Effects of Times and Methods of N-Fertilizer Placement on Yields and Fertilizer Utilization of Maize-Mung Bean Intercrops as Indicated by ^{15}N

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ABSTRACT

A field experiment was conducted, using N^{15}-labelled urea, on a Reddish Brown Lateritic (or Paleustult) soil to examine effects of times and methods of placement of nitrogen fertilizer on the yields and fertilizer utilization of maize-mung bean intercrops.

It was found that, for maize-mung bean intercrops, banding of nitrogen fertilizer 4-cm below the cereal row at seeding was best placement, since it not only gave highest fertilizer utilization efficiency (46%) by the maize, but also tended to give highest maize grain yield. The results suggested that split application of nitrogen fertilizer was not likely to result in an increase in fertilizer utilization efficiency by the cereal.

INTRODUCTION

In Thailand, intercropping has been one of the recommended cropping systems for irrigated areas as well as rain-fed areas, for it help spread the risk of crop failure. For field-crop production, intercropping of legumes to maize has been a recommended system and appreciable research has been done to examine effects of the intercropping legume on maize (e.g. Suwanarit *et al.*, 1974, 1975, 1976 and 1977; Tongpae *et al.*, 1977; Senanarong *et al.*, 1979; and Suwanarit *et al.*, 1979 a and b).

This work was a part of the FAO/IAEA Coordinated Programme on Nuclear Technique in the Development of Fertilizer and Water Management Practices for Multiple Cropping. The main objective was to examine effects of placement methods and time of application on N-fertilizer in maize-mung bean intercropping system.

MATERIALS AND METHODS

Experiment Site and Soil

A field experiment was conducted from Aprils 5 to July 9, 1981 at the National Corn and Sorghum Research Center, Pakchong, Nakornrajsima province. The soil were of clay loam texture classified as Pakchong series. Reddish Brown Lateritic (Paleustult) Great Group. Some properties of the soil are given in Table 1.

Plants and Plant Spacing

Maize grown at 40,000 plants/ha was intercropped with mung bean at 80,000 plants/ha. Plant spacing were 1.00 m between rows and 25 cm between hills of one plant for maize and 1.00 m between rows and 12.5 cm between hills of one plant for mung bean. One mung bean row was in between the adjacent maize rows and thus 50 cm from the maize rows. Both maize and mung bean were grown on ridges of 15 – 20 cm height on the same date. Maize *(Zea mays Linn.)* was of Suwan 2 variety and mung bean *(Vigna radiata Linn.)*. Mung bean was inoculated with appropriate Rhizobium by mixing inoculant with seeds using tapioca paste as sticker.

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Table 1 Properties of the soil before experiment.

Item	Analysis
pH (1 : 1 soil : water)	5.2
O.M. (Walkley and Black's method), %	2.53
Available P. (Bray II's method), ppm P	16.5
Available K (N Ammonium Acetate, pH 7), ppm K	262.7
SO_4 (Acetate-Acetic method), ppm S	163.5
NH_4-N (2 N KCl extraction), ppm N	10.9
NO_3-N (2 N KCl extraction), ppm N	27.7
Total N (Micro-Kjeldalh method), ppm N	2240.0
Texture	Clay loam
CEC, me/100g	19.9

Design and Treatments

A randomized Complete Block design with 6 replicates and 10 treatments was employed. Descriptions of Treatments are given in Table 2. Each plot was divided to yield subplot (4.0 × 6.0 m) and isotope subplot (4.0 × 1.5 m). The isotope area of each subplot was 3.0 × 1.5 m. The harvest areas were 2.0 × 1.0 m for Isotope Subplot and 3.0 × 5.5 m for yield subplot. The yield Subplot was for plant yields and nitrogen uptake whereas isotope subplot for ^{15}N-content of the plants.

For the Split Treatments, top dressing was done at 30 days of plant age.

Nitrogen fertilizer (80 kgN/ha) was applied as urea (46% N) to all Treatments except for N_8. Urea with 1% N^{15} a.e. and 3% N^{15} a.e. were used for the Non-split Treatments and Split Treatments, respectively.

Table 2 Description of Treatments

Treatment	Description
N_1	N broadcast uniformly and **incorporated over entire plot** at seeding (sub-plot labelled)
N_2	N broadcast and **incorporated near maize** row at seeding (sub-plot labelled)
N_3	N banded **near the maize row** (4 cm below seeds) at seeding (sub-plot labelled)
N_4	Split application : one-half N broadcast and incorporated at seeding **(sub-plot labelled)**; one-half side-dressed to the maize at 4 weeks after seeding by banding near maize row (non-labelled)
N_5	Split application : one-half N broadcast and incorporated at seeding (non-labelled); one-half side-dressed to the maize at 4 weeks after seeding by banding near maize row **(sub-plot labelled)**
N_6	Split application : one-half N incorporated near the maize **(sub-plot labelled)**; one half side-dressed to maize (non-labelled)
N_7	Split application : one half N incorporated near the maize (sub-plot non-labelled); one-half side-dressed to maize **(sub-plot labelled)**
N_8	No N-application
N_9	**Sole mung bean** with 80 kg.N/ha uniformly broadcast and incorporated over entire plot at seeding (non-labelled)
N_{10}	Sole maize with 80 kg.N/ha uniformly broadcast and incorporated over entire plot at seeding (non-labelled)

Basal Fertilizers

Double superphosphate at 120 kg available P_2O_5/ha and muriate of potash at 60 kg K_2O/ha were applied as basal fertilizers by uniformly broadcast and incorporated over the entire plot at seeding.

Weed and Pest Controls

Weed control was performed by hoeing twice, at 10 days and 25 days after seeding.

Since the mung plants were severely infested by leaf hopper *(Empoasca sp.)*, Furadan 3% (2-3 dihydro-2, dimethyl-7-benzofuranyl methyl carbamate) was applied at the rate of 37.5 kg/ha by banding on the mung rows at 47 days of plant age.

Irrigation

The plants were essentially rain fed. However, supplemental irrigation was performed, with sprinklers, when the plants began to wilt.

Harvest

Mature mung pods were collected twice, at 57 and 70 days of age. The stubbles were collected at 70 days of age by cutting at soil surface. All fallen leaves were collected immediately after falling.

Maize was harvest at physiologically-mature stage, 95 days of age.

Plant Sample Preparation

Sample plants of maize and mung bean were taken from the harvest area of each Yield Sub-plot and then chopped and mixed well. A Sub-sample was subsequently taken for moisture determination by drying in even at 70°C. The dried samples were then ground for determination of nitrogen content.

All of maize plants and mung bean plants in the harvest area of each Isotope Sub-plot were collected and then chopped and mixed well. Samples were then taken. Further processing was performed as described in the preceding paragraph.

Plant Analysis

Total nitrogen centent in plant samples was determined using semi-microkjeldahl method as decribed by Bremner (1965). N^{15}-content of plant samples of the Isotope Sub-plots were analysed by the Seibersdorf Laboratory of the International Atomic Energy Agency, Vienna, Austria.

Percent Fertilizer Utilization

Percentages of fertilizer nitrogen utilized by the plants were calculated as the following

Fraction of nitrogen in plant derived from fertilizer, fNdff

$$= \frac{\%\ ^{15}\text{N atom excess in plant}}{\%\ ^{15}\text{N atom excess in fertilizer}}$$

% Fertilizer Utilization

$$= \frac{\text{fNdff} \times \text{Total N-uptake}}{\text{Tatal N applied}} \times 100$$

RESULTS AND DISCUSSION

Maize Yields

Grain and stover dry weights of maize of the Yield Sub-plots, are shown in Figure 1. There were no significant different effects of

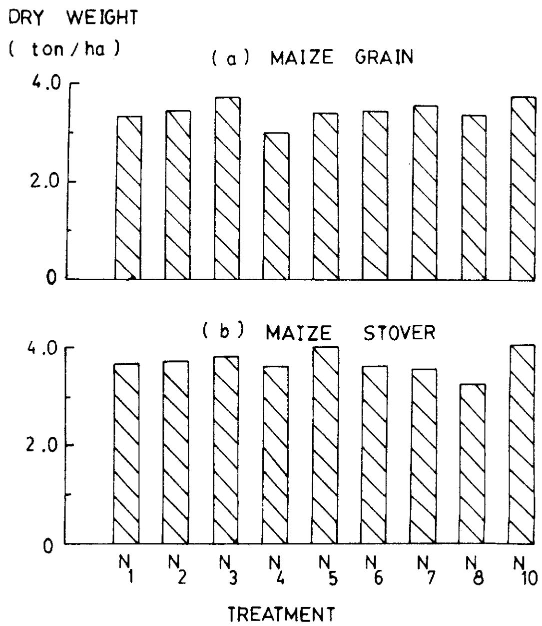

Fig. 1 Dry weights of maize, (a) grain and (b) stover. Differences are not significant at the .05-level in both (a) and (b). % C.V. : for (a) = 11.8, for (b) = 14.9

the Treatments. It may be noteworthy that intercropping mung bean to maize in this experiment did not reduce maize yield significantly. This is in appreciable agreement with finding of Tongpae *et al.* (1977). They reported that intercropping mung reduced the maize yield in one experiment but did not reduce the yields in another experiment. The authors deduced that one or more of the following factors might be responsible for the difference, namely, soil moisture supply, Rhizobium activity, and phosphorus status of the soil. In present experiment, most, if not all, of these factors were appreciably favourable.

Maize yields obtained were comparable to those obtained by Tongpae *et al.* (1977) at similar levels of N-fertilizer from an adjacent plot. It is surprising that no response to N-fertilizer was not obtained in present experiment, for Thongpae *et al.* obtained large response from soil of an adjacent plot of similar cropping history.

Mung Bean Yields

Mung bean grain and stover dry weights, of the Yield Sub-Plots, are shown in Figures 2. The yields were rather too low, presumably due to severe infestation of leaf hopper followed by hopper burn at about early flower-forming stage. It was felt that the desired mung population was too low. Tongpae *et al.*, for example, grew mung bean at two sides of each maize row (1.00 m row spacing) at 300,000 plants/ha.

Only sole mung bean (N_9) gave significantly higher grain and stover yields than other Treatments. Yields of mung bean intercropped to corn were 30 – 40% of those of sole mung bean.

Nitrogen Uptake

Total amounts of nitrogen accumulated in grain and stover of maize are shown in Figure 3. Only the plot with no nitrogen application (n_8) gave significantly lower total nitrogen uptake than some of the other Treatments. Among Treatments other than N_8, there were no significant differences.

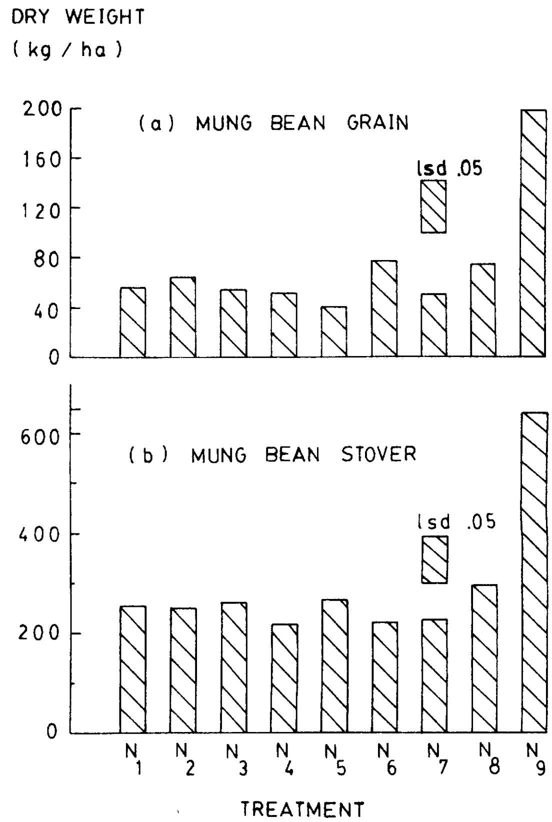

Fig. 2 Dry weights of mung bean, (a) grain, and (b) stover. % C.V. : for (a) = 48.5, for (b) = 27.6

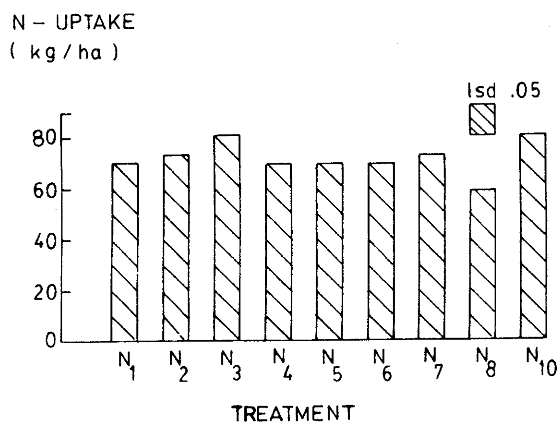

Fig. 3 Nitrogen uptake in grain plus in stover of maize. % C.V. = 12.9

Total amounts of nitrogen accumulated in grain and stover of mung bean are shown in Figure 4. The sole mung bean plots gave

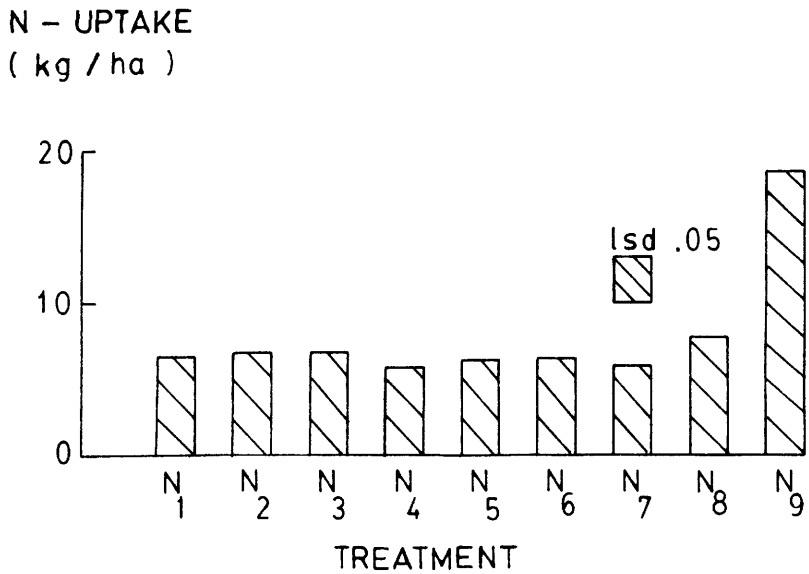

Fig. 4 Nitrogen uptake in grain plus in stover of mung bean (Yield Sub—plot). % C.V. = 29.2

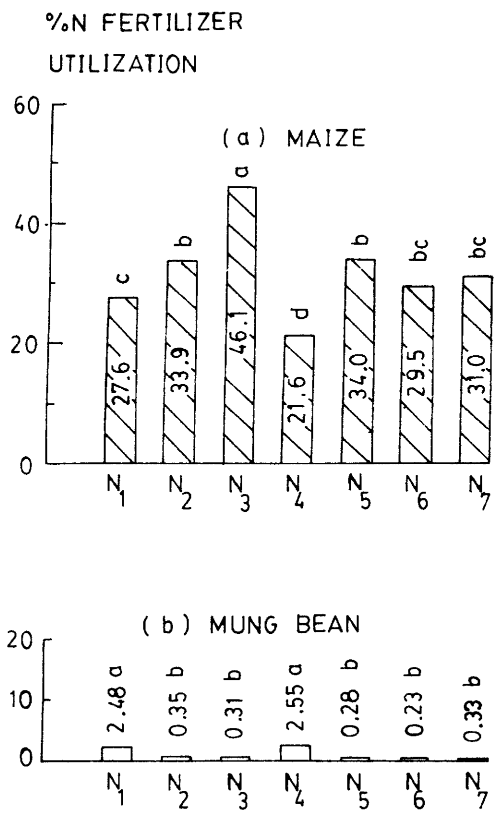

Fig. 5 Percent utilization of nitrogen fertilizer by (a) maize and (b) mung bean. Data with a common letter are not different as determined with lsd .05. % C.V. for (a) = 15.3, for (b) = 16.6

about twice as much nitrogen uptake as other Treatments. Among Treatments other than N_9, there were no significant differences.

Percent Fertilizer Utilization

Percentage of the fertilizer nitrogen utilized by maize and mung bean are shown in Figure 5. Banding of the fertilizer below the maize row at seeding gave the highest percent fertilizer use efficiency of 46.1% by maize. The N-fertilizer use efficiency of maize were in the following order:

Nitrogen applied in band below the maize row at sowing (N_3) > nitrogen applied by broadcasting and incorporating near the cereal (N_2) > nitrogen applied by broadcasting and incorporating uniformly over the plot (N_1) > nitrogen at one half of the rate applied by broadcasting and incorporating uniformly over the entire plot (N_4).

Side-dressing of nitrogen when the maize was about 4 weeks of age was about as effective as broadcasting and incorporating near the cereal at seeding time but was more effective than broadcasting and incorporting uniformly over the entire plot (i.e. by comparing N_7 to N_6 and N_5 to N_4, respectively). Fertilizer use efficiencies of N_2, N_6 and N_7 suggest that split application of nitrogen fertilizer is not likely to result in an increase of efficiency of nitrogen fertilizer applied to the cereal.

Nitrogen applied by broadcasting uniformly and incorporating over the entire plot at seeding (N_1 and N_4) gave higher fertilizer utilization of mung bean than the other placements did. Among the other Treatments there were no significant differences in fertilizer utilization of mung bean. However, fertilizer utilization of the legume was negligible when compared to that of the cereal.

Results from maize of this experiment are in appreciable agreement with those of Estrada (1968) who concluded from non-tagged experiments with sole maize that single application of low rate nitrogen fertilizers (62.5 – 125 kg N/ha) at sowing gave higher nitrogen recovery than split application did, but at a higher rate (250 kg/ha), the later gave higher recovery. Estrada did not find appreciable advantages of split application in plant yields either.

CONCLUSIONS

From present investigation it may be concluded that, for maize-mung bean intercrops banding of nitrogen fertilizer 4 cm below the cereal row at seeding was best placement, since it not only gave highest fertilizer utilization efficiency, but also tended to give highest maize grain yield. Split application of nitrogen fertilizer was not likely to result in an increase in fertilizer utilization efficiency of the cereal.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Bremner, J.M. 1965. Total nitrogen (In) *Methods of soil analysis, part II : Chemical and microbiological properties.* Madison, Wisconsin : American Society of Agronomy. p. 1149-1236 (American Society of Agronomy : Agronomy no. 9)

Estrada, R.J. 1968. Effects of trace elements, the rates and times of Application of nitrogen on the yield and nitrogen uptake of Guatemala corn. Bangkok : Graduate Studies, Kasetsart Univ. 65 leaves. (Thesis M.S.)

Senanarong, Narongsak and others. 1979. Research on cultural practices in corn and corn based cropping system (In) *Thailand National Corn and Sorghum Program : 1979 annual report.* Bangkok : Dept. of Agricultural Extension, Dept. of Agriculture, Kasetsart Univ. and the Rockefeller Foundation. p. 278-284.

Suwanarit, Amnat and others. 1974. Studies on the effects of intercropping legumes on corn (In) *Thailand National Corn and Sorghum Program : 1974 annual report.* Bangkok : Kasetsart Univ. and the Rockefeller Foundation. p. 161-167.

Suwanarit, Amnat and others. 1975. Studies on effects of intercropping legumes on corn (In) *Thailand National Corn and Sorghum Program : 1975 annual report.* Bangkok : Kasetsart Univ. and Dept. of Agriculture. p. 255-261.

Suwanarit, Amnat and others. 1976. Effect of intercropping legumes and corn-legume rotation on corn (In) *Thailand National Corn and Sorghum Program : 1976 annual report.* Bangkok : Kasetsart Univ. and Dept. of Agriculture. p. 229-232.

Suwanarit, Amnat and others. 1977. Effects of intercropping legumes and corn-legume rotation on corn (In) *Thailand National Corn and Sorghum Program : 1977 annual report.* Bangkok : Kasetsart Univ. and Dept. of Agriculture. p. 113-117.

Suwanarit, Amnat and others. 1977. A study on effects of intercropping legume-phosphate and intercropping legume-Rhizobium interactions on corn. Ibid. p. 117-128.

Thongpae, Suthep Amnat Suwanarit and Chairerk Suwannarat. 1977. Effects of soybean, mungbean and peanut intercropped to corn on growth, yields and nitrogen requirement of corn. *J. of Agric. Sci.* 10(6) 553-567. (in Thai)