

# **STUDIES ON THE EFFICIENT USE OF SOME NITROGEN FERTILIZERS USING TRACER TECHNIQUES**

**BY**

**Emad El-Din Abd El-Hakim El-Aakel**



## **A THESIS**

**SUBMITTED IN PARTIAL FULFILLMENT**

**OF THE REQUIREMENTS**

**FOR THE DEGREE OF**

**MASTER OF SCIENCE**

**IN**

**Agriculture ( Soil Science )**



**Soils Department  
FACULTY OF AGRICULTURE  
AIN SHAMS UNIVERSITY**



**1988**

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ  
وَبِهِ نَسْتَعِينُ

”رَبَّنَا ...

آتِنَا مِنْ لَدُنْكَ رَحْمَةً ...

وَهِيَئْ لَنَا مِنْ أَمْرِ نَارِ شَدًّا “

صَدَقَ اللَّهُ الْعَظِيمُ



ACKNOWLEDGEMENT

The author wishes to express his appreciation to Prof. Dr. T. El-Kobbia, and Prof. Dr. Ismail, Soils Dept., Faculty of Agriculture, and Prof. Dr. M. A. Massoud, Helwan University, Soil and Water Researches, for their valuable advice, supervision and help in the manuscript.

The author also wishes to express his appreciation to Dr. M. E. Ali, Lecturer, Faculty of Agriculture (Moshtohor), for his help and encouragement during the course of the study.

Thanks are also due to the staff of the Water Research Dept., Atomic Energy Research Establishment, for their help and cooperation.

APPROVAL SHEET

Name: Emad El-Din Abd El-Hakim El-Aakel.

Title: Studies on the efficient use of some nitrogen fertilizers using tracer techniques.

This Thesis has been Approved by:

Prof. Dr. A. H. El-Damatty

Prof. Dr. R. S. Abd El-Coul

Prof. Dr. A. S. Ismail

Committee in Charge

Date: / / 1988.

## C O N T E N T S

	Page
I. INTRODUCTION .....	1
2. REVIEW OF LITERATURE .....	3
2.1. Forms of Nitrogen fertilizers .....	3
2.2. Factors affecting utilization of nitrogen fertilizer by rice plants .....	4
2.2.1. Methods of application .....	4
2.2.2. Time of application .....	10
2.2.3. Sources of nitrogen fertilizer .....	12
2.3. Factors affecting hydrolysis of urea in soils ...	14
2.3.1. Amount of added urea .....	15
2.3.2. Soil texture .....	15
2.3.3 Soil reaction .....	16
2.3.4. Soil content of calcium carbonate .....	17
2.3.5. Soil organic matter content .....	17
2.3.6. Soil moisture content .....	18
2.3.7. Effect of soil salinity .....	18
2.4. Nitrification of urea in soils .....	19
2.5. Nitrogen losses from soil .....	21
2.5.1. Volatilization of ammonium from soil .....	23
2.5.2. Bacteria denitrification .....	24
2.5.3. Leaching .....	25
3. MATERIALS AND METHODS .....	26
4. RESULTS AND DISCUSSION .....	35
4.1. Effect of application time and sources of nitrogen fertilizer on rice plants .....	35

	Page
4.1.1. Dry matter .....	35
4.1.2. Content and total uptake of nitrogen .....	41
4.1.3. Content and total uptake of phosphorus .....	48
4.1.4. Content and total uptake of potassium .....	54
4.2. Effect of different sources and placement of nitrogen fertilizer on the growth and nutritional status of rice .....	61
4.2.1. Rice-straw (80 days ) .....	61
4.2.2. Utilization of fertilizer <sup>15</sup> N by rice .....	66
4.2.3. Rice-straw and grains (140 days) .....	68
5. SUMMARY .....	75
6. REFERENCES .....	80
ARABIC SUMMARY	

✓

# LIST OF TABLES

Table		Page
1	Certain characteristics of the soil sample .....	27
2	Effect of different application times of urea and ammonium sulphate on the dry weight of rice straw (80 and 140 days) and grain yield (140 days) .....	36
3	Effect of different application times of urea and ammonium sulphate on N content (%) of rice straw (80 and 140 days) and grain yield (140 days) .....	42
4	Effect of different application times of urea and ammonium sulphate on N uptake of rice straw (80 and 140 days) and grain yield (140 days) .....	45
5	Effect of different application times of urea and ammonium sulphate on P content of rice straw (80 and 140 days) and grain yield (140 days) .....	49
6	Effect of different application times of urea and ammonium sulphate on P uptake of rice straw (80 and 140 days) and grain yield (140 days) .....	51

Table		Page
7	Effect of different application times of urea and ammonium sulphate on K content of rice straw (80 and 140 days) and grain yield (140 days) .....	55
8	Effect of different application times of urea and ammonium sulphate on K uptake of rice straw (80 and 140 days) and grain yield (140 days) .....	57
9	Effect of different sources and placement of nitrogen fertilizers on the dry matter yield of rice straw (80 days), utilization of nitrogen fertilizers and the content and uptake of N, P and K .....	62
10	Effect of different sources and placement of nitrogen fertilizers on the dry matter yield of rice straw and grains (140 days from planting) and the content and uptake of N, P and K .....	69



# LIST OF FIGURES

Figure		Page
1	Effect of different application times of urea and ammonium sulphate on the dry weight of rice straw after (1) 80 days and (2) 140 days from planting .....	37
2	Effect of different application times of urea and ammonium sulphate on dry matter yield in rice grains (2) 140 days from planting .....	38
3	Effect of different application times of urea and ammonium sulphate on the N-uptake in rice straw after (1) 80 days and (2) 140 days from planting .....	46
4	Effect of different application times of urea and ammonium sulphate on N-uptake in rice grains after (2) 140 days from planting .....	47
5	Effect of different application times of urea and ammonium sulphate on the P-uptake in rice straw after (1) 80 days and (2) 140 days from planting .....	52
5(Cont.)	Effect of different application times of urea and ammonium sulphate on P-uptake in rice grains after (2) 140 days from planting .....	53
6	Effect of different application times of urea and ammonium sulphate on the K-uptake in rice straw after (1) 80 days and (2) 140 days from planting .....	58

Figure		Page
6(Cont.)	Effect of different application times of urea and ammonium sulphate on the K-uptake in rice grains after (2) 140 days from planting .....	59
7	Effect of different application methods of (1) deep and (2) surface of urea and ammonium sulphate on N, P and K uptake in rice straw after 80 days from planting .....	63
8	Effect of different application methods of (1) deep and (2) surface of urea and ammonium sulphate on % Ndff and % Ndfs in rice straw after 80 days from planting .....	64
9	Effect of different application methods (1) deep and (2) surface of urea and ammonium sulphate on dry matter in rice straw and grains after 80 and 140 days from planting..	70
10	Effect of different application methods (1) deep and (2) surface of urea and ammonium sulphate on N, P and K-uptake in rice straw after 140 days from planting .....	71
11	Effect of different application methods (1) deep and (2) surface of urea and ammonium sulphate on N, P and K-uptake in rice grains after 140 days from planting .....	72

## I. INTRODUCTION

Nitrogen occupies a unique position among the elements essential for plant growth because of the large amount required by most agriculture crops. The combined nitrogen in soil is largely bound to organic matter and mineral materials, however, only a few kilograms per feddan exist in available mineral forms (as  $\text{NO}_3^-$  and exchangeable  $\text{NH}_4^+$ ) for plant use.

Nitrogen fertilizers application has had by far the most important effects in terms of increasing crop production. Numerous field experiments carried out in the past have shown that for many soils, nitrogen is the most important growth limiting factor. The level of nitrogen that should be applied to a crop depends on the particular crop species and on the prevalent soil conditions.

The major characteristic of submerged soils is the depletion of  $\text{O}_2$  throughout most of the root zone. The greater release of  $\text{NH}_4^+$  during anaerobic decomposition is extremely important for lowland rice culture. In these soils the forms of N present are generally similar to those of upland soils with the exception in the relative

contents of  $\text{NO}_3^-$ -N and  $\text{NH}_4^+$ -N. This difference in behavior of these soils is due largely to the difference in activity of the microorganism under aerobic and anerobic conditions. In a well drained soil, most N transformations are carried out by aerobic or sometimes facultative anerobic bacteria while in submerged soils facultative anerobic and true anerobic bacteria predominate. As in aerobic soils, the major microbial processes involving N in submerged soil are mineralization, immobilization, nitrification, denitrification, and N fixation.

A unique characteristic of flooded soils is that all of these processes could occur at the same time because of the presence of both aerobic and anerobic zones. Thus, N transformation is usually very difficult to evaluate the significance of any single reaction. Therefore, the present investigation was carried out to study the effect of different N forms, proper time and method of applications on dry matter, N, P, K contents and their uptake. Using the tracer technique, the utilization of N fertilizers was studied.

## II. REVIEW OF LITERATURE

### 2.1. Forms of nitrogen fertilizers:

For N fertilization the following fertilizers are commonly used: ammonium sulphate, ammonium chloride, ammonium nitrate, potassium nitrate urea and anhydrous ammonia. For most N fertilizers,  $\text{NO}_3^-$  and  $\text{NH}_4^+$  are the N carriers.  $\text{NH}_4^+$  is partially adsorbed on soil colloids and its uptake rate is usually therefore lower than that of  $\text{NO}_3^-$  under field conditions. For this reason, most crops do not respond as quickly to  $\text{NH}_4^+$  fertilizers as to  $\text{NO}_3^-$  application. On the other hand, the nitrate form is subjected to loss by leaching in coarse textured soils, under high rainfall, Tisdale and Nelson (1975). On the other hand, one form of organic N that can be taken up directly by plants is urea which is considered the primary dry N fertilizer source in agriculture today (Harris and Harre, 1979). Inorganic N that occurs in soil are  $\text{NO}_3^-$  (nitrate),  $\text{NH}_4^+$  (ammonium),  $\text{NO}_2^-$  (nitrite),  $\text{N}_2\text{O}$  (nitrous oxide), NO (nitric oxide) and  $\text{N}_2$  (elemental nitrogen). The last form of nitrogen is inert, except for its utilization by rhizobia and other nitrogen fixing microorganisms. From the standpoint of soil fertility, the  $\text{NH}_4^+$ ,  $\text{NO}_2^-$  and  $\text{NO}_3^-$  forms are of

greatest importance. These three forms usually represent from 2 to 5% of the total soil nitrogen, Tisdale et al. (1985).

## 2.2. Factors affecting utilization of N fertilizer by rice plants:

### 2.2.1. Methods of application:

The efficiency of grain production and utilization of applied N from ammonium sulphate and urea was more or less comparable whereas in this respect nitrate fertilizers were inferior for rice plants. Placement of the former two fertilizers and their fractional, application further increased efficiency for grain production and fertilizer utilization compared to broadcast application on the surface. El-Kobbia and Shalaby (1969) showed that broadcasting of ammonium sulphate in nursery to rice plants is superior to deep application at all rates of N application. It seems that broadcasting allows rice seedlings to take up its nitrogen more rapidly during early growth. They also indicate that high yield could be obtained, if sulphate of ammonia is applied in deep layer instead of broadcast. Eid et al. (1974) found that percentage of N in the rice

plants derived from fertilizers ammonium sulphate and urea, were nearly equal in their efficiency, sodium nitrate was the least efficient and ammonium nitrate occupied an intermediate position. They added that this percentage was found to decrease in plants with time until it reached lowest values at maturity in grains and straw due to the contribution of soil nitrogen in supplying the plants with their needs of nitrogen. Moreover, amounts of nitrogen fertilizer utilized by grains and straw were found to be nearly the same for ammonium sulphate, regardless the time of its application, whereas, application of urea and ammonium nitrate on the soil surface two weeks before primordial initiation was more effective than their application on shallow placement at transplanting. However, sodium nitrate was found to be more effective when applied at two weeks before primordial initiation as a top-dressing but even so it did not reach the levels of efficiency of the other three nitrogenous fertilizers.

Muhamad et al. (1974) found that N-uptake by rice plant from the fertilizer top-dressed at the heading stage from an ammonium source was twice as much as that from