los cultivos ha sido propuesta por organizaciones de desarrollo. Cultivos de Mucuna (*Mucuna pruriens* (L.) DC. var. *utilis*), Canavalia (*Canavalia ensiformis* (L.) DC.) y Dolichos [*Lablab purpureus* (L.)] fueron intercalados con maíz (*Zea mays* L.) en un suelo Typic Ustifluvent en Honduras (14 00' N, 87 05'W). Los cultivos intercalados no aumentaron la producción de maíz comparado con monocultivo. El año con la menor biomasa de cultivo intercalado resultó con la mayor producción de maíz. Un aumento en la incidencia de la pudrición de la mazorca del maíz [*Stenocarpella maydis* (Berk.) Sutton] se notó con Dolichos y Canavalia en diferentes años. La falta de respuesta a los cultivos intercalados puede deberse a la falta de sincronización entre la liberación de los nutrientes de la biomasa y los periodos críticos en el crecimiento del maíz. Sin rotación, la intensificación de los sistemas de producción de maíz con leguminosas comestibles se debe evaluar y promover en términos de la producción total de ambos cultivos.

Palabras clave: Agricultura de subsistencia, cultivos intercalados maíz-leguminosa, efectos en rendimiento y enfermedades.

Introduction

This study was conducted with the goal of evaluating the practice of intercropping that is promoted by some development institutions as a component of potentially sustainable hillside cropping systems. The objectives of the study were to determine the effect of intercropping maize (*Zea mays* L.) with some of the legumes promoted for this purpose, on maize yield and quality.

Intercropping maize with legumes has been consistently proposed in small farm situations in developing nations to reduce and replace the use of chemical fertilizers (CIDICCO, 1991; Bunch, 1993). These intercropping systems are distinct from relay intercropping because the legume is planted before the reproductive stage of the maize, and from rotation because the maize is cultivated in the same area in consecutive growing seasons.

Typically these intercrop systems are not of large scale commercial importance, and the research into them is oriented toward smaller scale farmers and tends to be varied and dependent on the particular interests of the researcher. N transfer in pasture systems has been documented (Stern, 1993), but the extension to intercrop systems in maize has not been

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well validated. The analyses of these systems have focused on improved crop production in terms of improvement of soil properties and increased production of edible and saleable product.

Greenhouse and pot studies have shown the possibility of N transfer from legumes to maize in intercropping systems. Transfer of N in low fertility situations is expected to be greatest when growth of the legume does not suppress maize growth (Senaratne and Ratnasinghe, 1993). Patra *et al.* (1986) found that 16% of total N uptake by maize was from N fixation contributed by legume intercrops, and increased N_2 fixation of cowpea (*Vigna unguiculata*) in intercropping was found. The recovery of ^{15}N was greatest with suppression of the intercrop, with little N contribution from the roots of the legume (Jordan *et al.*, 1993). Estimates of N transfer in intercropping systems must be regarded with caution due to the N sparing effect of the legume that may be mistaken for transfer to maize (Chalk and Smith, 1994).

Estimates of N present in the biomass vary from 80 kg N ha^{-1} from intercropping alternate rows (Singh *et al.*, 1986), 97 kg N ha^{-1} with Mucuna (Mandimba, 1995) and 120 kg N ha^{-1} (Sanginga *et al.*, 1996). Management practices also vary greatly in the literature. Wani *et al.* (1995) found that, even with the removal of the biomass, mineralizable N contents could be increased, while Power et al. (1998) found that maize residue alone increased yields. The amount of N_2 fixed by legumes increased when intercropped with maize, suggesting that competition with maize influences the proportion of N from fixation (Sanginga *et al.*, 1996). To take advantage of the N_2 fixing ability of the legume, the basic principal is that the release of nutrients must be synchronized with crop response and nutrient requirement (Mandimba, 1995).

Generally, no increase (or a decrease) in maize production is found under intercropping systems compared with mono-cropping. It is the land use efficiency, the total usable production from a given area, that increases, due to the co-production of an edible legume (Siame *et al.*, 1998; Adhikary *et al.*, 1991; Khandkar and Nigam, 1996; Mandimba, 1995; Arias and Muñoz, 1983; Ahmed and Gunasena, 1979; Chowdhury and Rosario, 1993). Most increased economic benefit comes from the additional production of a saleable legume (Khan *et al.*, 1996; Abbas *et al.*, 1995; Ahmed and Gunasena, 1979; Francis *et al.*, 1986). Benites *et al.* (1993) found that no intercrop was more productive than mono-cropping its individual components, suggesting the need for an evaluation of the spatial patterns of the cropping systems.

The reduction of competition with maize by intercropping in strips, and choosing legumes of greater N_2 fixing ability to substitute natural resources for purchased inputs (Midmore, 1993) accounts for much of the variation in promoted maize/legume intercrop systems. Myaka (1995) found increased intercrop production with paired rows compared with single rows and earlier intercrop planting; and alternate rows increased maize yields and lowered legume yields (Francis *et al.*, 1986). Intercropping practices may also be more stable over different environments (Rezende and Ramalho, 1994) than mono-cropping.
Increasing the density of the legume intercrop increased N in maize plant tissue (Senaratne et al., 1995). Legume intercrop productivity decreased with lower intercrop populations and increasing maize density (Chowdhury and Rosario, 1993; Tonye and Titi-Nwel, 1996). Different crop arrangements help control soil erosion as well. Combining surface cover with contour strip cropping significantly reduced erosion (Francis *et al.*, 1986). In steeper hillside environments, improving cover can complement, but not replace, other erosion control measures (Walle and Sims, 1998). Considering the relevant socio-economic factors of resource availability and risk aversion. Peter and Runge-Metzger (1994) determined that a combination of mono/intercropping and rotation were optimal, further complicating the intercropping panorama.

The application of chemical N fertilizer has been found to dominate the intercrop benefits to maize yield (Siame *et al.*, 1997; Power et al., 1998). Effects range from zero with N fertilizer application at planting (Ramirez, 1972) and no response to intercropping without fertilizer (Hesterman *et al.*, 1992); to an interaction between intercrops and N fertilizer (Power *et al.*, 1998; Siame *et al.*, 1998). Increased fertilizer use efficiency has been observed (Obiagwu, 1995), but sensitivity analysis of N fertilizer costs is always required (Nair *et al.*, 1979) for an adequate economic analysis.

Despite improved soil properties from cover cropping, a need for fertilizer for the succeeding crop is recognized (Adhikary *et al.*, 1991; Obiagwu, 1995). Comparison of practices labelled organic may be misleading, when inadequate comparisons are made (Mausolff and Farber, 1995). Reeves *et al.* (1997) found 100 kg N ha^{-1} incorporated from legume biomass increased maize yield compared with 100 kg ha^{-1} fertilizer N, presumably due to the addition of other nutrients present in the biomass as well as the benefits of incorporating a legume into the soil as in a typical crop rotation. Improved soil fertility status does not always raise succeeding maize yield (Khandkar and Nigam, 1996) and requires further intensification with fertilizer or irrigation (Khan *et al.*, 1996). Legumes other than *Phaseolus* spp. that fix greater quantities of N may be needed to raise yields in succeeding maize crops (Pilbeam *et al.*, 1995).

Materials and Methods

The study was conducted at the Pan-American Agriculture School, Francisco Morazán, Honduras (14 00' N, 87 05'W). The soil is classified as a Typic Ustifluvent, loamy, isohyperthermic. Maize was grown in the traditional way as practised by local farmers: two seeds per planting location, with a row spacing of 0.9 m and inter-planting distance of 0.4 m, to give a seeding rate of 55,555 ha^{-1}. Legume intercrops of Mucuna (*Mucuna pruriens* (L.) DC. var. utilis), Canavalia (*Canavalia ensiformis* (L.) DC.) and Dolichos (*Lablab purpureus* (L.)) were sown between plantings of maize with a seeding rate of 55,555 ha^{-1} 7-21 days after maize emergence, depending on rainfall. In 1996 and 1997 a mulch of cut Vetiver grass (*Vetiveria zizanioides* (L.) Nash) was applied, at approximately 3 t ha^{-1} biomass, as an additional treatment to blocks 5, 6 and 7.

A basal fertilization typical of farmer practice (42 kg N ha^{-1}, 13 kg P ha^{-1}) was applied in the form of diammonium phosphate after maize emergence and urea after germination of the intercrop. Lorsban (0,0-diethyl 0-(3,5,6-trichloro-2 pyridinyl) phorthioate) was used for control of *Spodoptera* spp. pests when they appeared. Pre-planting weed control was with glyphosate (N-(phosphonomethyl) glycine). Both chemicals were applied at rates recommended by the manufacturers.

The experimental design comprised randomized complete blocks with seven replications. Each plot measured 5 m by 7 m and consisted of 7 maize rows. Additional areas were sown for destructive sampling of the intercrop contiguous to each plot. Maize yield, biomass production of the legumes and their N content were measured, and the incidence of disease recorded. All maize was bent over (doblado) as is local practice, to protect the cobs from rain and birds. The five inner rows of maize were harvested at physiological maturity, and grain yield adjusted to 14% moisture. The biomass of the legume intercrops was measured by sampling three plants at random from each plot at approximately two week intervals. Dry matter was determined by drying at 60 C for 48 hrs. N content was measured by micro-kjeldahl, for foliar samplings of the legume intercrop. Other macro-nutrients (P, K, Ca, Mg) were determined by atomic absorption.

The results were analysed using ANOVA and treatments compared by LSD ($\alpha \leq 0.10$) and orthogonal contrast (intercrop vs. mono-cropping).

Results

Grain yield

Differences occurred between years, but no treatment by year interaction was found (Table 1). In the first year, 1995, mono-cropped maize and maize intercropped with Canavalia yielded more than the other intercrops. No difference was found between mono and intercropping treatments in 1996. All yields were greater in 1997 than in the two previous years, with mono-cropped maize yielding more than intercropped maize. Orthogonal contrast between treatments showed that intercropping lowered maize yields overall.

Intercrop productivity

Biomass: Dolichos produced less biomass than Canavalia in each of the years, and less than Mucuna in 1995 and 1996 (Table 1). Decreases in intercrop biomass for 1997 were a result of limited rainfall after maize emergence, delaying sowing of the intercrop and slowing early development in relation to the maize. Reduced intercrop biomass in 1997 correlates with overall higher maize yields in that year, further suggesting that competition favoured maize. Under conditions that favour the maize, such as the later sowing of the intercrop in 1997, Canavalia produced more biomass than the other legumes, suggesting that it is a more versatile legume for intercropping. When conditions favoured the intercrop, Mucuna may produce more biomass during maize growth than Canavalia, such as in 1996.

Nutrient content: N content in the intercrop biomass decreased at maturity, although the accumulation of biomass showed significant potential additions of N to the cropping system. Accumulation of other macro-nutrients in the biomass contribute to the recycling of nutrients within the system. Estimates of nutrients in the intercrop biomass are presented in Table 2, for comparison with chemical fertilization.

The possible N contributions of the legume intercrops ranged from 27-88 kg N ha^{-1}, but did not increase maize yield. This is roughly equivalent to the application of 45-135 kg urea ha^{-1}, rates at which a positive crop response would be clear under local conditions.

Disease incidence: No significant difference for pests was noticed between cropping systems, although there were significant block effects in the incidence of *Spodoptera* and *Mocis* spp. An important problem in Honduras is the incidence of maize ear rot, *Stenocarpella maydis* (Berk.) Sutton.

In 1995 the incidence of maize ear rot was less in Canavalia and mono-cropped maize than in intercrops of Mucuna and Dolichos (Figure 1). In 1996 the incidence of ear rot was greater in Dolichos than the other intercrops and mono-cropped maize. The application of Vetiver mulch gave the lowest incidence of maize ear rot. This may be accounted for by the lack of a previous season's maize residue in the plots. In 1997 Canavalia produced the highest incidence, there was no difference between the other treatments. Significant variations between years were noted with maize ear rot increasing for Canavalia and decreasing for Mucuna. Adequate explanations for the variations are not available from the data.

Table 1. Maize yield and intercrop biomass (kg ha^{-1}), 1995-1997, Francisco Morazán, Honduras

	1995		1996		1997	
Treatment	Legume	Maize	Legume	Maize	Legume	Maize
Monocrop		3311 a		1745		5060 a
Mucuna	6761 a	1134 b	8147 a	1521	1189 b	3464 b
Canavalia	7501 a	2353 ab	6410 b	1591	2966 a	4178 b
Dolichos	2965 b	1562 b	4156 c	1428	1178 b	3768 b

Means within a column followed by a different letter are different by $LSD_{0.10}$.

Table 2. Foliar analysis and nutrient content of legume biomass, 1997, Francisco Morazán, Honduras

Legume	N	P	K	Ca	Mg
			%		
Canavalia	2.97	0.32	2.70	0.82	0.23
Mucuna	2.88	0.31	2.14	0.67	0.26
Dolichos	2.33	0.23	2.54	0.73	0.24
			kg ha^{-1}		
Canavalia	88	9	80	24	7
Mucuna	34	4	25	8	3
Dolichos	27	3	30	9	3

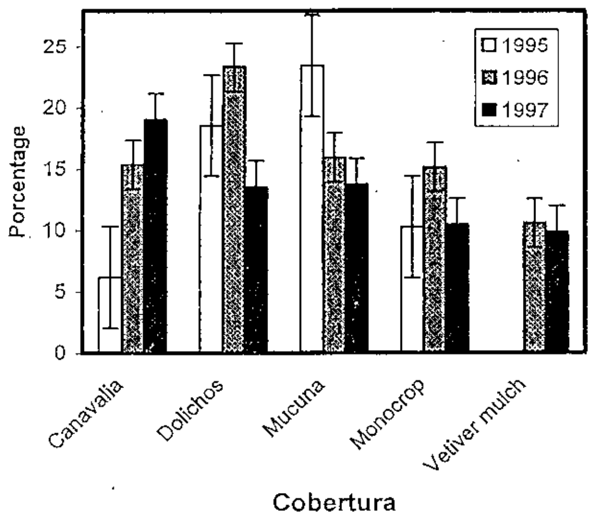

Figure 1. Incidence of maize ear rot, *Stenocarpella maydis* (Berk.) Sutton, 1995-1997, Francisco Morazán, Honduras. Error bars represent $LSD_{0.10}$.

Conclusions

Intercropping maize with the studied legumes may not improve maize production in the ustic areas of Honduras. Canavalia, Mucuna and Dolichos did not increase maize yields, and in two of three cropping seasons suppressed them. Although the legumes studied accumulated significant amounts of N in the biomass, this was not translated into greater maize yields, due to competition with the maize and a release of nutrients that was not synchronous with crop growth.

Where other factors such as land availability and rainfall permit, the legumes in this study should be considered for use in rotation systems to improve soil fertility and crop production. The interaction with additional chemical fertilizer, both N and P because of their limited quantities in the biomass, should be considered, rather than insistence on the replacement of chemical fertilizer to meet non-agricultural objectives. Where rotation is not feasible, edible legumes should be considered for increasing total food production on available land.

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