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Effect of Increasing Concentration of Nitrogen on the Composition and Yield of Rice

By

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ABSTRACT

A hydroponic experiment was conducted to study the effect of increasing levels of N on the yield and plant composition and critical levels of nitrogen in the straw for maximum grain and straw yield for the rice variety, Ratna. There was a sharp increase in nitrogen concentration and uptake upto 100 ppm N and thereafter it was gradual. Up to 40 ppm the concentration of N in the grain was more than that of the straw and vice versa at still higher levels. N was more concentrated at higher levels in the straw than in the grain.

The concentration of plant nutrients like P, K, Mg and Fe as well as uptake increased from 40 to 60 ppm N and remained more or less constant at still higher levels. These nutrients are highly essential for the better utilization of absorbed nitrogen whereas SiO_2 and Ca concentration and uptake decreased progressively with N uptake. The lodging of rice plants observed at higher levels of nitrogen might be due to the decreased concentration of these elements in the plants.

INTRODUCTION

The assimilation and uptake of any plant nutrient is mainly governed by its concentration on the growth medium. Very little information is available on the nutrient assimilation and composition of rice as influenced by concentration of nutrient elements in the medium. Ishizuka and Tanaka (1950) conducted a series of experiments on the influence of N, P and K on the growth and composition of *japonica* rice. Similar work was conducted with tall *indica* varieties by Tanaka *et al.* (1958). So far not much work has been done on this fundamental aspect on high yielding dwarf *indica* varieties under tropical conditions, even though a number of field investigations have been conducted to study the response to fertilizers by the high yielding varieties. Under field conditions, plant composition and yield are difficult to be correlated due to the complexity of soil components. When the direct effects of plant nutrients are to be distinguished from indirect effects, the best method is to adopt hydroponics. The present experimet was designed to study the changes in composition and uptake of different

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nutrients as influenced by the concentration of nitrogen in the growth medium and to fix up optimum levels of N in the grain and straw for maximum grain yield.

MATERIALS AND METHODS

Seeds of the rice variety 'Ratna' were sown in seed pans, containing soil and river sand at 1 : 4 ratio. Fifteen days old seedlings were transplanted with proper support in porcelain pots of 6 litre capacity taining nutrient solution so that the root system of the plants remained completely immersed in the solution. Nine levels of nitrogen, viz., 0, 5, 10, 20, 40, 60, 100, 150 and 200 ppm were tried with nine replications in randomised block design. Nutrient solutions were having the following composition :

$NH_4 NO_3$ to supply the above nitrogen levels.

$Na H_2 PO_4 . 2H_2O$	–	10 ppm P
KCl	–	25 ppm K
$CaCl_2$ (Fused)	–	20 ppm Ca
$MgCl_2 . 6H_2O$	–	20 ppm Mg
Fe. EDTA	–	2 ppm Fe
Silicic acid	–	5 ppm Si

Micronutrients were given according to the formulations of Johnson *et al.* (1957). The initial pH of the nutrient solution was adjusted to a value at 4.8 to 5.2. Nitrogen treatment was started at the second week only. After harvest, the grain and straw samples were analysed for N, P, K, Ca, Mg, Fe, Mn and SiO_2.

The grain and straw samples were digested with nitric, perchloric and sulphuric acids (Johnson and Ulrich, 1959). P was estimated colorimetrically, K and Ca by flame photometry, Mg by versenate method, and Fe and Mn by thiocyanate and periodate method (Snell and Snell, 1949). The residue after triple acid digestion was washed with 0.1 N HCl, ignited and weighed as $Si 0_2$.

The total uptake of all nutrients in grain and straw was computed from the dry weight. The study was conducted at the Central Rice Research Institute, Cuttack under hydroponics.

RESULTS AND DISCUSSION

Influence of nitrogen levels on the composition of grain and straw: The changes in composition of grain and straw and total uptake of nutrients as influenced by the levels of N are presented in Fig. 1 and 2. Nitrogen concentration in both grain and straw increased with increasing concentration of N in the root medium. The increase in concentration was sharp upto 60 ppm N and thereafter it was gradual. After 150 ppm N, the concentration of N in both grain and straw remained more or less constant or slightly reduced. N uptake also followed the same pattern as that of concentration. Upto 40 ppm N, the concentration of N in grain was more than that of straw but at higher levels, it was more in the straw than in the grain, indicating that at higher nitrogen levels, the absorbed nitrogen is chiefly

FIG. 1

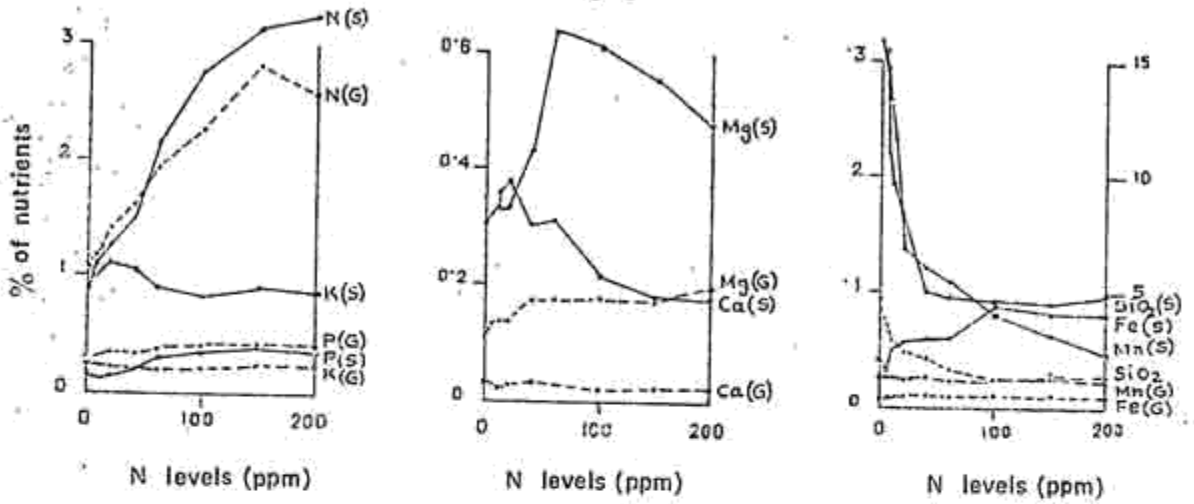

Fig. 1. EFFECT OF N ON NUTRIENT CONCENTRATION IN GRAIN (G) AND STRAW (S)

FIG. 2

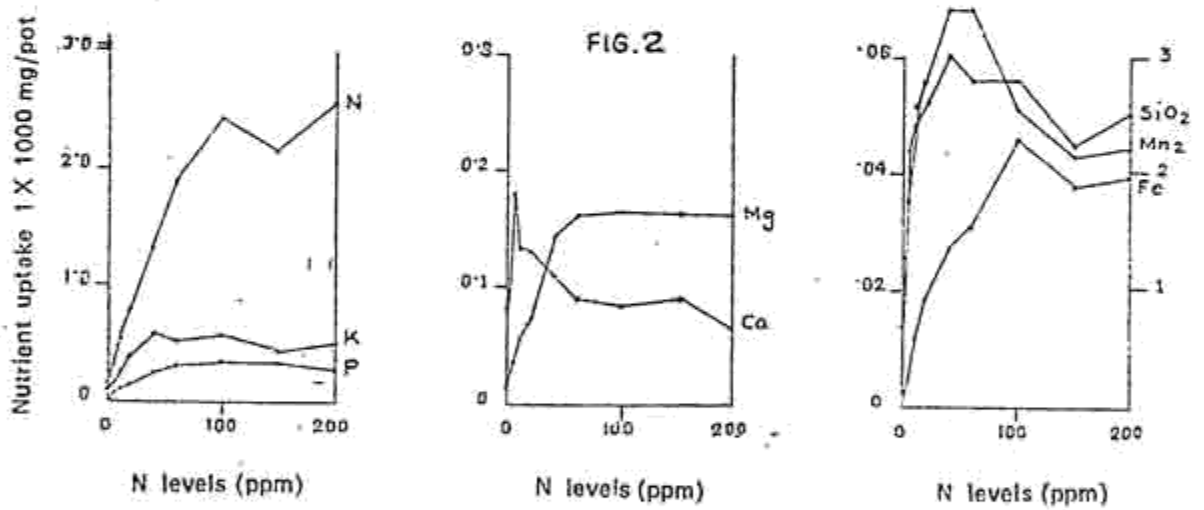

Fig. 2. EFFECT OF N ON NUTRIENT UPTAKE

utilized for straw production instead of grain production. The relationship between nitrogen levels, and nitrogen concentration and uptake were linear upto 100 ppm N and more or less constant thereafter.

P concentration and uptake increased upto 60 ppm N and thereafter remained more or less constant. Phosphorus plays an important role in nitrogen transformations.

K concentration was low at O ppm N level. From 5 to 40 ppm N, both concenration and uptake increased but there was no considerable reduction at higher concentrations of N. K acts as a catalyst in protein synthesis and hence N uptake was not reduced at high N

level due to metabolic absorption of K at those levels (Mitsin, 1955). Ca concentration increased in the straw upto 20 ppm N but decreased at still higher levels, whereas Ca concentration in grain remained more or less constant. Mg concentration of straw increased upto 60 ppm N and then decreased at still higher levels whereas Mg content of grain decreased after 20 ppm N. Unlike Ca, Mg uptake increased with increasing concentration of N in the root medium upto 60 ppm N and thereafter remained more or less contant. This clearly indicates that Mg, being a constituent of chlorophyll molecule, was utilized at a higher rate with increasing uptake of N.

Fe concentration as well as uptake increased upto 100 ppm N, but remained more or less constant at still higher levels. Fe acts as a catalyst in the synthesis of chlorophyll. After 100 ppm N, uptake of N also remained more or less constant and hence there was no further requirement of greater quantity of Fe to catalyse chlorophyll synthesis. In contrast to Fe concentration, Mg concentration and uptake decreased with increasing uptake of nitrogen.

SiO_2 concentration decreased sharply upto 40 ppm N in both grain and straw and thereafter it remained more or less constant, whereas SiO_2 content decreased after 40 ppm N. Silicate ions are mainly absorbed in exchange of OH ions of the protoplasmic surface of the root hairs (Amos and Dadswell, 1948). Hence any reduction in the root system particularly root hairs at high nitrogen levels might have reduced the silica uptake. A similar observation was made by Okuda and Takahashi (1961).

Critical levels and concentration of N in straw for optimum grain yield: Ishizuka and Tanaka (1950) and Tanaka *et al.* (1958) observed that the optimum levels of N for its efficient utilization for grain production were 60 and 40 ppm respectively for *japonica* and *indica* varieties under hydroponics.

In order to find out the optimum level, as well as the upper and lower critical levels of N for the variety under study, the grain yields obtained at different levels of N were plotted against the percentage of N in the straw at the respective levels (Fig. 3). Four distinct stages could be made out from the graphical representation.

1. A deficiency stage from 0-10 ppm where the percentage of N in the plant increased with increase in grain yield.

2 A normal absorption stage from 10 to 60 ppm where the percentage increase in N was not proportional to increase in grain yield.

3. An excess stage above 60 ppm, where N concentration in the plant increased while the yield decreased or the absorbed N was not utilized for grain production, but utilized for increasing vegetative growth as evidenced by increased straw yield than grain yield at higher N levels.

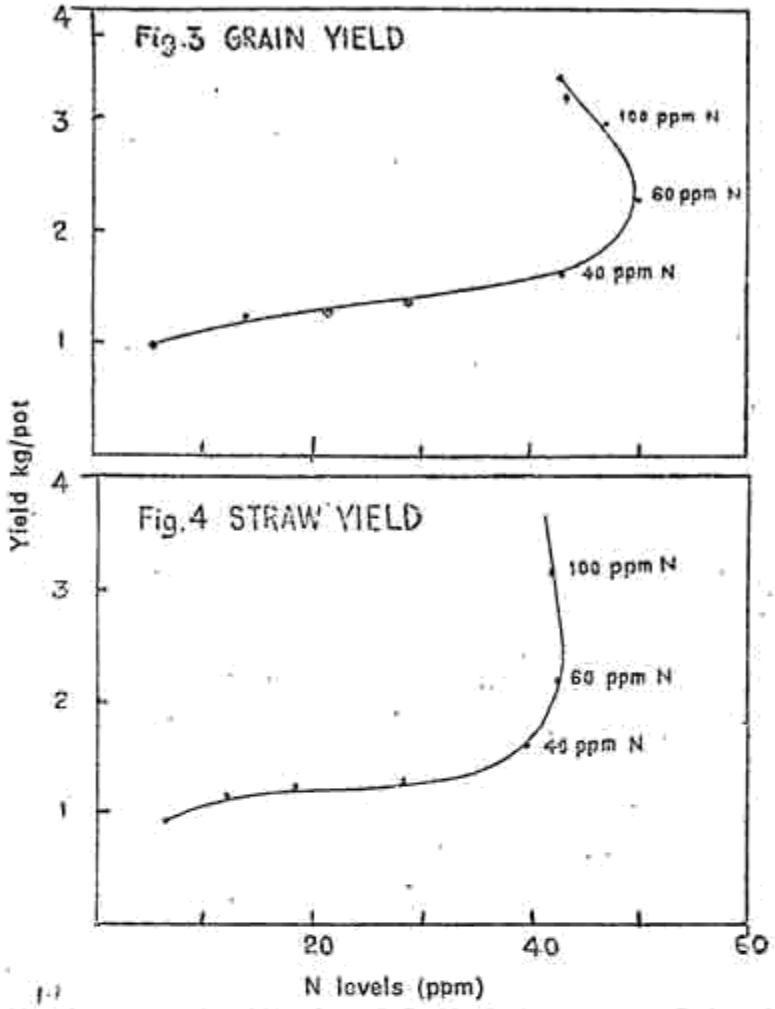

Fig. 3-4. EFFECT OF N LEVELS ON THE YIELD OF GRAIN AND STRAW AND N CONTENT

4. A fourth stage of steady yield was observed between 40 and 100 ppm N where the percentage of nitrogen increased but grain yield remained more or less stable. The lower level of this stage (40 ppm N) may be taken as lower critical level and upper level (100 ppm N) as the upper critical level and the inflexion point from the normal absorption stage to excess stage (60 ppm N) as the optimum level of N for the high yielding variety 'Ratna' for maximum grain yield in hydroponics.

In order to find out the optimum level of N for maximum straw yield for the high yielding variety, the straw yields obtained at different levels of N were plotted against percentage of N in the straw and presented in Fig. 4. The following three stages could be made out from the graph:

1. A deficiency stage from 0-10 ppm N where the percentage of N in the plant increased with increase in grain yield.

2. A normal absorption stage from 10 to 40 ppm where the percentage increase in N was not proportional to increase in grain yield.

3. A luxury consumption stage above 40 ppm, where the percentage of N in the straw increased with increase in concentration of N in the root

medium but the straw yield remained more or less constant.

Thus the inflexion point from normal absorption stage to luxury consumption stage (40 ppm N) may be taken as the optimum level of N for maximum straw yield for the high yielding variety 'Ratna'.

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