

## **Effects of Intercropping Groundnut and Green-Manure Legumes to Corn on the Yields of Corn and Productivity and Chemical Properties of Soil**

**A. Suwanarit<sup>1</sup>, N. Lekhasoonthrakorn<sup>1</sup>, J. Rungchuang<sup>2</sup>, and S. Kritapirom<sup>1</sup>**

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### **ABSTRACT**

As an effort to find green-manure production methods that did not need complete devotion of land during the cropping season, a field experiment with three successive annual cropping was conducted in Thailand to examine effects of repetitive intercropping groundnut and green-manure legumes to corn for two successive years on the yields of the intercropped corn and soil productivity and chemical properties. Groundnut and green-manure legumes, which included creeping thornless mimosa, rice bean, sword bean, pigeon pea and lab lab, were intercropped to corn plants, which were grown with double-row spacing, and allowed to continue growing after harvesting and cutting down the stubble of the intercropped corn and were then chopped and plowed into the soil at about one month before the following annual cropping (9-10 months after planting). Productivity of the soils were compared in the third cropping in which the plots for all of the treatments were planted to corn.

Grain yields of corn intercropped with groundnut, lab lab, mimosa, pigeon pea, rice bean and sword bean in the first cropping were 102%, 92%, 86%, 79%, 76%, and 73% of that of the sole corn, respectively, whereas those obtained in the second cropping were 116%, 166%, 190%, 185%, 151%, and 123% of that of the sole corn, respectively. Grain yields of corn grown in plots previously cropped to corn-mimosa intercrops, corn-pigeon pea intercrops, corn-lab lab intercrops, corn-sword bean intercrops, corn-rice bean intercrops and corn-groundnut intercrops were 230%, 186%, 177%, 131%, 123%, and 112% of that of the plots previously treated with the sole corn. In general, the corn-mimosa intercropping system was the best and the corn-pigeon pea intercropping system and the corn-lab lab intercropping system were the second best in improving soil chemical properties. With the planting configuration used, intercropping corn with mimosa was most recommended and intercropping corn with pigeon pea or lab lab was the second most recommended for simultaneous production of green-manure and corn.

**Key words** : chemical properties, corn, intercropping, legumes, productivity, soil, yields, green manure

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1 Department of Soil Science, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

2 The National Corn and Sorghum Research Center, Kasetsart University, Pakchong, Nakhon Ratchasima, Thailand.

## INTRODUCTION

The advantages of growing green-manure legumes for plowing into the soil prior to planting of crop have been well recognized and practiced in many countries (Allison, 1973). However, very few Thai farmers have adopted this soil improvement practice though the practice has been strongly recommended by concerned governmental institutions. The main reason for this failure to convince the farmers has been that most of the agricultural areas are rain-fed resulting in limited time for crop production and high risk of crop failure due to drought. Moreover, most of the farmers are poor and always desperately need money. Accordingly, the farmers prefer to use their lands for crop production throughout the growing season rather than to devote their lands during a part of the season for producing green manure. It is therefore of concerns to find soil improvement practices that do not need devotion of land during a part or the whole of the growing season.

Intercropping grain legume to corn have been shown to be beneficial to the intercropped corn when the soil is very poor in N (Thongpae *et al.*, 1977) and to corn grown in the following season (Suwanarit *et al.*, 1989). To enhance growth and N<sub>2</sub> fixation of the intercrop groundnut, Suwanarit *et al.* (1989) arranged corn plants in double row spacing system and grew one or two rows of groundnut in the space between two adjacent double rows of corn plants. Results of their experiment showed that intercropping with the legume had no significant affect on the yields of the intercropped corn. This suggests that with the double-row corn plant spacing it may be possible to intercrop corn with a green-manure legume without drastic reduction in yield of the intercropped corn. This may be a method with which green-manuring legumes and corn can be grown simultaneously. Moreover, the intercrop green manure legume may

be left to continue growing during the fallow period after harvest of the intercropped corn.

As an effort to find methods for growing green-manure legume for soil improvement and producing corn simultaneously, the present experiment was conducted, using the double-row spacing of corn of Suwanarit *et al.* (1989), to examine effects of intercropping groundnut and green-manure legumes to corn on the yield of the intercropped corn and on soil productivity and chemical properties.

## MATERIALS AND METHODS

Three successive field cropping were conducted in three successive years. The first and the second cropping were to repetitively apply the experimental treatments twice and the third was to examine the residual effects of the treatments applied in the two previous years on soil productivity.

### Site and soil

The experiment were conducted on a Pakchong series soil at the National Corn and Sorghum Research Center, Nakhon Ratchasima Province, Thailand. The soil was of Reddish Brown Lateritic Group (Oxic Paleustult). The plow layer soil had a sandy clay loam texture, pH (1:1, soil:water) 6.1, 28.2 gm/kg organic matter, 237 mg/kg available P (Olsen and Dean, 1965), 277.5 mg/kg NH<sub>4</sub>OAc (pH 7.0)-extractable K.

### Design and treatments

A randomized complete block design with 9 treatments and 4 replications was employed. Each plot measured 7.0 m × 7.0 m.

#### The first and the second cropping

The treatments applied in the first and the second years were as follows:

C: sole corn (*Zea mays*, Linn.) grown with

the conventional spacing, 75 cm between rows and 25 cm between hills of one plant.

Cf: as C but 50 kg N/ha was applied.

C+G: double-row corn intercropped with groundnut (*Arachis hypogaea*, Linn.), without fertilizer.

C+Gf: as C+G but 50 kg N/ha was applied.

C+M, C+R, C+S, C+P and C+L: as C+G but creeping thornless mimosa (*Mimosa invisa*, Mart. ex Colla), rice bean [*Vigna umbellata* (Thumb.) UHWI and UHASH.], sword bean [*Canavalia gladiata* (Jacq.) DC], pigeon pea [*Cajanus cajan* (L.), Huth.] and lab lab [*Lablab purpureus* (L.), Sweet], respectively, were used instead of groundnut and the intercrop legumes were allowed to continue growing during the dry season until the land preparation for the following cropping.

For intercrop systems, two rows of the legume were grown between corn double rows of which spacing were 150 cm between the centers of adjacent double rows, 40 cm between the two rows within each double row and 25 cm between hills of one plant. Spacing for the intercrop legumes was 40 cm between rows and 12.5 cm between hills. Two plants in the cases of lab lab and sword bean and three plants in the cases of groundnut, mimosa, rice bean and pigeon pea were grown per hill. Crop varieties were Suwan-3 corn and Tinan-9 groundnut. Ammonium sulfate, as N source for all of the N fertilizer, was applied by banding between the two rows of each double row of corn at planting. No basal fertilizer was applied. The planting of all plants was done on July 28, 1993 for the first cropping and August 29, 1994 for the second cropping.

### Third cropping

In the third cropping, all plots for the treatments of the first and second cropping were planted to KU hybrid-3504 corn on August 15, 1995. The plant spacing was the recommended one, 75 cm

between rows and 25 cm between hills of one plant.

### Irrigation and harvest

To ensure adequate moisture supply, supplemental irrigation was applied during the growing periods when the moisture supply from rains was insufficient. In the first cropping, harvest of corn and groundnut were done after maturity of each crop. Only pods of sword bean, lab lab and pigeon pea were harvested. Mimosa and rice bean pods were not harvest because it was presumed that mimosa pods will not be harvested in the farmers' practice and the rice been yielded very few pods. In the second cropping, corn and groundnut were harvested at 69 days of age because they were damaged by rain storm. However, the other legumes were left to continue growing. In the third cropping, harvest was done after maturity of corn.

### Biomass management

Corn and groundnut stubble of the first and the second cropping were left on the soil surface until land preparation for the following cropping in which the residue was plowed into the soil. All of the aerial parts of the green-manure legumes, after harvest of pods in the case of sword bean, pigeon pea and lab lab, were chopped and then plowed into the soil. Chopping of the biomass of the legumes and plowing were done at the end of July, 1994 and early August, 1995 for the first and the second cropping, respectively, which were about 1 month before the planting of the following cropping.

### Soil sampling

Soil samples for chemical analysis were taken a few weeks before chopping and plowing the green-manure legumes and plant residues into the soil in land preparation for the third cropping. Within the central area of 5 m × 5 m of each plot, the soil in an area of 75 cm × 25 cm, across the crop rows and along the crop rows, respectively, was

dug up in three separated layers, i.e. layers of 0-15 cm, 15-30 cm, and 30-45 cm depths. The soil obtained from each layer was then well mixed and about 2 kg of the soil was taken, air-dried and crushed to pass a 2-cm sieve for chemical analyses.

### Chemical analyses of soil samples

pH of the soil suspension was measured with pH meter, using soil:water ratio of 1:1. The cation exchange capacity (CEC) was measured according to Chapman (1965), using neutral  $N$   $NH_4OAc$  and 10% NaCl as saturating and replacing solutions, respectively. Organic matter content of the soil was measured according to Walkley and Black (1934). Total N content of the soil was measured by Kjeldhal method (Jackson, 1958), using the  $H_2SO_4 + Na_2SO_4 + Se$  digestion mixture. The available P was measured by Bray II method (Olsen and Dean, 1965). Exchangeable K was measured as described by Pratt (1965), using neutral  $N$   $NH_4OAc$ .

### Chemical analyses of plant samples

Grain and stubble of corn were analyzed for N, P and K contents by semimicro Kjeldhal (Jackson, 1958). Total N in the digest was then measured with micro Kjeldhal distillation method (Bremner, 1965). P content of the digest was measured with the vanadomolybdophosphoric yellow colorimetric method (Jackson, 1958) using a Spectronic-20 colorimeter. K content of the digest was measured by flame photometry.

## RESULTS AND DISCUSSION

### Cumulative effects on crop yields

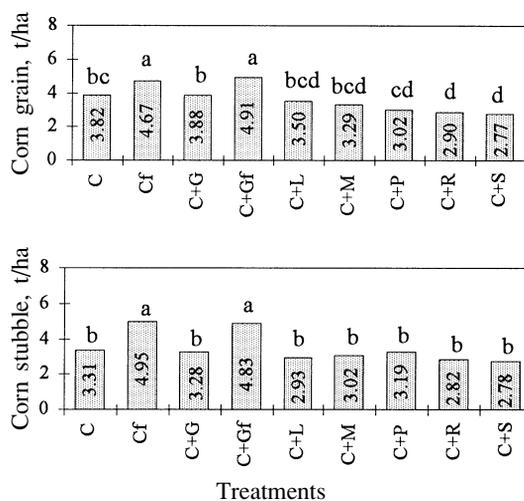
#### Corn yields in the first-year cropping:

Intercropping groundnut to corn in the first year did not show significant affect on grain and stubble yields of the intercropped corn, regardless of N fertilizer application (Figure 1). However,

intercropping rice bean and sword bean reduced both grain and stubble yields of the intercropped corn while intercropping the other legumes, i.e., mimosa, pigeon pea and lab lab showed trends to reduce yields of the intercropped corn. Grain yields of corn intercropped with groundnut, lab lab, mimosa, pigeon pea, rice bean and sword bean were 102%, 92%, 86%, 79%, 76% and 73 % of that of the sole corn, respectively.

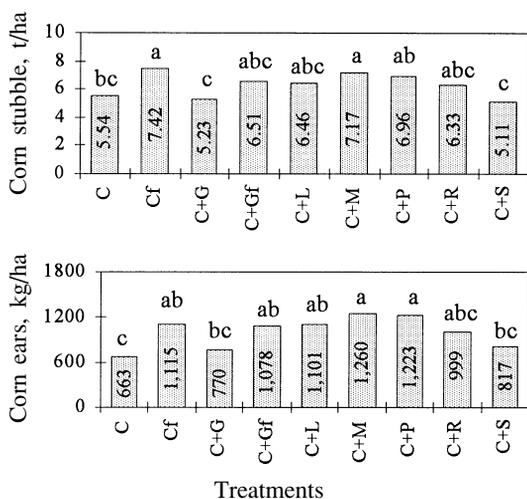
#### Corn yields in the second-year cropping:

In the second-year cropping, ear (de-husked) and stubble yields of corn intercropped with groundnut



**Figure 1** Grain (15% moisture) and dry stubble yields of corn in the first-year cropping as affected by the N fertilizer and legume intercropping. Within each group, bars with a common letter were not significantly different by DMRT.05. % CV: 14.1 for grain; 12.8 for stubble. C = sole corn; Cf = sole corn with 50 kg N/ha; C+G, C+L, C+M, C+P, C+R and C+S = corn intercropped with groundnut, lab lab, mimosa, pigeon pea, rice bean and sword bean, respectively; C+Gf = corn intercropped with groundnut with 50 kg N/ha.

were comparable to those of the sole corn and markedly increased by the N fertilizer, showing that the soil was very low in N supply (Figure 2). The corn-mimosa, corn-pigeon pea and corn-lab lab intercrops were generally superior to the sole corn in corn yield production whereas the corn-rice bean and corn-sword bean intercropping systems showed only trends to be superior to the sole corn system. Using the corn ear yields for estimation, grain yields of corn intercropped with groundnut, lab lab, mimosa, pigeon pea, rice bean and sword bean were 116%, 166%, 190%, 185%, 151% and 123% of that of the sole corn, respectively. These results showed that beginning from the second repetitive cropping the yield of the corn intercropped with any of the legumes would be higher than the yield of sole corn, with the yield of corn intercropped with mimosa being the highest and those of corn intercropped with pigeon pea and lab lab were the second highest and the third highest, respectively.



**Figure 2** Dry ear and dry stubble yields at 69 days of age of corn in the second year cropping as affected by the N fertilizer and different corn-legumes intercropping. CV: 14.1 for grain; 12.8 for stubble. Refer to Figure 1 for captions.

**Legume yields:** The yields of the intercrop legumes in the first and the second cropping are shown in Table 1. Kernel and stubble yields of the intercrop groundnut in the first-year cropping and total dry matter of the groundnut at 69 days of age in the second-year cropping were decreased by the N fertilizer. These effects might be attributed to the increased growth, and accordingly increased shading and competition for other growth factors of the intercropped corn. Before chopping and plowing into the soil after the first cropping, dry weights of shoots of the green-manure legumes ranged from 2.1 to 11.3 t/ha, with that of the pigeon pea being the highest and that of the sword bean being the lowest. In the second cropping, dry weights of shoots of the green-manure legumes ranged from 1.3 to 4.8 t/ha, with that of the sword bean being the highest and that of the mimosa being the lowest. Before chopping and plowing into the soil after the second cropping, dry weights of shoots of the green-manure legumes ranged from 1.9 to 15.0 t/ha, with that of the pigeon pea being the highest and that of the rice bean being the lowest.

### Residual effects on the soil

**Soil productivity:** Grain yields and total dry matter (DM), i.e. dry weight of all aerial parts, of corn grown in the third cropping are shown in Figure 3. The results on grain yields and DM of corn showed that all of the intercrop green-manure legumes improved soil productivity. The corn-mimosa intercropping system was the best and corn-lab lab and corn-pigeon pea intercropping systems were the second best in this aspect. The plots planted to corn-mimosa, corn-pigeon pea, corn-lab lab, corn sword bean, corn-rice bean, and corn-groundnut intercropping systems produced grain yields that were 230%, 186%, 177%, 131%, 123% and 112%, respectively, of that of the sole corn system.

**Table 1** Grain (13 % moisture), kernel (13 % moisture) and dry stubble yields and total dry matter (DM) (t/ha) of the intercrop legumes at harvest of the intercropped corn and before plowing into the soil<sup>1</sup>.

Treatments	First cropping			Second cropping		
	At corn harvest		Stubble (dry) before plowing	DM at corn harvest	Before plowing	
	Kernel	Stubble			Grain	Stubble
C + G	0.18	2.5	-	3.1	-	-
C + Gf	0.14	1.4	-	2.6	-	-
C + L	nd	nd	3.9	1.8	1.5	4.0
C + M	nd	nd	4.1	1.3	nd	4.4
C + P	nd	nd	11.3	2.7	2.1	15.0
C + R	nd	nd	3.1	2.0	nd	1.9
C + S	nd	nd	2.1	4.8	1.4	5.3

1 Stubble yields of groundnut included the roots whereas those of the other legumes did not; DM included roots and, in the case of groundnut, pods; nd = not determined.

**N status:** The corn-mimosa intercrops produced the largest amount of N in shoot (i.e. the amounts of N in all aerial parts) of corn and the corn-lab lab and corn-pigeon pea intercrops produced the second largest (Figure 4). The results suggested that the corn-mimosa intercropping system was the best and the corn-lab lab and corn-pigeon pea intercropping systems were the second best in improving N status of the soil. All of the other intercropping systems produced amounts of N in shoot that were comparable to that of the sole corn.

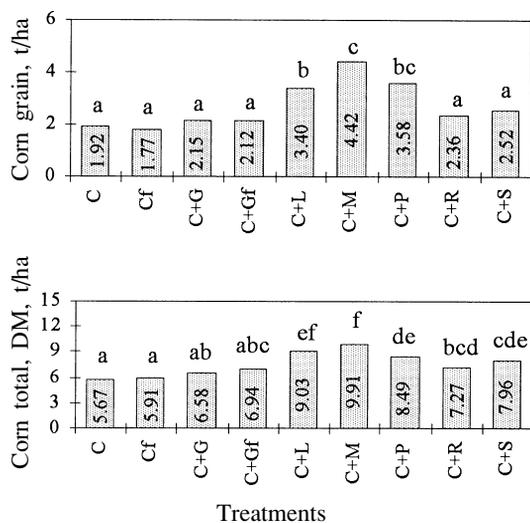
**P status:** Only the corn-pigeon pea intercropping system produced larger amounts of P in shoot (i.e. the amounts of P in all aerial parts of corn) than the sole corn system (Figure 4). All of the other treatments, except the sole corn with 50 kg N/ha, showed only trends to produce larger amounts of P in shoot than that of the sole corn system. These results suggested that the corn-pigeon pea intercrops was the best in improving P status of the soil.

**K status:** The amounts of K in shoot showed that all of the intercropping systems, but corn-groundnut intercropping system without N fertilizer, were superior to the sole corn system (Figure 4). The results suggested that the corn-mimosa intercropping system was the best and the corn-lab lab the second best in improving K status of the soil.

**pH:** All of the intercropping systems were comparable in their effects on pH of soils in the 0-15 cm and 15-30 cm layers (Figure 5).

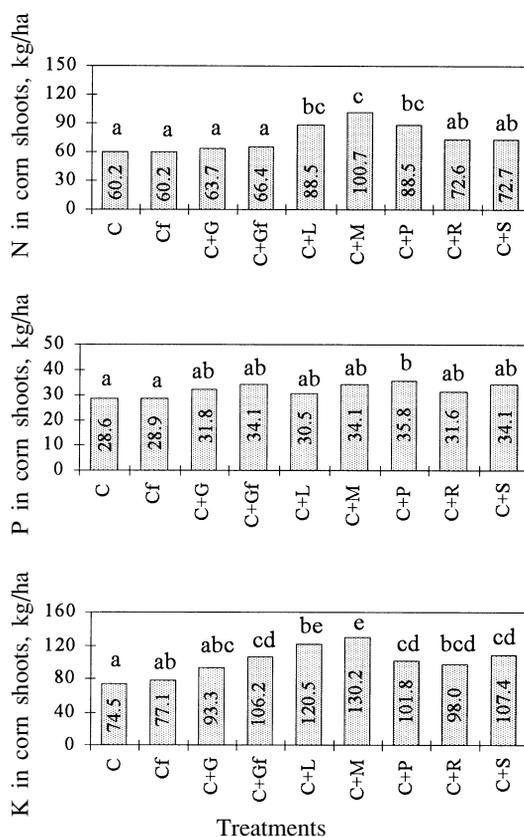
**CEC:** Only the corn-mimosa and corn-sword bean intercrop systems gave higher cation exchange capacities (CEC) of the soils in the 0-15 cm layer than the sole corn system. All of the other systems gave CEC's that were comparable to that of the sole corn system (Figure 6). All of the cropping systems gave comparable CEC's of the soils in the 15-30 cm layer.

**OM:** Organic matter (OM) contents of soils in the 0-15 cm layer of the corn-lab lab, corn-mimosa, corn-pigeon pea and corn-sword bean intercropping systems were higher than whereas



**Figure 3** Grain yields (15% moisture) and total dry matter (DM) of corn in the third year cropping as affected by cropping systems consecutively applied in the previous two years. Bars with a common letter were not significantly different by DMRT.05. %CV: 22.3 for grain; 10.8 for DM. C, sole corn in the previous two years; Cf, sole corn with 50 kg N/ha in the previous two years; C+G, C+L, C+M, C+P, C+R and C+S, corn intercropped with groundnut, sword bean, mimosa, pigeon pea, rice bean and lab lab, respectively in the previous two years; C+Gf, corn intercropped with groundnut with 50 kg N/ha in the previous two years.

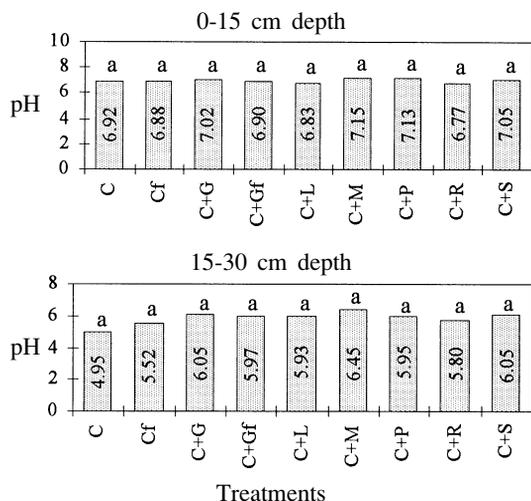
those of all of the other systems were comparable to that of the sole corn system (Figure 7). OM contents of soils in the 15-30 cm layer of all of the intercropping systems, but corn-groundnut intercrops without N fertilizer, were higher than that of the sole corn system. OM contents of soils in the 30-45 cm layer of all of the cropping systems were comparable to that of the sole corn system.



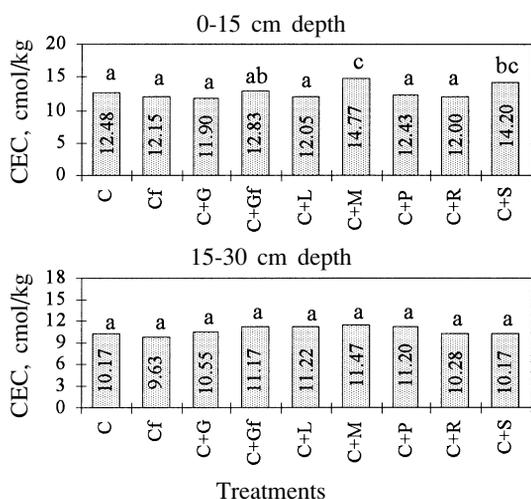
**Figure 4** Amounts of N, P and K in corn shoot as affected by cropping systems consecutively applied in the previous two years. %CV: 14.0 for N; 11.7 for P; 14.0 for K. Refer to Figure 3 for captions.

The results on OM contents of the soils in the 15-30 cm layer suggested that all of the green-manure legumes were superior to groundnut in root penetration into the 15-30 cm soil layer. In general, the corn-mimosa intercropping system was the best and the corn-lab lab the second best in improving OM content of the soil.

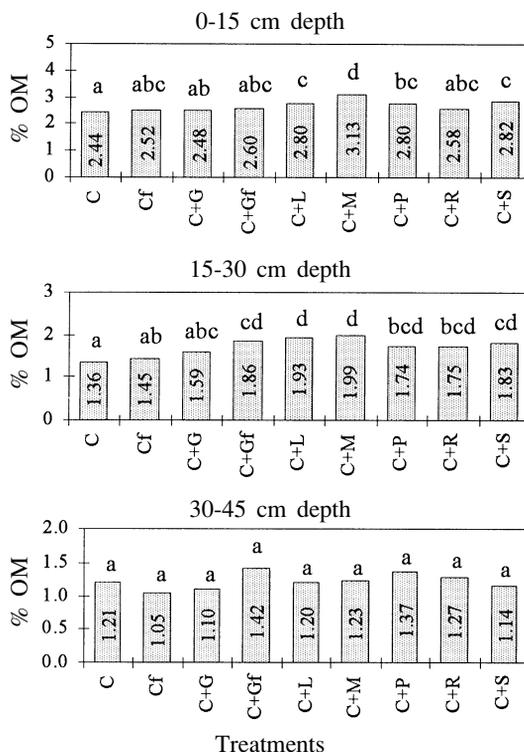
**Total N:** Only the corn-mimosa and corn-lab lab intercropping systems gave higher total N in soils of the 0-15 cm layer than the sole corn (Figure 8). All of the other systems showed only trends to



**Figure 5** pH's of soils in the 0-15 cm and 15-30 cm layers as affected by cropping systems consecutively applied in the previous two years. %CV: 3.3 for 0-15 cm layer; 10.5 for 15-30 cm layer. Refer to Figure 3 for captions.



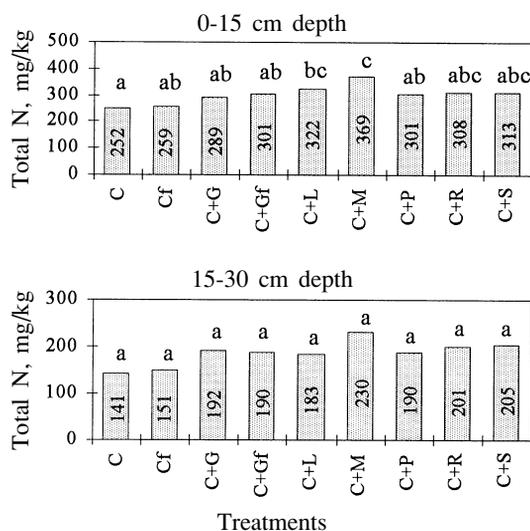
**Figure 6** CEC's of soils in the 0-15 cm and 15-30 cm layers as affected by cropping systems consecutively applied in the previous two years. %CV: 6.9 for 0-15 cm layer; 7.8 for 15-30 cm layer. Refer to Figure 3 for captions.



**Figure 7** Percent of organic matter (OM) of soils in the 0-15 cm, 15-30 cm and 30-45 cm layers as affected by cropping systems consecutively applied in the previous two years. %CV: 6.2 for 0-15 cm layer; 10.2 for 15-30 cm layer and 13.2 for 30-45 cm layer. Refer to Figure 3 for captions.

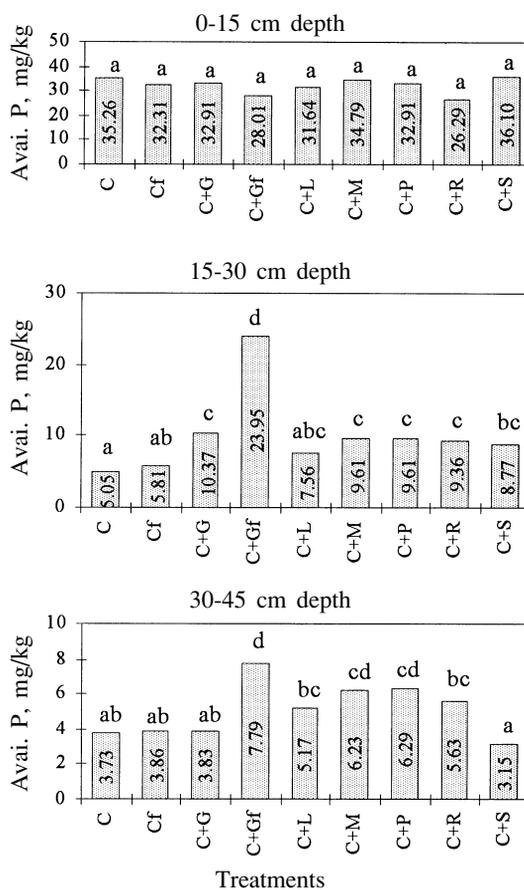
give higher total N than the sole corn. In the case of soils in the 15-30 cm layer, all of the cropping systems showed only trends to give higher total N in the soils than the sole corn system, with the corn-mimosa intercropping system showing the highest trend (Figure 8). In general, the corn-mimosa system was the best and the corn-lab lab the second best in improving the total N.

**Available P:** The amounts of available P in soils of different layers of different treatments are



**Figure 8** Total-N contents of soils in the 0-15 cm and 15-30 cm layers as affected by cropping systems consecutively applied in the previous two years. %CV: 11.1 for 0-15 cm layer; 21.3 for 15-30 cm layer. Refer to Figure 3 for captions.

shown in Figure 9. The results showed that none of the intercrop legumes affected the amount of available P in the plow layer but all of the intercrop legumes increased the amount of available P in the soils of the 15-30 cm layer. All of the intercrop legume, except the groundnut when grown without N fertilizer and sword bean, increased the amount of available P in the soils of the 30-45 cm layer. Application of the N fertilizer to the intercropped corn dramatically increased the effect of the intercrop groundnut on the amount of available P in the soils under the plow layer. It may be note worthy that both corn and groundnut were harvested at 69 days of age which was at pod-forming stage of groundnut. At this stage of groundnut, P in the plant was presumably accumulated in the root for pod formation. The application of N fertilizer to the intercrop corn resulted in higher competition for P between corn and groundnut in the intercropping



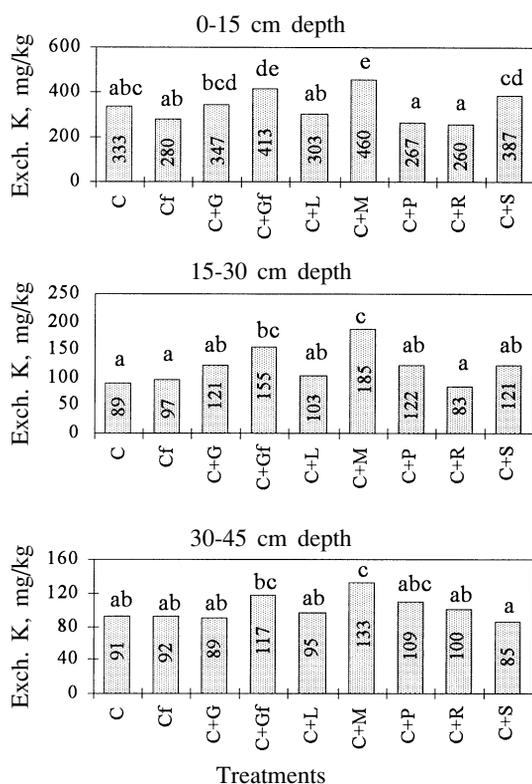
**Figure 9** Available-P contents of soils in the 0-15 cm, 15-30 and 30-45 cm layers as affected by cropping systems consecutively applied in the previous two years. %CV: 16.5. for 0-15 cm layer; 16.5 for 15-30 cm layer and 20.4 for 30-45 cm layer. Refer to Figure 3 for captions.

system and accordingly in more groundnut root penetration down to the soil under the plow layer. This resulted in accumulation of P in groundnut roots in the soil under the plow layer and P in this form was recovered by the analysis of available P. This may explain why the N-fertilizer applied to the intercropped corn increased the amount of

extractable P.

**Exchangeable K:** The amounts of exchangeable K in the soils of different layers of different treatments are shown in Figure 10. The corn-groundnut intercrops without N fertilizer, corn-groundnut intercrops with N fertilizer, corn-mimosa intercrops and corn-sword bean intercrops gave higher exchangeable K in soils of the 0-15 cm layer than the sole corn. Only the corn-groundnut intercrops with N fertilizer and the corn-mimosa

intercrops gave higher exchangeable K in soils of the 15-30 cm and 30-45 cm layers. In general, the corn-mimosa intercrops showed the largest effect and the corn-groundnut intercrops with N fertilizer the second largest effect in increasing the amount exchangeable K. The dramatic effects of N fertilizer applied to the intercropped corn, especially in the cases of soils in the 15-30 cm and 30-45 cm layers may be explained in a way similar to that for the effects of N fertilizer on the amounts of available P given above.



**Figure 10** Exchangeable-K contents of soils in the 0-15 cm, 15-30 cm and 30-45 cm layers as affected by cropping systems consecutively applied in the previous two years. %CV: 11.5 for 0-15 cm layer; 23.1 for 15-30 cm layer and 15.9 for 30-45 cm layer. Refer to Figure 3 for captions.

Since the intercrop mimosa produced much lower shoot dry matter yield than the intercrop pigeon pea (Table 1), it was unexpected that intercropping mimosa to corn was most effective in improving soil productivity. However, it was observed that, at the time of chopping and plowing into the soil, the stems of the pigeon pea plants were woody and so large that some of them were 2.5 cm in diameter. This suggested that the stem residue still did not decompose and transform to humus by the time of soil sampling though the stems were chopped into pieces of about 2.5 cm in length. Stems of the mimosa, on the other hand, were more slender and softer than those of the pigeon pea and were presumably decomposed and transformed to humus by the time of soil sampling. In the case of the lab lab shoots which were leafier than the shoots of mimosa were presumably be so readily decomposed that release of N in the residue did not match with crop requirement and much of the residue was converted to CO<sub>2</sub> by the time of soil sampling.

## CONCLUSIONS AND RECOMMENDATION

1) With the planting configuration used in this study, the effects in the first cropping of intercropping legumes to corn varied from slight increases in grain yield to significant decreases in

grain yield depending on kind of the intercrop legume. However, repetitive intercropping with the green-manure legumes in the following years would result in higher grain yields than repetitive cropping with sole corn.

2) The corn-mimosa intercropping system was the best and the corn-pigeon pea intercropping system and the corn-lab lab intercropping system were the second best in improving soil productivity and chemical properties.

3) Intercropping corn with creeping thornless mimosa to corn is most recommended and intercropping corn with pigeon pea or lab lab are the second most recommended for simultaneous production of green-manure and corn.

#### ACKNOWLEDGEMENT

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