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UTILIZATION OF UREA FERTILIZER UNDER TRINIDAD CONDITIONS

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ABSTRACT

Field experiments designed to evaluate the effect of applied N^{15} and N, and bagasse (crushed stalk residue of sugarcane) mulch on N uptake and yield of maize were conducted during a 24-month period. The results indicated that the efficiency of use of the applied $(NH_2)_2CO$-N and $(NH_2)_2CO$-N fertilizers could be as high as 45.0% to 105.3% of the added N and that mulching has a beneficial effect on accummulation of N in the maize plant during the dry season. During the wet season, use of mulch resulted in water-logging and created alternating anaerobic soil conditions. Significantly (P=0.05) greater amounts of N were accummulated in plants in the unmulched fertilized plots compared to the uptake by plants in the mulched fertilized plots. In both harvests, use of fertilizer resulted in significantly (P=0.05) greater uptake of N and grain yields. Use of mulch also resulted in significant (P=0.05) increases in grain yield during the dry season, however, during the rainy season mulch had no significant effect on grain yield.

INTRODUCTION

Research on the utilization of nitrogenous fertilizers conducted in the past in the Caribbean region indicated that recovery by the crop to which fertilizer N was added ranged from as low as nil to 100 per cent, depending upon the crop, the nature of the soil, the rate of application and the rainfall conditions.

For pasture crops growing on soils with adequate drainage and with application rates of less than 100 kg N ha^{-1} per application, high recoveries were obtained (Ahmad et al., 1969). Conversely when crops, even pasture crops, are grown on poorly drained soils, the recovery could be just over 20 per cent (Fletcher, 1971). It was also observed that fertilizer use did not result in increases in the total soil N and therefore it was concluded that losses either in gaseous forms or through leaching may be very important.

Evidence also indicates that the recovery of N by small grains is dependent on the soil texture, crop cultivar and general cropping systems. El-Shakweer et al., (1973), showed that uptake was twice as great on a clay soil than on a coarse textured soil. Mohammed (1979) observed that uptake of N by maize from a loam soil varied depending on the cultivar, plant density and rate of fertilizer N application.

The objective of this research was to evaluate the crop utilization of added labelled and unlabelled urea fertilizers.

EXPERIMENTAL TECHNIQUES

Preliminary Experiment

Previous research in the agricultural use of N^{15} was conducted on the movement of N and crop recovery of N (Carter et al., 1967, Janson, 1963, Owens, 1960), on denitrification (Carter and Allison, 1960, Cady and Bartholomew, 1960), and on NH_3 volatilization and NH_4^+ fixation (Legg and Allison, 1959, Overrein, 1968). A preliminary field experiment was carried out employing $(NH_2)_2CO$-N^{15} fertilizer with maize as a test crop. The study was initiated on the 15th November, 1977 as part of the International Atomic Energy Agency Program at the Soil Science Department, University of the West Indies.

The site was located at Field B at the U.W.I. Campus, St. Augustine, which was previously planted to cocoa (**Theobroma cacao**). The soil is a St. Augustine loam which was developed on colluvial material from the Northern Range of Trinidad where the dominant rocks are schists and phyllites rich in muscovite (Ahmad, Personal communication). Smith (1974) classified the St. Augustine series as an Orthoxic Tropudult. All the experiments were conducted on this loam soil.

The experiment was completely randomized and included 8 field plots ($2m^2$ each). The plots were planted with maize (**Zea mays** L. var. Pioneer X304B) at 39 cm spacing in 3 rows which were 60 cm apart, producing 12 plants per plot. The two treatments were mulched and fertilized (MF), and unmulched and fertilized (UMF). $(NH)_2CO$-N^{15} was applied at a rate of 100 kg ha^{-1} (or 10 g N m^{-2}) and bagasse mulch was applied to a depth of 2 cm. The treatments were replicated 4 times.

Soil samples were taken at harvest (120 days after planting), air dried and crushed to 2 mm for analysis of total soil -N^{15}. The plant samples were also analyzed for total -N^{15}. Plant material taken at harvest was prepared for analysis by sorting into stems, leaves and seeds, and these fractions were then oven-dried, ground and analyzed.

Crop Utilization of Added N

Two experiments were conducted on St. Augustine loam between December 1978 to March 1979 and July 1979 to October 1979. These experiments were designed to study the effect of mulching and N fertilization on yield and uptake of maize over seasons. The total area on which the experiments were established amounted to 32 m^2 except for the interbed drains. The area was subdivided into 16 plots each 2 m^2.

A completely randomized design with four treatments and four replicates was used. The four treatments were as follows: Mulched and fertilized (MF), Unmulched and fertilized (UMF), Mulched and unfertilized (MNF), and Unmulched and unfertilized (UMNF).

The fertilizer was applied to the soil at 100 kg N ha^{-1} and Ca $(H_2PO_4)_2$ and KCl were added at rates of 100 g P ha^{-1} and 150 kg K ha^{-1}, respectively. Maize variety Pioneer hybrid X304B was hand planted at 39 cm spacing in 3 rows 60 cm apart. There were twelve plants per plot.

Five whole plants, taken at harvest from each plot, were oven dried at 80ºC, weighed and ground before analysis. Four soil samples per plot were taken for soil moisture measurements at 30 cm depth interval at approximately weekly intervals. Samples were mixed in the field and subsequently oven-dried at 105ºC. Soil samples were also taken at harvest (108-120 days after planting), air-dried and crushed to 2mm for analysis for NO_3^- -N and NH_4^+-N.

RESULTS AND DISCUSSION

Preliminary Experiment

Amounts of $(NH_2)_2CO$-N^{15} fertilizer accumulated by the stems were significantly greater in the mulched plots. However, accumulations in the leaves and seeds (Table 1) were not significantly different. This experiment showed that mulching increased the accumulation of N and suggests that uptake was greatest in these plots. The recovery of N^{15} in the mulched plots was 56 per cent compared to 45 per cent in the unmulched plots. Since only leaves, stems and seeds were analyzed, the result reported would be lower than if the whole plants had been analyzed. Ahmad et al. (1969) obtained recoveries above 50 per cent for pasture crops growing in soils with good drainage when N- application rates were less than 100 kg ha^{-1} per application. Conversely, Fletcher (1971) found that crops grown on poorly drained soils recovered just over 20 per cent of the N added. In experiments utilizing N^{15}, recovery by the plant ranged between 20 and 90 per cent of the total N applied (Carter et al., 1967; Janson, 1963). The results herein presented are within this range.

Table 1. Effect of fertilizer (100 kg $(NH_2)_2CO$-N^{15} ha^{-1} (10% excess N^{15}) and mulch (2 cm depth) on fertilizer -N accumulation in plant parts of maize (1977-78 dry season)

Treatment	Fertilizer-N (mg $plant^{-1}$)		
	Seed	Stem	Leaves
Unmulched	7.7	1.4	1.1
Mulched	9.6	2.0	1.1
LSD (0.05)	1.2	0.5	0.4
C.V.	6.9	13.2	16.6

C.V. = coefficient of variation.

Analysis of soil samples for total -N^{15} indicated no recovery of applied N since per cent excess N^{15} in the samples did not exceed natural abundance (0.366 per cent). In a previous study, Fletcher (1971) observed that fertilizer use did not result in increases in total soil -N, and therefore concluded that losses in either gaseous form or through leaching may have been very important. In the present experiment it seems that the applied N^{15} was taken up by the plant or lost through other processes such as leaching, denitrification or NH_3 volatilization. Since sampling was carried out 120 days after planting, it was not possible to closely categorize the processes involved.

Carter et al. (1967) performed experiments utilizing N^{15} to determine the recovery of fertilizer N under field conditions. $NaNO_3^-$ -N^{15} and $(NH_4)_2SO_4$-N^{15} were applied at different levels. It was shown that consistent losses of N occurred regardless of the form of N added. They suggested that the losses were due to denitrification since they were enhanced with leaching of NO_3^--N^{15} into the lower layers where anaerobic sites were likely to develop.

This preliminary experiment indicated that:

- Unaccounted losses could be as high as 44 to 55 per cent of added N. Leaching and gaseous losses may be responsible for this unaccounted N.

- Mulching has a beneficial effect on accumulation of N in the maize plant.

- A higher level of fertilizer or a 10 per cent excess N^{15} is necessary to achieve a reasonable ratio between field N^{15} and fertilizer N^{15}. In this study 10 per cent excess N^{15} was applied at 100 kg ha^{-1}.

- In similar experiments, NH_4^+-N^{15} and NO_3^--N^{15} in the soil should be periodically measured to trace the fate of applied N^{15} in the soil.

Crop Utilization of Added N

Mean yields in response to the N and mulch treatments in the field plots are shown in Fig. 1. N additions significantly ($P = 0.05$) increased yields and in the fertilized plots mulching increased yields significantly during the dry season (December, 1978-March, 1979). Note that the soil was at field capacity at planting and that as the dry season advanced, the soil water content of the surface layer of the mulched plots did not decrease as rapidly as that of the unmulched plots (Nkrumah, 1982). It is also possible that the other effects of mulching, such as weed control and soil temperature amelioration, might have resulted in beneficial effects for plants growing on mulched plots. However, during the rainy season (July, 1979-October, 1979) adequate moisture was available in both the mulched and unmulched plots (Nkrumah, 1982) and yields were not then significantly affected by the mulch treatment.

Uptake of N for treatments are shown in Fig. 2. Results for both the dry season and wet season showed significant differences between the fertilized and unfertilized plots. During the harvest of 1978-79, differences between uptake from fertilized mulched and unmulched plots were statistically significant ($P = 0.05$). This shows that mulching enhances soil conditions for N utilization through improved soil water relationships (Nkrumah, 1982). However, during the wet season harvest uptake of N was significantly ($P = 0.05$) greater in the unmulched fertilized plots compared to the mulched fertilized plots. Soil moisture measurements (Nkrumah, 1982) showed that mulching contributed to more periodic water-logging of the surface layer (30 cm depth) following heavy rainfall in the wet season, thus creating alternating anaerobic conditions.

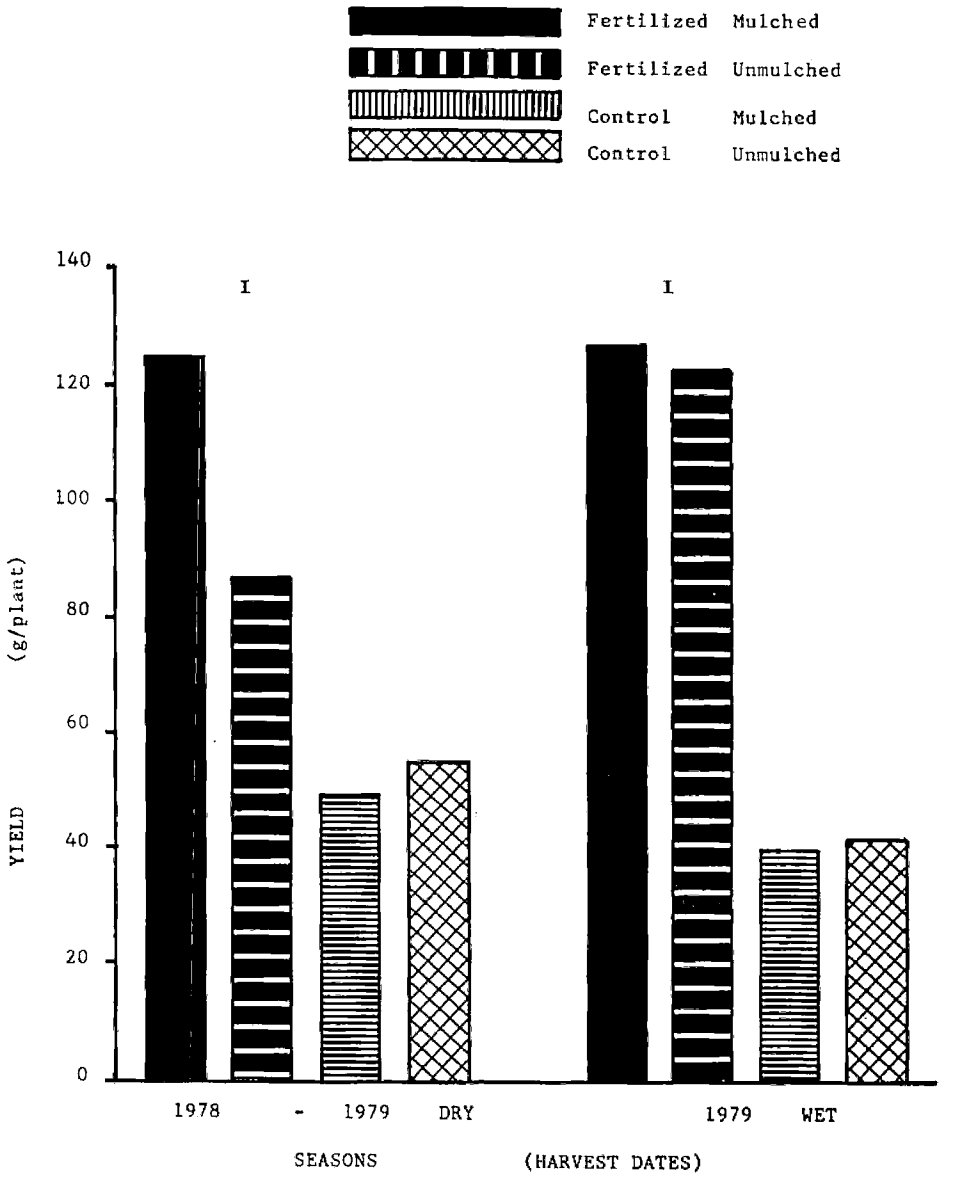

Fig. 1. Effects of fertilizer and mulch on grain yield over seasons.

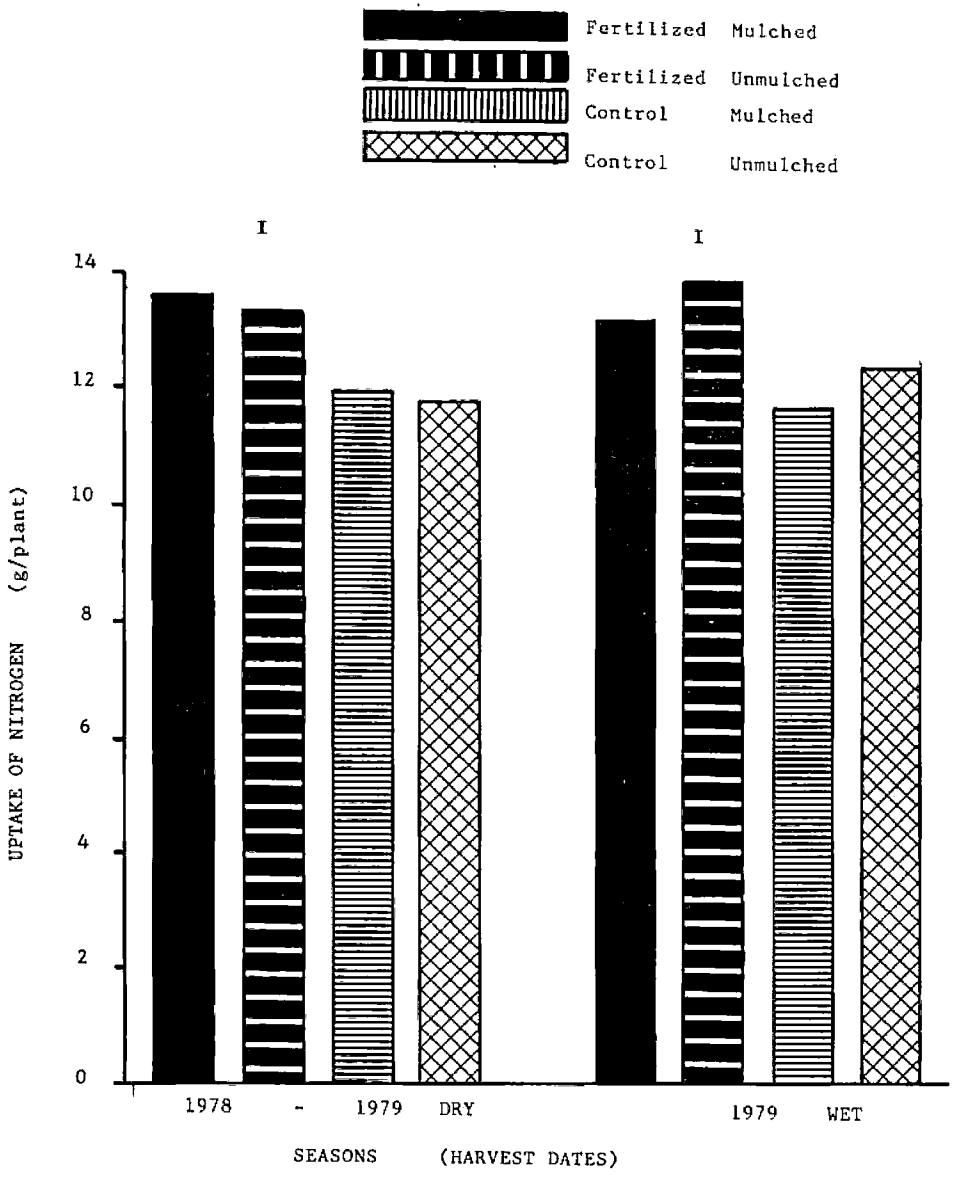

Fig. 2. Effects of fertilizer and mulch on uptake of nitrogen over seasons.

Based on the uptake of N by the plant in the fertilized and unfertilized plots, the efficiency of N fertilizer was calculated and the values were 105.3 per cent and 90.4 per cent in the mulched and unmulched plots, respectively, for the dry season (December, 1978 - March, 1979) harvest. For the wet season (July, 1979 - October, 1979) harvest the values were 85.2 per cent and 92.7 per cent in the mulched and unmulched plots, respectively. These values are high. Pot experiments with small grains and grasses using labelled and unlabelled forms of N showed that uptake of N ranged between 20 per cent to 90 per cent of the total applied (Carter et al., 1967; Grable & Johnson, 1960; Jansson, 1963; Lowenstein et al., 1957). In a preliminary experiment with N^{15} it was shown that recovery by the maize plant ranged from 45 to 56 per cent. The results of that experiment and the values reported for recovery by the maize plant in this section are not strictly comparable since whole plants were measured in the study, whereas analysis of N^{15} uptake in the preliminary experiment was done on leaf, seed and stem portions only, and N^{15} was not recovered in the soil. According to Allison (1965), the two approaches of tracer and non-tracer methods of determining N recovery normally agree closely if the N^{15} in the soil after harvest is included in the calculation. Nevertheless the tracer method is considered to be more accurate (Allison, 1965; Olson, 1978). However, for practical evaluation of fertilizer response, the non tracer method is normally employed (Allison, 1965).

The unaccounted for N ranged from 44 to 55 per cent in the preliminary experiment with N^{15} and 7.3 per cent to 14.8 per cent in the experiment with unlabelled N, except during the dry season when the values for the mulched plots indicated complete recovery. The unaccounted for N is believed to be lost form the soil-plant system in gaseous forms (Legg and Allison, 1967; Martin et al., 1963) or by leaching (Fletcher, 1971 and Carter et al., 1967).

CONCLUSIONS

- Under the experimental conditions outlined the efficiency of use of urea fertilizer by plants could range between 45 to 105 per cent.

- Mulch is a beneficial soil ammendment for dry season farming. However, during the wet season it results in water-logging creating alternating anaerobic soil conditions.

- The major losses under field conditions in Trinidad most likely occurred with gaseous forms of N.

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