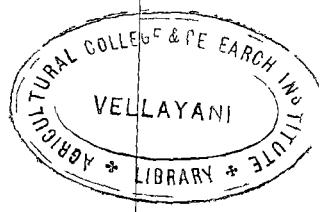
STUDIES ON THE EFFECT OF NITROGEN ON THE GROWTH, YIELD AND NUTRIENT UPTAKE OF TWO NEWLY INTRODUCED RICE VARIETIES (*Tainan 3 and Taichung Native 1*)



By

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THESIS

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C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Smt. M.K. Prema under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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INTRODUCTION

INTRODUCTION

Rice being the basis of nutrition for a large section of human race, plays a part of no small importance in the World's economy. It is the principal and probably the exclusive food of several million people in the Far east and more so for those in South India.

The cultivation of rice originated in remote antiquity, the exact time and place being uncertain. Wild species occur not only in Asia, but also in Africa and America, and it is difficult to determine today, which of these species have given rise to the cultivated forms. However, it appears that there are two centres of origin of cultivated rice, one in the Far East, and the other in West Africa, these correspond respectively to Oryza sativa and O. glaberrima. From the first centre came the crops of India, Burma, Siam and China.

It is not possible to state a definite climatic type for rice. Examination of the various places where it grows indicates that the plant can adapt itself to

extreme variations, always, provided its water requirements are met and the amount of warmth available during the cycle of growth does not fall below a certain minimum. This versatality has been extended still further by the creation of innumerable cultivated varieties.

Though Asia alone has about ninety percent of this area under this crop representing almost the same percentage of total rice production, Asian countries have to import rice to meet the food requirement of their people. This is because the population growth is not well compensated by an improvement in the yield of crops. In the present situation in which the population increase year by year in accelerating tempo, all feasible measures should be taken to augment the production of rice, the basic food of the least well nourished people of the world. A major break through in Agricultural production is required so that our food output can keep pace with population growth. This is of particular significance in the context of the present acute food scarcity in India in general, and more particularly so for Kerala.

In this context, therefore, the problem of stepping up rice production in every conceivable way,

is one of supreme importance. In Kerala, where the scope for increasing the area under rice cultivation is rather limited, the problem could be tackled only by adopting methods of intensive cultivation making use of newer and high yielding varieties and by translating into action the latest research findings on the fertilizer requirement of the crop. Practical experience has confirmed the paramount importance of manuring rice, it has also shown that manuring varies according to the condition of each region and that it must be adapted to the climatic and pedological conditions. Selection, moreover, has produced new varieties which promise increasing yields, but at the same time, more exacting in their manurial requirements. If the soils in their natural state are rich enough for older varieties, they are no longer so for the newer ones, which undoubtedly have the potential for greater production.

The information available at present regarding the manurial requirement of some of the newly introduced high yielding varieties is far from adequate. It is therefore felt that a critical assessment of the manurial requirement of the newly introduced varieties is highly essential. With this end in view, a comprehensive programme of research is initiated with the varieties

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Tainan 3 and Taichung Native 1 in the Agricultural College and Research Institute, Vellayani by three post graduate students and as part of which a study on the influence of nitrogen on these two varieties is taken up by the author, with the following objectives.

1. To determine the response of Tainan 3 and Taichung Native 1 to application of varying doses of nitrogen.

2. To study the effect of varying levels of nitrogen on the yield of paddy from these two varieties.

3. To study the deficiency symptoms if any exhibited due to lack of nitrogen.

REVIEW OF LITERATURE

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1. Nitrogen uptake by rice and other crops

Of the various nutrient elements essential for plant growth, nitrogen plays a major and vital role. A knowledge of the manner in which the uptake of this nutrient varies with the phases of growth is very important, this being of particular importance in the case of rice, with its rapid vegetative cycle. The absorption of nitrogen is rapid during the early days in the seed bed, it slows down subsequently, but shows a marked rice again at transplanting, reaching a maximum between the tillering and flowering stage (1956). This fact has been confirmed by the data obtained by Tanaka et al (1959). According to Basak et al (1960) absorption and assimilation of soil and applied nitrogen were found to depend on soil types, moisture conditions in the field during crop growth and cultural practices followed. Patnaik (1964) concluded from his investigations on the nutrient assimilation by rice plant, that, by and large, most varieties continued to yield well at higher nitrogen levels and that during the reproductive stage the ratio of soluble to protein

nitrogen in the straw increased. From their studies on different soil types in Taiwan, Chin and Li (1965) concluded that nitrogen application apparently increased nitrogen percentage in grain and straw.

There are distinct interactions between the three elements, nitrogen, potash and phosphoric acid Williams (1948) noted that phosphorus deficiency greatly depressed nitrogen uptake in graminaceous plants in the early stages of growth, apparently due to the differential effects of phosphorus on the growth of roots and shoots. Subbiah and Desai (1952) from their field trials on wheat showed that the absorption by plants of nitrogen and phosphorus was governed by their relative availability at the time of growth and that fallowing increased the nitrogen uptake at the expense of phosphorus. Behrens (1952) noted from his pot experiments with oats that the effect of phosphorus on metabolism depended on the nitrogen nutrition and the content of sugar in the plant, mainly of disaccharide was decreased by phosphate when insufficient nitrogen was applied, but the content of nitrogen, proteins and chlorophyll was increased. Further more, the opposite was observed when nitrogen nutrition was low and the non-protein nitrogen and nitrate nitrogen contents varied inversely with

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application of phosphorus. Garaudeaux (1954) reported that barley lodging could be avoided at high nitrogen levels if potassium was applied and the tendency of nitrogen to lower the grain/straw ratio was more than counteracted by liberal application of potash. A decrease in the ammoniacal nitrogen content and an increase in the carbohydrate content in plants at higher phosphorus level was observed by Takahashi and Yoshida (1955). Tueva (1960) reported that when pumpkin plants were grown in complete nutrient solution, in a solution deficient in nitrogen and phosphorus, or in a solution deficient in phosphorus, ammoniacal nitrogen increased the synthesis of phosphates and nucleoproteins when phosphorus was supplied again. Widdowson et al (1961) from their experiments with nitrogen and potash on barley in soils containing little acid soluble K, concluded that nitrogen manuring was related to the previous cropping under heavy rainy and windy conditions. It was also noted from these experiments that large nitrogen dressings tended to mark the responses to potash under fine summer conditions. Place and Sims (1965) stated that on silt loam soil, phosphorus applied to Blue bonnet 50 rice at preplant at mid season in combination with N decreased grain yield and increased lodging.

2. Time and method of application of nitrogen

In the formulation of a schedule of manuring rice, the period during which the appropriate amounts of assimilable nutrients should be made available and their mode of application are matters of special interest. Prasad (1947) observed that plants receiving nitrogen from the very beginning of the life cycle showed decidedly greater growth of leaves and branches and were sturdier than those receiving nitrogen at later stages. Fujiwara and Ohira (1951) stated that rice in pots gave highest yields with dressings of ammonium sulphate three weeks before heading. Tanaka and others (1959) concluded from water culture experiments that for Indica rice, under field conditions, nitrogen should be given in split applications, the first as basal manuring or at an early stage of vegetative growth and the second as a top dressing at the reproductive stage. From experiments conducted at the Rice Research Institute, Cuttack (1961) it was concluded that fractional application of ammonium sulphate in three split doses, namely at planting, one month after planting, and two to three weeks before flowering was more efficient than application of the entire quantity in one dose. Vasistha et al (1961) reported that when the two early rice varieties T136 and N22 were supplied with ammonium sulphate and

urea at the rate of 50 lb nitrogen per acre, the crop transplanted in June gave highest grain yield, but the yield of straw increased as transplanting was delayed. Ghosh (1962) while studying the effect of different times of application of nitrogenous fertilizers on Aman paddy in the Gangetic soils, found that application of nitrogen in two split doses one at puddling and the other 4 weeks after transplanting was better than the other times of application. It was observed by Ganser (1962) that nitrogen applied at the time of broadcasting or before transplanting increased grain yields considerably on fertile soils. Haranjan (1962) reported that excessive doses of nitrogen fertilizers increased the intensity of respiration in the stem elongations, but decreased the intensity during later stages of development, it being concluded that fertilizers should be applied during tillering and stem elongation. In the case of two spring wheat varieties, however, Van Burg (1965) observed that applying all nitrogen at sowing gave better results.

Fujiwara et al (1952) observed that top dressing of nitrogen increased the total mineral matter absorbed by the plant and when rice plants previously deprived of nitrogen were supplied with nitrogen, protein was

rapidly formed, through amide nitrogen, in plants containing no stored carbohydrates, there was no protein formation, but an accumulation of principally amide nitrogen. Langfield (1959) obtained a significant increase in the grain yield of the Indica and Japonica varieties of rice by the placement of ammonium sulphate at 3 inches, compared to the shallow or surface placement. Widdowson et al (1961) suggested that combined drilling of 0.3 or 0.6 cwt nitrogen per acre as ammonium sulphate will result in higher yields than broadcasting. However, drilling 0.9 cwt nitrogen per acre checked early growth and reduced mean yields two out of three seasons, while supplementing 0.3 cwt nitrogen per acre combine drill with an equivalent top dressing of nitrochalk consistently out yielded a single drilled or broadcast dressing, supplying the same total quantity of nitrogen. Krishna Rao and Venkateswarulu (1962) observed that non-protein nitrogen of rice increased significantly with increase in the concentration of urea used as a spray. From the experiments at the Central Rice Research Institute, Cuttack (1963) it was observed that a 2 percent foliar spray of urea to supply 15-30 kg nitrogen per hectare was significantly superior to soil application. Further, it was noted that continuous application of ammonium sulphate for 13 years did not leave any deleterious effect on soil productivity.

Patnaik and Nanda (1964) stated that the application of the entire quantity of the nitrogenous fertilizers at seedling appeared to be best suited for optimal grain yield. According to Mahapatra and Chaudry (1964) placement and fractional application of fertilizers in 3 splits - at flowering, one month after planting and 3 weeks before flowering was significantly superior to the customary practice of broadcast. Donahue (1965) reported that urea could be used satisfactorily either as basal dressing or as a top dressing on paddy and it would give equal responses per pound of nitrogen to that of ammonium sulphate. Significant increases in yields were obtained by Isfan and Oproiu (1965) by the placement of ammonium nitrate at 16 kg/ha of nitrogen and granular super phosphate at 16 kg/ha of phosphorus in a single band at sowing.

3. Relative merits of different nitrogenous fertilizers

The influence of different types of nitrogenous fertilizers on the growth and yield of paddy has been studied extensively in recent years. Lorenz and Johnson (1951) found that ammonium fertilizers provided greatly increased yields over nitrate fertilizers and that ammonium sulphate released native soil phosphate whereas

nitrogen from calcium nitrate and sodium nitrate did not. Rao, Balakrishna and Others (1958) showed that sodium nitrate compared favourably with ammonium sulphate as a fertilizer for rice, and the former was the better for the first crop, the latter for the second crop. According to Piacco (1959) urea was satisfactory as a source of nitrogen for rice. Tanaka and others (1959) reported that in rice variety Ptb10, with nitrogen at 20 ppm, its source did not influence yields of grain or straw, but with nitrogen at 100 ppm, the nitrate source gave better results. It was also noted that ammoniacal nitrogen given at an early stage promoted tillering and nitrate nitrogen and the uptake of calcium, magnesium, manganese, potassium and phosphorus from which it was concluded that the best results could be obtained by supplying at 100 ppm nitrogen as ammoniacal in the vegetative stage and as nitrate during the elongation and reproductive stage. Mukherjee (1960) observed that there was a significant difference in yield of paddy when ammonium sulphate and urea were used separately as manures. Jayasekera and Ariyanayagam (1962) while comparing relative efficiency of ammonium sulphate and urea found that urea was a more effective source of nitrogen for sandy soils. From the experiments conducted

at Central Rice Research Institute, Cuttack (1963) it was noted that the response obtained from ammonium sulphate nitrate, ammonium chloride, ammonium sulphate, ureaformaldehyde and ammonium phosphate the yield response was maximum with ammonium sulphate nitrate. Mahapatra and Sahu (1963) obtained significantly higher yields over control with all the five nitrogenous fertilizers viz., ammonium sulphate, ammonium sulphate nitrate, ammonium chloride, calcium ammonium nitrate and urea. While the maximum economic return was with the application of 60 lb nitrogen per acre of ammonium nitrate followed by ammonium sulphate nitrate and ammonium sulphate at 40 lb per acre. Mahapatra and Chaudry (1964) stated that in the 'no compost' series the yield of crop increased with the application of ammonium sulphate only upto the level of 22 kg nitrogen per hectare, while higher doses of nitrogen produced luxuriant vegetative growth which resulted in pre-mature lodging and thus reduction in yield. Bhattacharya et al (1965) from their extensive field experiments with different forms of nitrogen, phosphorus and complex fertilizers on paddy, in Bihar, noted that the different forms of nitrogenous fertilizers were equally effective in increasing the yield of paddy under the varied condition

of the State. Vachhani and Rao (1965) stated that from the point of view of mean yields and responses ammonium sulphate was much superior to ammonium phosphate and ammonium chloride for rice. According to these authors sodium nitrate and calcium cyanamide were not suitable nitrogenous fertilizers for the rice crop. Kochappan Nair and Koshy (1966) while evaluating the influence of different forms of nitrogen at the rate of 40 kg nitrogen per hectare on the growth and yield characters of some Kerala rice varieties reported that the number of tillers per plant, the plant height, length of earhead, and the number of rachis per earhead varied significantly with variety and of the different yield characters studied, variety influenced the total yield of grain the grain:chaff ratio and weight of thousand grains. These studies also revealed that ammonium sulphate produced the largest number of grains per earhead and ammonium nitrate the lowest, maximum grain yield was for ammonium sulphate. From the experiments at the Indian Agricultural Research Institute at New Dolhi (1961) it was revealed that slurry showed very little effect on yield while ammonium sulphate proved much superior, farm yard manure and dried slurry were alike.

4. Nitrogen fertilizers and yield of paddy

It has been shown from the results of numerous manurial trials that proper manurial treatment can give noteworthy increases in yield. As regards nitrogenous manures, this fact has been conclusively established.

Paul (1953) observed an improvement in the yields of grains and straw due to application of 20 lb of nitrogen per acre and there was a further improvement due to an additional dose of the same quantity of nitrogen. Digar (1955) reported that ammonium sulphate alone increased straw and grain yield significantly. Results of research conducted in Bombay, Madras, Bengal and Madhya Pradesh (1956) proved that application of nitrogen at 25 lb per acre increased rice yields by 3 md per acre over the cultivators' practice. Greatest grain yields were obtained by Digar (1958) when ammonium sulphate at 30 lb nitrogen per acre was applied in combination with farm yard manure. Maximum yield of straw resulted with ammonium sulphate at 60 lb per acre with farm yard manure. Digar (1960) obtained an increase in straw:grain ratio by an increased dose of ammonium sulphate and found that a combination of 30 lb of nitrogen and 60 lb P_2O_5 appeared to be the best for higher

production. Ponnamperuma (1959) stated that on moderately well-drained acid lateritic soils, the response of rice to nitrogen was linear in the range 0-60 lb nitrogen per acre, and averaged 9 lb grain per lb of nitrogen applied. He noted that top dressing certain fields with 100 lb ammonium sulphate increased grain yields by almost 12 bu per acre or 25 percent. Mariakulandai and Srinivasan (1959) in a discussion of the findings over 2500 demonstrations and trials conducted on paddy in Madras State reported the superiority of a combination of P_2O_5 and N in increasing the yield by 39.4 percent. From the experiments conducted at five different places in Thailand it was indicated that rice yields could be considerably stepped up by judicious application of fertilizers. Relwani (1960) emphasized that ammonium sulphate produced significant increase in wheat and nature of the response curve was quadratic. Widdowson et al (1961) reported that appreciable responses of nitrogen were obtained where barley followed a cereal in arable rotation and larger nitrogen dressings tended to mask response to potash. Guruchan and Jarnail (1963) stated that the grain yields could be increased progressively with the increase of nitrogen dose. From the experiments at the

Rice Research Institute at Cuttack (1963) it was noted that grain yield was significantly better than control when compost and ammonium sulphate alone and in combination were used. Sahu (1963) stated that the average response was about 1.3 md per acre higher when the dosage was increased from 20 to 40 lb nitrogen per acre and higher response of 10.7 md per acre were obtained with the combination of 20 lb nitrogen and 40 lb P_2O_5 per acre. Gupta et al (1965) reported that the yields of the subsequent rice crops could be increased with the depth of incorporation of green manure of the previous crop. Further it was noted that groen manuring markedly increased the rice yields. +Parasuram (1965) recorded the highest yield for variety W-140 from application of 135 kg nitrogen per hectare followed by treatment 90 kg nitrogen per hectare.

The effect of nitrogen fertilizers on the yield of paddy depends on the variety also. Noboru Yamada (1959) observed that all the 3 japonica and 2 indica varieties when examined at 3 levels of nitrogen application, showed remarkable increase in grain yield as the fertilizer application was increased with the exception of Murungakayan 302. Percentage increase in grain yield of nitrogen was about 50 percent with 3 japonica varieties

and 70 percent with H-4 and no increase in Murungakayam 302. Hood (1959) reported that even under high fertility conditions, stiff strawed cereal varieties gave economic responses to applications of about 70 lb nitrogen per acre. Takahashi et al (1959) showed that nitrogen and carbohydrate metabolism were instigated in 3 varieties at 3 levels of nitrogen but the variety least suited to heavy manuring (Ginnen-indica type) showed greater increase in soluble nitrogen content and greater decrease in sugar and starch than the most suitable variety (Norin 25) did. In the experiments in Central Rice Research Institute, Cuttack (1963), to find the high fertilizer response in rice variety it was noted that Japonica x indica cross, either in diploid or in tetraploid forms, exhibited higher response to nitrogen application due to the presence of gene blocks from japonica and indica autotetraploid, and Japonica x indica tetraploid showed an abrupt response at the lower level of nitrogen application due to the addition of an extra genome.

The composition of rice varies widely according to the variety, climate, soil, manurial treatment etc.

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5. Influence of nitrogen on physiological characters of rice

According to Mc Rae (1919) nitrogen fertilizers render varieties of paddy more susceptible to the disease caused by the fungus piriculari oryzae. Snider (1946) observed that high nitrogen increased the susceptibility of rice to stem rot. This view has been supported by the findings of Cralley (1947) also.

Almeda (1937) reported an increase in the ash content of the tops and dry matter content, with increase in the dose of ammonium sulphate applied. Sathe et al (1952) revealed that ammonium sulphate increased the thiamin content where ammonium nitrate and urea had little effect. Basak et al (1960) reported that no correlation was found to exist among the three nutritive elements in the grains and the protein content of the grain could be increased significantly by timely application of fertilizers. Ghose et al (1960) stated that nitrogen deficiency leads to stunted growth, poor tillering, pale yellow green leaves, small earheads and low yield of grain. It was further noted that an excess of this nutrient has also been found harmful, resulting in poor yield of grain and production of more straw.

Lal and Subba Rao (1960) from their work on sand culture of rice reported that nitrogen deficiency reduced height, tillering, leaf number, leaf size and dry weight of component parts. Tsui and Yen (1964) observed that high nitrogen level increased the number of spikes, but decreased the number of grains per spike. Further, it was found that starch accumulated more in the sheath and stem at low nitrogen levels and was translocated to the spike heading. Srinivasulu and Pawar (1965) indicated that nitrogen produced significant effect on economic characters such as plant height, number of ear bearing tillers, length of panicle, number of mature and chaffy grains per panicle etc. Kochappan Nair and Koshy (1966) from their studies on the influence of different forms of nitrogen at 40 kg/ha, on the growth and yield characters of Kerala rice varieties, concluded that the number of tillers per plant, the plant height, length of ear head and the number of rachis per earhead will vary significantly with variety.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study was undertaken with a view to study the influence of nitrogen on the growth and yield of two high yielding varieties of paddy, Tainan 3 and Taichung Native 1. For this study a pot culture experiment in randomised block design with three replications was laid out.

A. Analysis of growth medium

A representative sample of the medium (sand) was taken from the bulk quantity collected for the pot culture study, sieved through a 2 mm sieve and was analysed for mechanical composition and chemical constituents.

(a) Mechanical analysis

International pipette method (Piper, 1950) was adopted for determining the various mechanical fractions of the sand.

(b) pH

A photovolt pH meter with glass electrode was used for measurement of pH, using 1:2 sand-water ratio.

(c) Analysis for chemical constituents of the medium

Preparation of hydrochloric acid extract

20 g of sand was taken and digested with 2:1 hydrochloric acid and filtered. The filtrate was made upto a known volume. Using the hydrochloric acid extract the following determinations were made.

(1) Sesquioxide

Sesquioxides were precipitated in an aliquot of the hydrochloric acid extract, as hydroxides. They were filtered, ignited and weighed as combined oxides.

(2) Iron oxide

A separate aliquot of hydrochloric acid extract was taken for the determination of iron oxide and it was determined by reduction with zinc and dilute sulphuric acid and iron estimated by titration against standard potassium permanganate.

(3) Aluminium oxide

The difference between percentage of sesquioxide and iron oxide percent was taken as the percentage of aluminium oxide.

(4) Calcium

Calcium was estimated volumetrically from the filtrate of iron and alumina estimation by precipitation as oxalate in ammoniacal medium.

(5) Magnesium

Magnesium content was determined gravimetrically by precipitation as magnesium ammonium phosphate from the filtrate after calcium estimation.

(6) Total nitrogen

Total nitrogen was estimated by Kjeldhal method (A.O.A.C.).

(7) Total phosphoric acid

Total phosphoric acid was precipitated as ammonium phospho molybdate in a known volume of the extract and estimated volumetrically (Piper, 1950).

(8) Total potassium

Total potassium was determined volumetrically by precipitation with sodium cobaltinitrite.

(9) Acid insolubles

The residue obtained in the preparation of hydrochloric acid extract was taken and the acid insolubles were determined gravimetrically. The results of analysis of the growth medium are furnished below.

Table I

Mechanical and chemical composition of the sand used in the pot culture experiment

Mechanical analysis			Chemical analysis		
Coarse sand	(percent)	88.60	pH	6.3	
			Nitrogen	0.012	percent
Fine sand	,,	6.90	Phosphorus (P_2O_5)	0.021	,,
Silt	,,	1.50			
Clay	,,	1.40	Potash (K_2O)	0.005	,,
			Calcium (CaO)	0.064	,,
			Magnesium (MgO)	0.086	,,
			Sesquioxides	1.230	,,
			Iron (Fe_2O_3)	0.940	,,
			Aluminium (Al_2O_3)	0.290	,,
			Insolubles	96.230	,,

B. Pot culture experiment

1. Growth medium and preparation of pots

Sand, as medium, was collected from Thiruvallam river bed, near the Agricultural College and Research Institute, Vellayani. Concrete pots of size 100 cm x 100 cm x 15 cm were used for the experiment. These pots were filled with the river sand to a height of 10 cm.

2. Layout and treatments

A randomised block design with 8 treatments and three replications was adopted.

3. Application of fertilizers

All the pots received a basal application of micronutrients in the form of a commercial product known as 'Spartin' manufactured by M/s. Swati Industries (Private) Limited, Bombay, and having the following composition.

Fe	-	1.65 percent
Mn	-	0.36 ,,
Cu	-	0.16 ,,
Zn	-	0.16 ,,

B	-	0.02 percent
Ca	-	19.00 ,,
Mg	-	5.25 ,,

P_2O_5 at 80 kg/ha and K_2O at 100 kg/ha in the form of superphosphate (16 percent P_2O_5) and muriate of potash (60 percent K_2O) respectively, were applied to each pot. Different levels of nitrogen applied in the form of ammonium sulphate (21 percent) were 0, 60, 120, 180 kg N/ha. The N, P_2O_5 and K_2O were applied in 5 split doses as given below:-

	$N_0P_{80}K_{100}$ (Treatments V_1N_0PK and V_2N_0PK)	$N_{60}P_{80}K_{100}$ (Treatments V_1N_1PK and V_2N_1PK)
Basal	$N_0P_{20}K_{20}$	$N_{10}P_{20}K_{20}$
15th day	$N_0P_{30}K_{30}$	$N_{20}P_{30}K_{30}$
30th day	$N_0P_{20}K_{20}$	$N_{10}P_{20}K_{20}$
45th day	$N_0P_{10}K_{10}$	$N_{10}P_{10}K_{10}$
60th day	$N_0P_0K_{20}$	$N_{10}P_0K_{20}$

$N_{120}P_{80}K_{100}$ (Treatments V_1N_2PK and V_2N_2PK)	$N_{180}P_{80}K_{100}$ (Treatments V_1N_3PK and V_2N_3PK)
Basal $N_{20}P_{20}K_{20}$	$N_{30}P_{20}K_{20}$
15th day $N_{30}P_{30}K_{30}$	$N_{40}P_{30}K_{30}$
30th day $N_{30}P_{20}K_{20}$	$N_{40}P_{20}K_{20}$
45th day $N_{20}P_{10}K_{10}$	$N_{40}P_{10}K_{10}$
60th day $N_{20}P_0\ K_{20}$	$N_{30}P_0\ K_{20}$

All these nutrients were applied as a 5 percent solution, basal application being done on the day previous to sowing. For subsequent applications water in the pots was drained prior to the addition of fertilizer solution.

4. Seeds and sowing

Paddy strains selected for the experiment were Tainan 3 and Taichung Native 1. Four sprouted seeds were dibbled in each hole, with a spacing of 20 cm x 20 cm, on 18-12-1966. After 14 days the number of seedlings per hole was reduced to two. Thus each pot contained 25 hills, each hill containing two plants.

The rest of the seedlings were cut and buried in the sand in each pot.

5. Irrigation

The seedlings were irrigated periodically with tap water so as to maintain a constant level of 3 cm of water over the surface of sand.

Plant protection measures were taken by spraying for pests and diseases.

6. Observations

To find out the effect of different treatments on plant performance and yield attributes the following observations were recorded.

(a) Plant height

This was recorded at fifteen days interval from the date of sowing. The measurement was made from the base of the plant to the upper-most leaf tip.

(b) Vegetative tillers

The tiller counts were made at intervals of 15 days from the date of sowing.

(c) Productive tillers

The productive tillers counts were recorded, one day before harvest.

(d) Yield

The plants, except those in the pots receiving no nitrogen, were harvested on 10-4-1967. As the plants in the treatments V_1N_0 and V_2N_0 came to flowering considerably late, they could be harvested only 18 days later.

The grain, straw and root yields from each pot were recorded after drying in air to constant weight. The roots were carefully gathered after emptying the pots and washing off the sand particles completely with water.

Length of panicle, weight of panicle, 1000 grain weight and percentage of chaff were also recorded.

(e) Deficiency symptoms

The deficiency symptoms in plants from the pots which received no nitrogen application were also noted.

C. Analysis of plant parts

1. Nitrogen

This was estimated by the Kjeldhal method.

2. Phosphorus and potassium

These were estimated in the extract obtained by the wet digestion of a weighed quantity of the dry sample with a mixture of nitric, perchloric and sulphuric acid in the ratio 4:1:1.

Phosphorus was determined in an aliquot of the triple acid extract colorimetrically by the procedure outlined by Jackson (1962).

Potassium was determined volumetrically by the sodium cobaltinitrite method (Piper, 1950).

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Table II

Effect of different levels of nitrogen on the height of two varieties of rice at three stages of growth

Treatment		Height of plant (cm) on the		
		30th day	45th day	60th day
V_1N_0		18.2	26.4	33.5
V_1N_1		29.3	44.1	64.4
V_1N_2		31.3	35.4	73.5
V_1N_3		29.2	51.8	81.3
Mean		26.9	39.4	63.2
V_2N_0		12.3	20.2	38.9
V_2N_1		21.2	29.7	39.9
V_2N_2		21.7	32.9	45.0
V_2N_3		24.9	38.2	53.0
Mean		20.2	30.3	44.2
	N_0	15.3	23.3	36.2
Mean for level	N_1	25.3	36.9	52.1
	N_2	26.5	34.2	59.3
	N_3	27.0	44.9	67.2
C.D.(0.05) for level		5.15	11.58	11.58
C.D.(0.05) for variety		3.86	8.15	8.15
C.D.(0.05) for interaction		7.29	-	16.30

RESULTS

R E S U L T S

The results obtained in the present study are given in Tables II to XIII. The data obtained are statistically analysed and conclusions drawn.

A. GROWTH

The various growth measurements made were height of plant, number of tillers, number of productive tillers and length of panicle.

The data are presented in Tables II, III, IV and VII.

1. Height of plant

The measurement of plant height at three different stages of plant growth (Table II) showed that at all the stages, the varietal as well as treatment differences were highly significant. Interaction between variety and level of nitrogen was also found to be significant.

At all stages during growth Tainan 3 excelled Taichung Native 1 in height. Though application of nitrogen tended to produce taller plants than control,

Table III

Effect of different levels of nitrogen on the number of tillers of two varieties of rice at three stages of growth

Treatment		Number of tillers on the		
		30th day	45th day	60th day
V_1N_0		2.0	2.1	2.3
V_1N_1		7.0	9.3	8.9
V_1N_2		6.7	12.0	17.9
V_1N_3		4.8	14.1	17.1
Mean		5.2	9.4	11.6
V_2N_0		2.3	2.5	2.6
V_2N_1		4.7	7.1	11.0
V_2N_2		4.7	9.4	19.4
V_2N_3		6.1	16.0	26.2
Mean		4.4	8.8	14.8
Mean for level	N_0	2.2	2.3	2.5
	N_1	5.8	8.2	9.9
	N_2	5.7	10.7	18.7
	N_3	5.5	15.1	21.7
C.D.(0.05) for level		2.18	3.22	4.5
C.D.(0.05) for variety		-	-	3.22
C.D.(0.05) for interaction		-	-	-

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difference in height of plants between levels of nitrogen was not very significant. Increased height of plants were obtained by increasing the level of nitrogen. The height of plants increased with increase in the period of growth and reached a maximum at harvest. The maximum height of plants (90.1 cm) was for Tainan 3 for an application of 180 kg nitrogen per hectare, whereas for Taichung Native 1 it was only 58.7 cm for the same treatment. When the average values for all the treatments were compared, it was found that for Tainan 3 maximum height was 70.3 cm at harvest as against 50.3 cm for Taichung Native 1. Even though application of nitrogen increased the height of plants more than the control, there was no significant differences between the different levels of the treatments. Though application of increasing levels of nitrogen markedly increased the height of plants there was no lodging for them even for the high level viz., 180 kg N/ha.

2. Number of tillers

The data pertaining to this growth character are given in Table III. As regards the number of tillers highly significant differences were noted for the different treatments. Varietal differences at early

Table IV

Effect of different levels of nitrogen on the height and number of productive tillers of two rice varieties at harvest

Treatment		Height (cm)	Number of productive tillers
V_1N_0		41.1	1.8
V_1N_1		70.2	5.8
V_1N_2		79.8	11.0
V_1N_3		90.1	14.6
Mean		70.3	8.3
V_2N_0		38.0	2.4
V_2N_1		48.3	7.5
V_2N_2		56.2	16.5
V_2N_3		58.7	19.3
Mean		50.3	11.5
	N_0	39.5	2.1
Mean for level	N_1	59.3	6.7
	N_2	67.9	13.8
	N_3	74.4	16.9
C.D.(0.05) for level		9.65	2.36
C.D.(0.05) for variety		6.79	2.27
C.D.(0.05) for interaction		13.51	-

stages were not significant but later showed significant difference at the initial stages of growth, Tainan 3 produced plants with more tillers than Taichung Native 1 but later Taichung Native 1 excelled Tainan 3. Number of tillers increased upto the 60th day and thereafter it tended to decrease. Maximum number of tillers produced by Taichung Native 1 was 26.2 for an application of 180 kg of nitrogen per hectare, whereas for Tainan 3 it was 17.9 for an application of 120 kg nitrogen per hectare. Higher dose of nitrogen tended to produce more tillers.

3. Number of productive tillers at harvest.

In Table IV are given the height and number of productive tillers at harvest. In this case, treatment difference is significant at 1 percent level. There was also significant difference between varieties. The interaction between variety and level of nitrogen was significant at 5 percent level.

Tainan 3 is found to produce taller plants than Taichung Native 1.

Data on the number of productive tillers showed a significant difference between varieties at 1 percent level. Level of nitrogen also showed significant

difference at 1 percent level. Interaction between variety and treatment differences was not significant.

Taichung Native 1 recorded a maximum number of productive tillers at harvest (19.3 cm) for an application of 180 kg of nitrogen per hectare while the same dose produced a maximum of only 14.6 in the case of Tainan 3. The lowest number of tillers (2.4) was produced by Taichung Native 1 which received no nitrogen treatment, while the minimum value for Tainan 3 was only 1.8 when the average number of tillers for all the treatments was compared, the figure of 11.5 was obtained for Taichung Native 1 as compared to 8.3 for Tainan 3.

4. Length of panicle

Table VII show that length of panicle varies significantly with variety and treatment, but the interaction between the two was not significant.

The maximum length of panicle (22.9 cm) was noted for Tainan 3 due to an application of 180 kg nitrogen per hectare while for Taichung Native 1 the length of the longest panicle was only 18.0 cm for the same treatment. The average length of panicle of all treatments for Tainan 3 was 18.7 cm while for Taichung

Table V

Effect of different levels of nitrogen on the yield of grain, straw and root of two varieties of rice (Expressed as g/pot)

Treatment		Grain	Straw	Root
V_1N_0		8.3	70.0	101.3
V_1N_1		110.2	167.3	137.0
V_1N_2		208.9	339.3	254.6
V_1N_3		388.3	533.0	418.7
Mean		178.9	277.4	227.7
V_2N_0		14.0	36.0	80.0
V_2N_1		97.2	149.7	109.7
V_2N_2		198.5	273.0	203.3
V_2N_3		329.3	386.0	335.7
Mean		159.8	211.2	182.2
	N_0	11.2	53.0	90.7
Mean for level	N_1	103.7	158.5	123.3
	N_2	203.7	306.2	229.0
	N_3	358.8	459.5	377.2
C.D.(0.05) for level		41.80	54.26	54.05
C.D.(0.05) for variety		28.95	39.68	37.75
C.D.(0.05) for interaction		58.77	-	-

Table VI

Effect of different levels of nitrogen on the yield of grain, straw and root of two varieties of rice (Expressed as kg/ha)

Treatment		Grain	Straw	Root
V_1N_0		83.0	700.0	1013.0
V_1N_1		1102.0	1673.0	1370.0
V_1N_2		2089.0	3393.0	2546.0
V_1N_3		3883.0	5330.0	4187.0
Mean		1789.0	2774.0	2277.0
V_2N_0		140.0	360.0	800.0
V_2N_1		972.0	1497.0	1097.0
V_2N_2		1985.0	2730.0	2033.0
V_2N_3		3293.0	3860.0	3357.0
Mean		1598.0	2112.0	1822.0
Mean for level	N_0	112.0	530.0	907.0
	N_1	1037.0	1585.0	1233.0
	N_2	2037.0	3062.0	2290.0
	N_3	3588.0	4595.0	3772.0
C.D.(0.05) for level		418.0	542.6	540.5
C.D.(0.05) for variety		289.5	396.8	377.5
C.D.(0.05) for interaction		587.7		

Native 1 it was 15.4 cm. Increased dose of nitrogen tended to increase the length of panicle.

5. Deficiency symptoms

The plants getting no nitrogen application were stunted in growth with pale yellow green foliage. Considerable reduction in the number of tillers was also noted. Flowering duration was delayed by 18 days for plants getting N_0 treatment.

B. YIELD

The data pertaining to the effect of variety and level of nitrogen on yield characters such as weight of grain, weight of straw, weight of root, number of grains per panicle, grain:chaff ratio, 1000 grain weight and weight of panicle are recorded in Tables V and VII.

1. Yield of grain (Table V)

In the matter of yield of grain, treatment differences were significant at 1 percent level. However, there was no significant differences in grain yield between the varieties. A maximum yield of 388.3 g was noted for Tainan 3 for an application of 180 kg nitrogen per hectare, while for Taichung Native 1 the

maximum yield was 329.3 g per pot, for the same treatment. The figure for the average grain yield for all the treatments was 178.9 g for Tainan while for Taichung Native 1 it was a general trend for th increase in

2. Yield of straw

As far as the yield of straw is concerned there was a significant difference between the varieties and also the treatments. The maximum yield of straw for Tainan 3 was 533.0 g due to an application of 180 kg nitrogen per hectare while for Taichung Native 1, it was only 211.2 g for the same treatment. Application of nitrogen increased the yield of straw over the no nitrogen treatment. There was a positive correlation between the yield character and the higher doses of nitrogen.

3. Yield of root

The yield of root recorded in Table V, was also found to differ significantly with the treatment.

Table VII

Effect of different levels of nitrogen on yield characters of two varieties of rice

Treatment		No. of grain per panicle	Grain: chaff ratio	Panicle length (cm)	Panicle Weight (g)	Wt. of 1000 grains (g)
V_1N_0		32.9	7.6	12.1	0.85	23.99
V_1N_1		57.3	8.4	18.5	1.70	24.50
V_1N_2		77.9	7.4	21.2	2.37	25.83
V_1N_3		100.9	8.8	22.9	2.72	24.27
Mean		67.3	8.1	18.7	1.91	24.64
V_2N_0		34.4	8.4	11.0	0.74	20.16
V_2N_1		45.8	8.0	15.9	0.88	21.88
V_2N_2		53.8	3.8	16.6	1.29	21.22
V_2N_3		61.7	7.2	18.0	1.54	22.98
Mean		48.9	5.9	15.4	1.11	21.56
	N_0	33.7		11.6	0.79	22.07
Mean for level	N_1	51.6		17.2	1.29	23.19
	N_2	65.9		18.9	1.83	23.52
	N_3	81.3		20.4	2.13	23.63
C.D.(0.05) for level		8.14		0.257	0.848	-
C.D.(0.05) for variety		6.54		0.172	0.600	0.965
C.D.(0.05) for interaction		13.08		-	-	-

However the interaction between variety and treatment was not found to vary significantly.

Among the 2 varieties Tainan 3 produced the maximum yield of 418.7 g. This was due to an application of 180 kg nitrogen per hectare while the minimum for the same variety was only 101.3 g for no application of nitrogen. The 3 levels of nitrogen have a significant difference between the no nitrogen treatment. When the average figures for the various treatments were compared it was 227.7 for Tainan 3 as compared to 182.2 for Taichung Native 1. There was a general tendency for the yield character to increase steadily with increase in levels of nitrogen.

4. Number of grains per panicle

The data for the number of grains per panicle, given in Table VII, revealed a significant difference between the varieties and the various levels of nitrogen. Interaction between variety and levels of nitrogen was also found to vary significantly.

Tainan 3 was found to be superior in the number of grains per earhead. A maximum of 100.9 g/pot was recorded for Tainan 3 and of 61.7 g/pot for Taichung

Native 1 for an application of 180 kg N/ha. There was a significant difference between the 3 levels of nitrogen (N_1 , N_2, N_3) which also differed significantly from N_0 level. In the case of average number of grains per panicle also Tainan 3 was found to be superior to Taichung Native 1. Increased dose of nitrogen increased the number of grains per panicle as expected.

5. Grain:chaff ratio (Table VII)

In the case of grain:chaff ratio the two varieties differ significantly. The average value of grain:chaff ratio for Taichung Native 1 was only 5.9 while for Tainan 3 it was 8.1. However, it was found that increasing the level of nitrogen application had no tendency to increase the ratio significantly.

6. Thousand grain weight

Table VII shows that there was a significant difference between the 2 varieties, even though there was no significant difference between the various levels of nitrogen and the interaction between the variety and the various levels of nitrogen. Taichung Native 1 was inferior to Tainan 3 in 1000 grain weight. A maximum of 25.83 g were obtained for an application

of 120 kg/ha of nitrogen while the maximum for Taichung Native 1 was only 22.98 g for the highest application of 180 kg N/ha. On a comparison of the average values for 1000 grain weight, Taichung Native 1 was found to be inferior to Tainan 3. There was no tendency for an increase in the 1000 grain weight, with a corresponding increase in levels of nitrogen.

7. Weight of panicle

Data presented in Table VII shows that variety and level of nitrogen had a significant influence on the weight of panicle. There was also found to be a significant difference due to an interaction of variety and level of nitrogen. Tainan 3 was superior to Taichung Native 1 as regards the maximum grain yield. The maximum weight of panicle was 2.72 for an application of 180 kg/ha of nitrogen while the minimum was only 0.85. The maximum for Taichung Native 1 was only 1.53 for an application of 180 kg N/ha, while the minimum was 0.88. A general tendency for an increase in the weight of panicle due to increasing levels of nitrogen was noticed.

Table VIII

Effect of different levels of nitrogen on the nutrient content of grain of two varieties of rice (Expressed as percent)

Treatment		N	P_2O_5	K_2O
V_1N_0		1.48	0.62	1.32
V_1N_1		0.77	0.56	1.02
V_1N_2		1.01	0.74	0.89
V_1N_3		1.07	0.57	1.21
Mean		1.08	0.62	1.11
V_2N_0		1.29	0.54	1.44
V_2N_1		0.99	0.65	1.44
V_2N_2		0.98	0.63	1.16
V_2N_3		1.28	0.74	1.43
Mean		1.15	0.64	1.37
	N_0	1.38	0.58	1.39
Mean for level	N_1	0.88	0.61	1.23
	N_2	0.99	0.68	1.02
	N_3	1.17	0.66	1.32
C.D.(0.05) for level		0.170	0.023	0.054
C.D.(0.05) for variety		-	0.017	0.030
C.D.(0.05) for interaction		-	0.060	0.064

C. NUTRIENT CONTENT OF GRAIN AND STRAW

The data relating to the influence of variety and level of nitrogen on the nutrient content of rice are given in Tables VIII and IX

I. GRAIN

(a) Nitrogen

The data relating to the nitrogen content of grain showed that only level of nitrogen is significant at 1 percent level whereas varietal difference and interaction did not differ significantly.

In the case of nitrogen content of grain, Tainan 3 and Taichung Native 1 differ only very slightly. The maximum nitrogen content of 1.48 percent was obtained for Tainan 3 with no nitrogen application while the value for Taichung Native 1 was 1.29 for the same treatment. When the average values for all the treatments were compared it was found that Taichung Native 1 had a value of 1.15 percent and Tainan 3, 1.08 percent. The grains from pots receiving no nitrogen also contained a high percent nitrogen. This tended to increase with increasing doses of applied nitrogen. However the

increase in nitrogen content of grain with increase in the dose of nitrogen was not very significant.

(b) Phosphorus

In the case of phosphorus content of grain very high significant difference was found for variety, level of nitrogen and interaction.

The highest phosphorus content of grain of 0.74 percent was found for Taichung Native 1 as well as Tainan 3 for nitrogen application of 180 and 120 kg N/ha respectively. The average value for all the treatments was 0.64 percent for Taichung Native 1 and 0.62 percent for Tainan 3. Treatments N_2 and N_3 significantly differed from N_1 and N_0 in the content of this element in grain. Higher doses of nitrogen application have thus a beneficial effect in increasing the amount of phosphorus in grain.

(c) potassium

In the case of potassium content of the grain, high significance at 1 percent level was observed for variety, level of nitrogen and interaction.

Taichung Native 1 was found to be superior to Tainan 3 in the potassium content of grain. The maximum

Table IX

Effect of different levels of nitrogen on the nutrient content of straw of two varieties of rice (Expressed as percent)

Treatment		N	P_2O_5	K_2O
V_1N_0		0.73	0.42	2.48
V_1N_1		0.53	0.35	2.43
V_1N_2		0.57	0.28	2.32
V_1N_3		0.55	0.23	1.36
Mean		0.59	0.32	2.15
V_2N_0		0.94	0.32	2.57
V_2N_1		0.59	0.46	2.14
V_2N_2		0.43	0.25	2.03
V_2N_3		0.64	0.32	2.15
Mean		0.65	0.34	2.22
	N_0	0.84	0.37	2.53
Mean for level	N_1	0.56	0.40	2.28
	N_2	0.50	0.26	2.18
	N_3	0.59	0.27	1.76
C.D.(0.05) for level		0.039	0.039	0.360
C.D.(0.05) for variety		0.026	-	-
C.D.(0.05) for interaction		0.054	0.054	0.536

amount of 1.44 percent was obtained for Taichung Native 1 both for no nitrogen as well as for application of nitrogen at 60 kg N/ha, whereas it was 1.34 percent for Tainan 3 for no nitrogen application. When the average figures for all the treatments were compared it was found that Taichung Native 1 had 1.37 percent of potassium in grain as against 1.11 percent for Tainan 3. The values show that nitrogen application has a negative influence on potassium content since the maximum value was obtained for no nitrogen application. Treatment with no nitrogen application is found to be the best as far as the potassium content of grain is considered.

2. STRAW

(a) Nitrogen

The results given in Table IX show that as in the case of nitrogen content of grain, the nitrogen content of straw of Taichung Native 1 also, was higher than that for Tainan 3. The maximum amount of 0.94 percent nitrogen was obtained for Taichung Native 1 for a treatment with no nitrogen application and it was 0.73 percent for Tainan 3 for the same treatment. When the average value was compared for Taichung Native 1, the

percentage of straw was 0.65 and for Tainan 3 it was only 0.59 percent. There was a significant difference between treatments. It was found that highest amount of nitrogen was noted in the treatment with no nitrogen application and the least amount of nitrogen in the treatment, 120 kg N/ha.

(b) Phosphorus

Levels of nitrogen had a marked effect on the phosphorus content of straw as indicated by significance at 1 percent level. But varietal difference was not at all significant. High significance was observed for interaction between variety and level of nitrogen.

The data showed that as the application of nitrogen increased the phosphorus content also increased. Taichung Native 1 was superior to Tainan 3 though the differences were not statistically significant. The highest phosphorus content of 0.46 percent was found for Taichung Native 1 for an application of 60 kg N/ha, whereas the maximum value for Tainan 3 was 0.42 percent for no nitrogen application. The mean value of 0.34 percent was for Taichung Native 1 as compared to 0.32 percent for Tainan 3. All the different levels differed significantly in this respect. As regards the phosphorus

content of straw, the most effective treatment was application of 60 kg N/ha. It was also noted that higher level of nitrogen has a negative influence in the phosphorus content of straw.

(c) Potassium

In the case of potassium content of straw varietal difference was not significant whereas the difference between levels of nitrogen was significant at 1 percent level. High significance for interaction was also obtained.

As in the case of potassium content of grain, the potassium content of straw also was highest for treatment with no nitrogen application and it slightly tended to decrease as the levels of nitrogen increased. The highest amount of 2.57 percent was obtained for Taichung Native 1 for no nitrogen application while for Tainan 3 it was 2.48 percent for the same treatment. The mean value for all the treatments was 2.22 percent for Taichung Native 1 and 2.15 percent for Tainan 3. Among the lower levels, viz., application of 60, 120 kg N/ha and no nitrogen application there was no significant difference in this respect but they differed significantly with the highest level viz., application of 180 kg N/ha.

D. NUTRIENT UPTAKE

The data relating to the nutrient uptake by straw and grain are furnished in Tables X, XI, XII and XIII.

1. GRAIN

(a) Nitrogen

Taichung Native 1 was superior to Tainan 3 in the matter of total uptake of nitrogen but the difference was very little. The highest uptake of 4.213 g/pot (42.13 kg/ha) was found for Taichung Native 1 for an application of 180 kg N/ha while for Tainan 3, the value was 4.1548 g/pot (41.548 kg/ha) for the same treatment. The average value for all the treatments was 1.8089 g/pot (18.089 kg/ha) for Tainan 3 as compared to 1.8277g/pot (18.277 kg/ha) for Taichung Native 1. The effect of variety in this case is less marked but increased nitrogen uptake was found to result from higher doses of nitrogen applied.

(b) Phosphorus

The data relating to the uptake by grain showed that both variety and level of nitrogen had a significant

effect in the total uptake of phosphorus. The maximum uptake of 4.215 g/pot (42.15 kg/ha) was obtained for Taichung Native 1 for an application of 180 kg N/ha while it was only 2.2133 g/pot (22.133 kg/ha) for Tainan 3 for the same treatment. When the mean values were compared it was found that for Taichung Native 1 the value was 1.7144 g/pot (17.144 kg/ha) while for Tainan 3 it was only 1.1069 g/pot (11.069 kg/ha). As in the case of nitrogen uptake by grain, the absorption of phosphorus also significantly increased with increasing levels of nitrogen application.

(c) Potassium

Potassium uptake by grain was also influenced by variety as well as level of nitrogen. As the level of nitrogen increased the potassium uptake also increased considerably. Taichung Native 1 was found to be superior to Tainan 3 in this respect. The maximum uptake of 4.7089 g/pot (47.089 kg/ha) was obtained as a result of an application of 180 kg N/ha for Taichung Native 1 and 4.6984 g/pot (46.984 kg/ha) for Tainan 3 due to an application of the same dose. The average value for Taichung Native 1 was 2.1532 g/pot (21.532 kg/ha) as compared to 1.9482 g/pot (19.482 kg/ha) for Tainan 3.

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Table X

Effect of different levels of nitrogen on the nutrient uptake by grain in two varieties of rice (Expressed as g/pot)

Treatment		N	P_2O_5	K_2O
V_1N_0		0.1228	0.0515	0.1112
V_1N_1		0.8485	0.6171	1.1240
V_1N_2		2.1098	1.5458	1.8592
V_1N_3		4.1548	2.2133	4.6984
Mean		1.8089	1.1069	1.9482
V_2N_0		0.1806	0.0756	0.2016
V_2N_1		0.9622	0.6318	1.3996
V_2N_2		1.9553	1.9353	2.3026
V_2N_3		4.2130	2.3368	4.7089
Mean		1.8277	1.2496	2.1532
	N_0	0.1517	0.0635	0.1564
Mean for level	N_1	0.9054	0.6244	1.2618
	N_2	2.0325	1.7405	2.0809
	N	4.1839	2.2751	4.7036

Table XI

Effect of different levels of nitrogen on the nutrient uptake by straw in two varieties of rice (Expressed as g/pot)

Treatment		N	P_2O_5	K_2O
V_1N_0		0.5110	0.2940	1.7360
V_1N_1		0.8866	0.5855	4.0653
V_1N_2		1.9340	0.9500	7.8617
V_1N_3		2.9315	1.2259	7.2488
Mean		1.5658	0.7638	5.2279
V_2N_0		0.3384	0.1152	0.9252
V_2N_1		0.8832	0.6886	3.2035
V_2N_2		1.1739	0.6825	5.5419
V_2N_3		2.1075	1.2352	8.2990
Mean		1.1257	0.6661	4.4924
Mean for level	N_0	0.4247	0.2046	1.3306
	N_1	0.8849	0.6371	3.6344
	N_2	1.5539	0.8162	6.7018
	N_3	2.5195	1.2305	7.7739

Table XII

Effect of different levels of nitrogen on the nutrient uptake by grain in two varieties of rice (Expressed as kg/ha)

Treatment		N	P_2O_5	K_2O
V_1N_0		1.228	0.515	1.112
V_1N_1		8.485	6.171	11.240
V_1N_2		21.098	15.458	18.592
V_1N_3		41.548	22.133	46.984
Mean		18.089	11.069	19.482
V_2N_0		1.806	0.756	2.016
V_2N_1		9.622	6.318	13.996
V_2N_2		19.553	15.353	23.026
V_2N_3		42.130	23.368	47.089
Mean		18.277	12.496	21.532
	N_0	1.517	0.635	1.564
Mean for level	N_1	9.054	6.244	12.618
	N_2	20.325	17.405	20.809
	N_3	41.839	22.751	47.036

Table XIII

Effect of different levels of nitrogen on the nutrient uptake by straw in two varieties of rice (Expressed as kg/ha)

Treatment		N	P_2O_5	K_2O
V_1N_0		5.110	2.940	17.360
V_1N_1		8.866	5.855	40.653
V_1N_2		19.340	9.500	78.617
V_1N_3		29.315	12.259	72.488
Mean		15.658	7.638	52.279
V_2N_0		3.384	1.152	9.252
V_2N_1		8.832	6.886	32.035
V_2N_2		11.739	6.825	55.419
V_2N_3		21.075	12.352	82.990
Mean		11.257	6.661	44.924
	N_0	4.247	2.046	13.306
Mean for level	N_1	8.849	6.371	36.344
	N_2	15.539	8.162	67.018
	N_3	25.195	12.305	77.739

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2. STRAW

(a) Nitrogen

As in the case of nitrogen uptake by grain, the total nitrogen absorption by straw also was considerably influenced by variety as well as level of nitrogen. An increase in nitrogen uptake was noticed as the level of nitrogen increased. The highest nitrogen uptake of 2.9315 g/pot (29.315 kg/ha) was obtained for Tainan 3 for an application of 180 kg N/ha while for Taichung Native 1 it was 2.1075 g/pot (21.075 kg/ha) for the same treatment. The highest mean value for all treatments (1.5658 g/pot - 15.658 kg/ha) was for Tainan 3 as compared against 1.1257 g/pot (11.257 kg/ha) for Taichung Native 1.

(b) Phosphorus

The phosphorus uptake was also appreciably influenced by variety and level of nitrogen. The maximum uptake of 1.2352 g/pot (12.352 kg/ha) was for Taichung Native 1 for an application of 180 kg N/ha and for Tainan 3 it was 1.2259 g/pot (12.259 kg/ha). When the average values were examined Tainan 3 with an uptake of 0.7638 g/pot (7.638 kg/ha) of phosphorus was

superior to Taichung Native 1 having a phosphorus uptake value of 0.661 g/pot (6.661 kg/ha). The uptake of phosphorus significantly increased as the level of nitrogen increased.

(c) Potassium

The influence of variety as well as level of nitrogen was highly significant with respect to the total uptake of potassium. Taichung Native 1 was found to be superior to Tainan 3 with uptake values of 5.2279 g/pot (52.279 kg/ha) and 4.4924 g/pot (44.924 kg/ha) respectively. The maximum uptake of potassium was 7.8617 g/pot (78.617 kg/ha) for Tainan 3 for an application of 120 kg N/ha while for Taichung Native 1 it was 8.299 g/pot (82.99 kg/ha) for an application of 180 kg N/ha. The data show that increasing level of nitrogen has a significant effect in increasing the total uptake of potassium.

DISCUSSION

DISCUSSION

In the following pages are discussed the results of investigation on the influence of nitrogen on the growth and yield of paddy. The effect of nitrogen in varying doses on the agronomic characters of rice plant, yield of grain and straw and on the uptake of nitrogen, phosphorus and potash are considered in this discussion.

Influence of nitrogen on agronomic characters

The results have clearly brought out the influence of nitrogen on the various agronomic characters of the rice plant. Of the two varieties studied, Tainan 3 is a taller variety. It was observed that in both varieties, increasing application of nitrogen increased the height of plants. This effect has been evident at all stages of growth. Considering the mean values for the height of plants of both the varieties, it appears that, while upto the 45th day of growth, the rate of increase in height was more or less the same for both varieties, after this period the height of plants of Tainan 3 increased at a more rapid rate than that of Taichung Native 1. It is evident, therefore, that increasing

doses of nitrogen applied, had a markedly beneficial effect on the growth of plants of the two varieties. The same finding have been obtained by Srinivasulu and Pawar (1965). These authors concluded that nitrogen application had a significant effect on economic characters of plant, such as plant height, number of ear bearing tillers etc. A similar observation has been made by Rhode (1963) on wheat. Another result of interest observed in this study was that even though there were marked increases in the height of plants as a result of nitrogen application, there was no evidence of any symptoms of lodging during the entire period of growth. It is generally known that high nitrogen application would result in lodging. However the results of the present study are at variance from this commonly observed phenomenon. This fact is of particular significance in the case of these two varieties because it suggests that nitrogen application in large doses could be resorted to safely without any risk of lodging.

Considering the tiller counts at different periods, it will be seen (Table III) that in the initial stages of growth, the two varieties did not differ in the number of tillers. However, after 45 days the two

varieties exhibited marked differences in the number of tillers. Taichung Native 1 had the maximum number of tillers after this period. Tiller number, it would appear, is a varietal character. Kochappan Nair and Koshy (1966) while studying the influence of different forms of nitrogen on the growth and yield characters of some Kerala rice varieties also found that the number of tillers per plant varied significantly with variety. The results of the present study have shown that in both varieties, application of nitrogen in increasing doses, produced significant increase in the number of tillers per plant. It may be pointed out that similar results were reported by Tanaka et al (1959) and Patnaik (1964) also.

In the matter of height and number of productive tillers at harvest (Table IV) also, significant difference was noticed between the two varieties. The mean height of productive tillers is greater for Tainan 3 than for Taichung Native 1. However, the mean value for the number of productive tillers was much higher for Taichung o Native 1. The influence of different doses of nitrogen on the height and number of productive tillers also was very significant.

As regards the length of panicle (Table VII) there appeared to be significant difference between the two varieties. It was seen that panicle length was greater for Tainan 3. The same was found to be the case with regard to the weight of panicle also. The results obtained, clearly brings out the effect of nitrogen on the length and weight of panicle. Increasing doses of nitrogen applied produced significant increases in the length and weight of panicle of both the varieties. Maximum panicle length and weight was obtained with treatment of nitrogen at 180 kg/ha.

From the foregoing, it is evident that nitrogen application had significant influence on the various agronomic characters of the plant such as plant height, number of tillers, length and weight of panicle and number of productive tillers and that nitrogen application would not result in lodging. The two varieties exhibited marked differences in their agronomic characters.

Deficiency symptoms due to lack of nitrogen

The beneficial effects of nitrogen applied in increasing levels had manifested itself by the normal and healthy plants receiving this treatment. However

the plants which received no nitrogen application clearly exhibited deficiency symptoms, such as stunted growth, pale yellow green folliage and decreased tiller number. The results obtained from the present study is fully in agreement with the finding of Ghose et al (1960).

It would thus be evident that these varieties not only respond very favourably to nitrogen application, but are highly susceptible to nitrogen deficiency when they do not receive adequate supply of nitrogen.

Influence of nitrogen on the yield of grain and straw

It was observed that the two varieties did not differ significantly in grain yield. However, both varieties responded very favourably to increasing levels of nitrogen, the yield of grain significantly increasing with the increase in dose of applied nitrogen. The yield reached a maximum at 180 kg N/ha, for both the varieties. Considering the increase in yield for the different levels of nitrogen, over that of the control (N_0 level) it was found that a proportionate increase in yield resulted with increase in the level of nitrogen. Thus it would appear, that still higher yields are

possible if the level of nitrogen is increased beyond 180 kg/ha. The yield from the pots receiving no nitrogen was conspicuously low. The results thus bring out the importance of manuring these varieties with high levels of nitrogen. In the case of three japonica and two indica varieties, Yamada (1957) also observed that all the varieties gave remarkable increase in yield with increase in the dose of applied nitrogen. Identical results have been reported by Tanaka and others (1964) and also by Parasuram (1965) in the case of rice variety W.140.

It is evident from the results that the two varieties differ significantly for straw yield. Tainan 3 produced a greater amount of straw than Taichung Native 1. As in the case of grain yield, nitrogen application in increasing doses, resulted in significant increases in the yield of straw.

In the case of the weight of roots also, there was significant difference between the two varieties, Tainan 3 having a greater amount of roots. It would therefore appear that the yield of straw is in some way related to the amount of roots.

Of the two varieties studied, the grain/chaff ratio was higher for Tainan 3. In both the varieties this characteristic was not significantly affected by application of nitrogen. The grain/chaff ratio thus appears to be a varietal character, and with a higher grain/chaff ratio Tainan 3 appeared to be superior to Taichung Native 1. The fact that this ratio was not significantly affected by application of nitrogen would appear to suggest that high grain yields could be obtained for both the varieties with high dose of nitrogen application, without affecting in any way the grain/chaff ratio.

The study did not bring out any significant effect of nitrogen on the weight of 1000 grains. Thus in each variety the total carbohydrate content of the grain was unaffected by different levels of nitrogen. However there was significant difference between the two varieties in this respect, Tainan 3 being superior to Taichung Native 1. It is quite possible that the total carbohydrate content of Tainan 3 grains will be much higher than that for Taichung Native 1, probably as a result of greater photosynthetic activity in the former variety.

It would thus appear from the results so far discussed that nitrogen application had a very significant effect in increasing the yield of grain and straw of both the varieties. However, nitrogen application did not appear to influence markedly the quality of the grain as revealed from the data on 1000 grains weight and the grain/chaff ratio. Varietal difference appeared to be very significant as far as yield was concerned, Tainan 3 excelling Taichung Native 1.

Influence of nitrogen on the nutrient content of and on the uptake of nutrients by, grain and straw

The results showed that nitrogen content of grain was generally higher in Tainan 3. There was found to be a general decrease in the nitrogen content of grain with increase in the dose of nitrogen applied. In the case of the straw also the percentage of nitrogen generally decreased with increasing levels of nitrogen. A very high yield of grain and straw with increasing levels of nitrogen probably would have resulted in the total nitrogen absorbed being distributed over a larger quantity of plant material, consequently resulting in a decrease in the percentage of nitrogen with increase in the dose of nitrogen applied.

Considerable difference was noticed between the two varieties as regards the phosphorus content of the grain. In the case of both grain and straw, increasing doses of nitrogen generally tended to increase the P_2O_5 content. The two varieties did not differ appreciably in the P_2O_5 content of straw.

In the case of the potassium content of grain the two varieties differed significantly whereas such a difference was not found in thecase of straw. Nitrogen application had a depressing effect on the potash content of both grain and straw.

The results obtained thus indicates that application of nitrogen in increasing levels decreased the nitrogen and potash content of both grain and straw, whereas this slightly increased the phosphorus content of grain.

The total nitrogen uptake by grain expressed in grams per pot increased steadily with increasing doses of nitrogen applied. This was found to be true in the case of the straw also. This should be as it is, because application of nitrogen considerably increased the yield of both straw and grain, so much so, the total intake of nitrogen, by these plant parts also increased.

The same fact was noticed as regards the total uptake of phosphorus and potassium. Of the two varieties the total uptake of nitrogen, phosphorus and potassium was slightly higher for Tainan 3.

The results indicate that for both these high yielding varieties, the total uptake of the major nutrients, nitrogen, phosphorus and potassium was very high. When increased yields are achieved by higher dose of nitrogen, there is a corresponding increase in the total uptake of the nutrients by the plant. It is thus evident that while these varieties are high yielding, they are more exacting in their manurial requirements as indicated by the total uptake of nutrients.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

A pot culture study was conducted, using specially designed concrete pots to determine the response of Tainan 3 and Taichung Native 1 to applications of varying levels of nitrogen and to compare their performance. The study has enabled the following main conclusions to be drawn.

1. The two varieties exhibited marked differences in their agronomic characters.

2. Nitrogen application at varying levels had significant influence on the various agronomic characters, such as plant height, number of tillers per plant, length and weight of panicle and the number of productive tillers. All these were enhanced by increasing levels of nitrogen.

3. For both the varieties there was no risk of lodging consequent on high doses of nitrogen applied.

4. Nitrogen application significantly increased the yield of grain and straw for both the varieties.

5. Varietal difference appeared to be a significant factor as far as yield of grain was concerned, Tainan 3 excelling Taichung Native 1 in this respect.

6. Deficiency symptoms such as stunted growth, pale yellow green foliage and reduced tiller number resulted with zero nitrogen level, whereas application of nitrogen in increasing doses, apart from resulting in high yield, produced normal and healthy plants. The high nitrogen requirement of these two varieties is further confirmed by this observation.

7. Nitrogen application did not influence significantly either the grain/chaff ratio or the weight of 1000 grains.

8. Application of nitrogen in increasing levels decreased the nitrogen and potash content of both grain and straw, whereas this slightly increased the phosphorus content of grain for both varieties.

9. For both the varieties, the total uptake of the major nutrients, nitrogen, phosphorus and potash

was very high. Increasing doses of nitrogen resulted in a proportionate increase in the total uptake of nutrients, thus indicating the very exacting manurial requirements of these two varieties.

The results obtained in the present study clearly emphasize the significance of the high nitrogen requirement of Tainan 3 and Taichung Native 1, both from the point of view of high yield and also from that of normal and healthy growth of plant.

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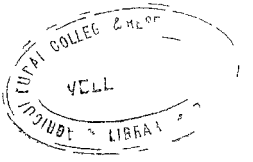
APPENDIX



Appendix 1

Analysis of variance for plant height (30th day)

Source	S.S.	Df	Variance	F ratio
Total	1193.3	23		
Block	84.08	2	42.04	2.48
Treatment	871.46	7	124.49	7.34**
V	291.90	1	291.90	17.20**
N	554.71	3	184.90	10.84 *
VN	24.85	3	8.29	0.49
Error	237.59	14	16.97	

Appendix 2

Analysis of variance for plant height (45th day)

Source	S.S.	Df	Variance	F ratio
Total	3373.34	23		
Block	30.76	2	16.93	0.19
Treatment	2102.76	7	300.39	3.39*
V	504.17	1	504.17	5.69*
N	1446.58	3	482.19	5.44*
VN	152.01	3	50.67	1
Error	1239.82	14	88.56	

* Significant at 5 percent level

** Significant at 1 percent level

Appendix 3

Analysis of variance for plant height (60th day)

Source	S.S.	DF	Variance	F ratio
Total	7933.47	23		
Block	243.90	2	121.95	1.40
Treatment	6479.67	7	925.58	10.70**
V	2160.31	1	2160.31	24.98**
N	3118.95	3	1003.60	11.60**
VN	1199.81	3	399.90	4.60*
Error	1210.50	14	86.46	

Appendix 4

Analysis of variance for plant height at harvest

Source	S.S.	Df	Variance	F ratio
Total	8142.10	23		
Block	112.80	2	56.40	1
Treatment	7183.28	7	1026.20	16.98**
V	2396.00	1	2396.00	39.64**
N	4139.46	3	1379.82	22.83**
VN	647.82	3	215.94	3.67*
Error	846.02	14	60.43	

* Significant at 5 percent level

** Significant at 1 percent level

Appendix 5

Analysis of variance for tiller counts at 30th day

Source	S.S.	Df	Variance	F ratio
Total	132.34	23		
Block	16.37	2	8.18	2.6
Treatment	71.41	7	10.27	3.3*
V	3.01	1	3.01	1
N	55.92	3	18.64	5.9**
VN	12.98	3	4.32	1.4
Error	44.06	14	3.14	

Appendix 6

Analysis of variance for tiller counts at 45th day

Source	S.S.	Df	Variance	F ratio
Total	627.03	23		
Block	23.17	2	11.58	2.34
Treatment	534.89	7	23.58	4.78**
V	2.35	1	2.35	1
N	511.57	3	170.52	34.58**
VN	20.97	3	6.99	1.4
Error	68.97	14	4.93	

* Significant at 5 percent level

** Significant at 1 percent level

Appendix 7

Analysis of variance for tiller counts at 60th day

Source	S.S.	Df	Variance	F ratio
Total	1744.61	23		
Block	43.61	2	21.8	1.7
Treatment	1515.02	7	216.43	16.3**
V	63.70	1	63.70	4.78*
N	1361.22	3	453.74	34.1**
VN	90.10	3	30.03	2.3
Error	185.98	14	13.28	

Appendix 8

Analysis of variance for tiller counts at harvest

Source	S.S.	Df	Variance	F ratio
Total	999.18	23		
Block	4.82	2	2.41	1
Treatment	900.17	7	128.59	19.1**
V	60.33	1	60.33	8.9**
N	815.84	3	271.94	40.4**
VN	24.0	3	8.00	1.2
Error	94.19	14	6.73	

* Significant at 5 percent level

** Significant at 1 percent level

Appendix 9

Analysis of variance for length of panicle

Source	S.S.	Df	Variance	F ratio
Total	4.120	23		
Block	0.002	2	0.001	1
Treatment	3.480	7	0.497	11.04**
V	0.630	1	0.630	14.00**
N	2.700	3	0.900	20.00**
VN	0.150	3	0.050	1.11
Error	0.638	14	0.045	

Appendix 10

Analysis of variance for grain yield

Source	S.S.	Df	Variance	F ratio
Total	42194.23	23		
Block	2001.80	2	1000.9	1
Treatment	404087.60	7	57726.80	50.979**
V	2202.32	1	2202.32	1.9
N	388718.00	3	129572.66	114.42**
VN	13167.28	3	4389.093	3.875*
Error	15852.83	14	1132.345	

* Significant at 5 percent level

** Significant at 1 percent level

Appendix 11

Analysis of variance for straw yield

Source	S.S.	Df	Variance	F ratio
Total	641105.00	23		
Block	6806.40	2	3403.2	1.671
Treatment	605791.00	7	86541.6	42.50**
V	26334.40	1	26331.4	12.932**
N	564575.20	3	188191.7	9.242**
VN	14881.40	3	4960.5	2.436
Error	28507.60	14	2036.3	

Appendix 12

Analysis of variance for root yield

Source	S.S.	Df	Variance	F ratio
Total	347700.00	23		
Block	5000.00	2	2500.00	1.32
Treatment	315800.00	7	45100.00	23.6**
V	12600.00	1	12600.00	6.63*
N	299800.00	3	99900.00	52.6**
VN	3400.00	3	1100.00	1
Error	26900.00	14	1900.00	-

* Significant at 5 percent level

** Significant at 1 percent level

Appendix 13

Analysis of variance for number of grains per panicle

Source	S.S.	Df	Variance	F ratio
Total	11680.42	23		
Block	76.20	2	38.10	1
Treatment	10811.08	7	1544.44	27.26**
V	2007.51	1	2007.51	35.43**
N	7439.99	3	2479.99	43.77**
VN	1363.58	3	454.52	8.02**
Error	793.14	14	56.65	-

Appendix 14

Analysis of variance for 1000 grain weight

Source	S.S.	Df	Variance	F ratio
Total	98.29	23		
Block	5.28	7	2.64	2.15
Treatment	75.79	2	10.83	8.8 **
V	57.14	1	57.14	46.45**
N	9.12	3	3.04	2.47
VN	9.53	3	3.17	2.58
Error	17.22	14	1.23	

** Significant at 1 percent level

Appendix 15

Analysis of variance for panicle weight

Source	S.S.	Df	Variance	F ratio
Total	11.90	23		
Block	0.04	2	0.02	1
Treatment	11.17	7	1.59	32.4**
V	3.87	1	3.87	78.9**
N	6.23	3	2.07	42.2**
VN	1.07	3	0.35	7.1*
Error	0.69	14	0.049	

Appendix 16

Analysis of variance for grain:chaff ratio

Source	S.S.	Df	Variance	F ratio
Total	97.33	23		
Block	2.03	2	1.015	0.35
Treatment	55.48	7	7.925	2.8*
V	20.96	1	20.96	7.4*
N	26.74	3	8.91	3.1
VN	7.78	3	2.59	1
Error	39.82	14	2.84	-

* Significant at 5 percent level

** Significant at 1 percent level

Appendix 17

Analysis of variance for nitrogen content of grain

Source	S.S.	Df	Variance	F ratio
Total	1.47	23		
Block	0.10	2	0.05	2.3
Treatment	1.06	7	0.15	6.9**
V	0.01	1	0.01	1
N	0.85	3	0.28	12.8**
VN	0.20	3	0.07	3.2
Error	0.31	14	0.022	-

Appendix 18

Analysis of variance for phosphorus content of grain

Source	S.S.	Df	Variance	F ratio
Total	0.140	23		
Block	0.005	2	0.0025	6.2*
Treatment	0.130	7	0.0180	45.0**
V	0.005	1	0.0050	12.5**
N	0.044	3	0.0146	36.5**
VN	0.081	3	0.0270	67.5**
Error	0.005	14	0.0004	-

* Significant at 5 percent level

** Significant at 1 percent level

Appendix 19

Analysis of variance for potassium content of grain

Source	S.S.	Df	Variance	F ratio
Total	0.97	23		
Block	0.04	2	0.02	14.3**
Treatment	0.91	7	0.13	92.8**
V	0.38	1	0.38	271.4**
N	0.45	3	0.15	107.1**
VN	0.08	3	0.03	21.4**
Error	0.02	14	0.0014	-

Appendix 20

Analysis of variance for nitrogen content of straw

Source	S.S.	Df	Variance	F ratio
Total	0.555	23		
Block	0.029	2	0.015	16.6**
Treatment	0.513	7	0.072	80.0**
V	0.033	1	0.033	36.6**
N	0.397	3	0.132	146.6**
VN	0.083	3	0.028	31.1**
Error	0.013	14	0.0009	-

** Significant at 1 percent level

Appendix 21

Analysis of variance for phosphorus content of straw

Source	S.S.	Df	Variance	F ratio
Total	0.144	23		
Block	0.002	2	0.001	1.1
Treatment	0.130	7	0.180	200.0**
V	0.003	1	0.003	3.3
N	0.080	3	0.027	30.0**
VN	0.047	3	0.016	17.7**
Error	0.012	14	0.0009	-

Appendix 22

Analysis of variance for potassium content of straw

Source	S.S.	Df	Variance	F ratio
Total	3.23	23		
Block	0.04	2	0.02	1
Treatment	3.06	7	0.44	4.9*
V	0.04	1	0.04	1
N	1.85	3	0.62	6.9**
VN	1.17	3	0.39	4.3*
Error	0.13	14	0.09	-

* Significant at 5 percent level

** Significant at 1 percent level

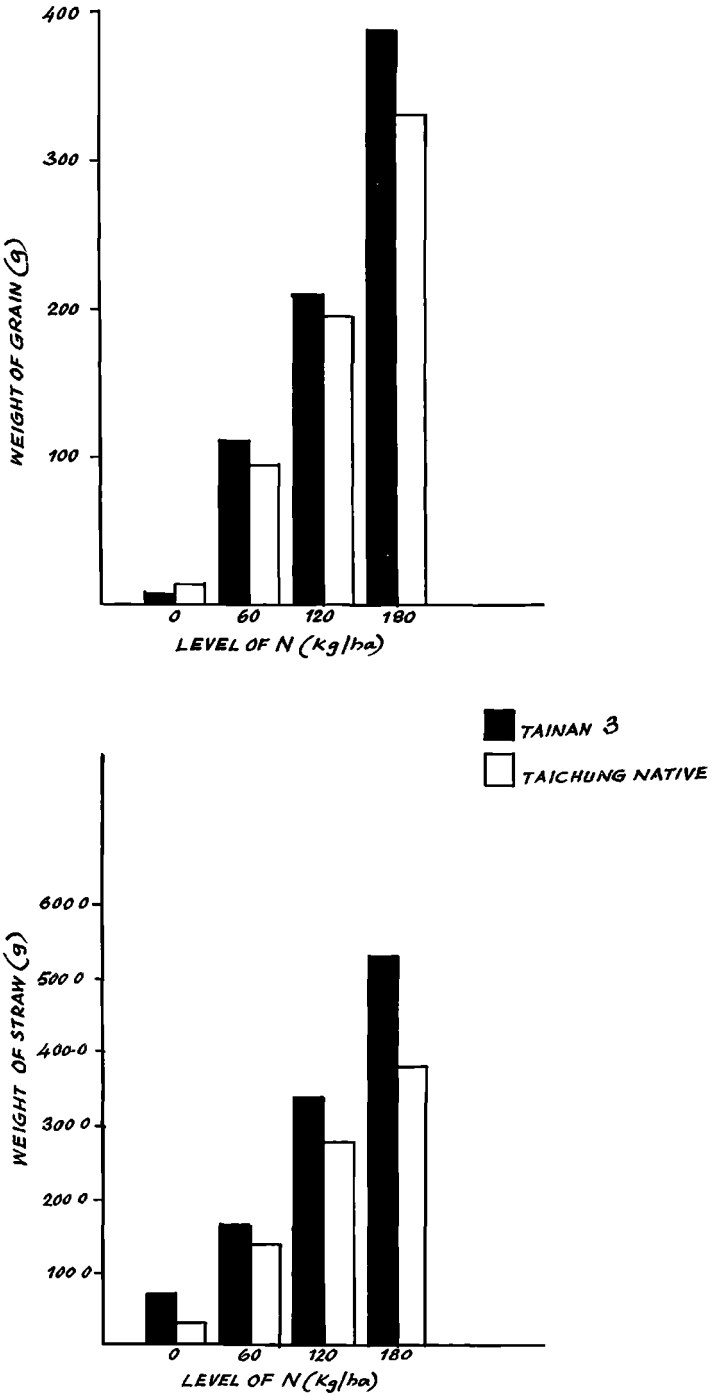


FIG.1 HISTOGRAMS SHOWING YIELD OF RICE GRAIN AND STRAW FOR DIFFERENT NITROGEN TREATMENTS

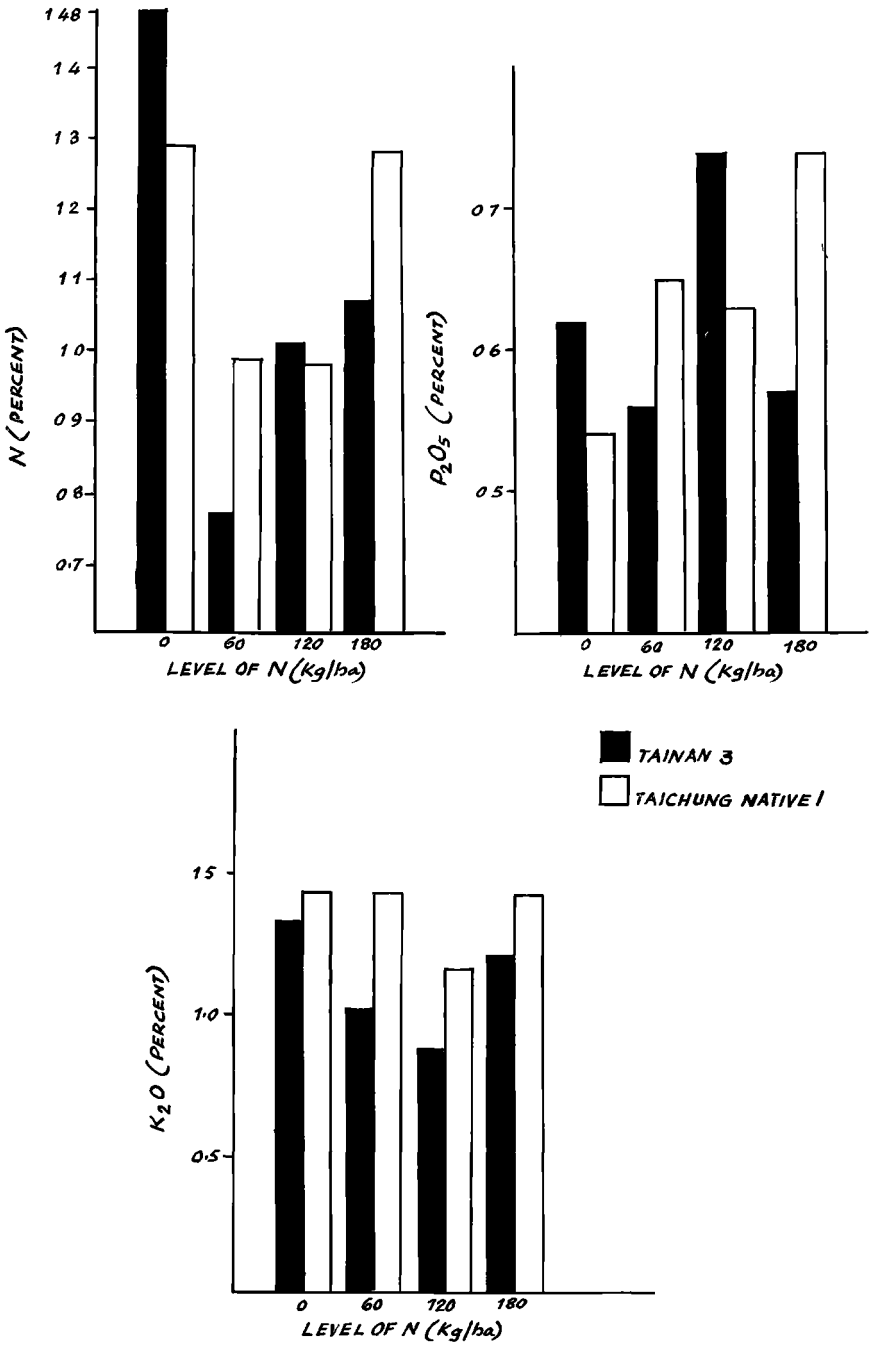


FIG. 2 HISTOGRAMS SHOWING NUTRIENT CONTENT OF RICE GRAIN FOR DIFFERENT NITROGEN TREATMENTS

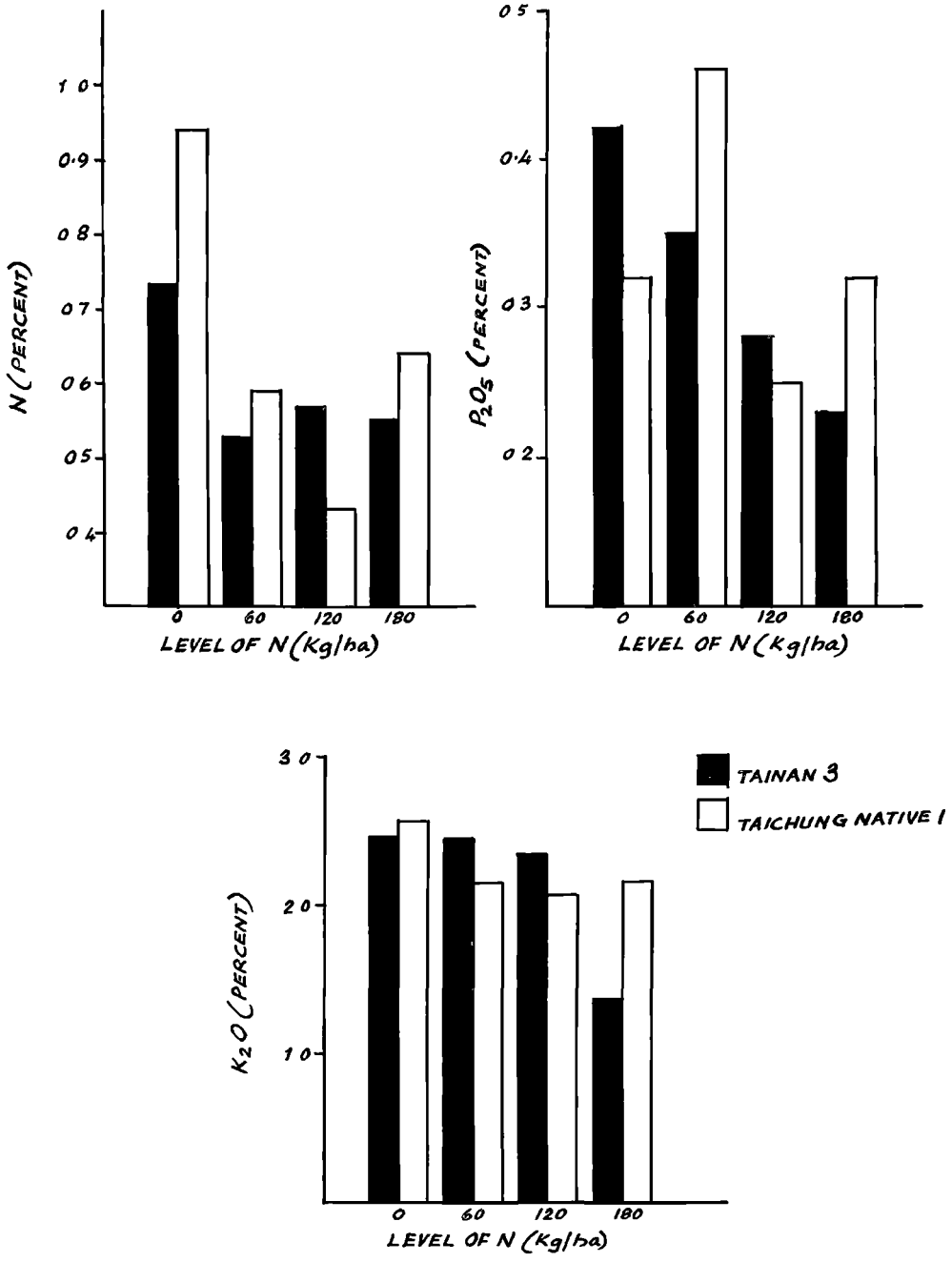


FIG 3 HISTOGRAMS SHOWING NUTRIENT CONTENT OF RICE STRAW FOR DIFFERENT NITROGEN TREATMENTS

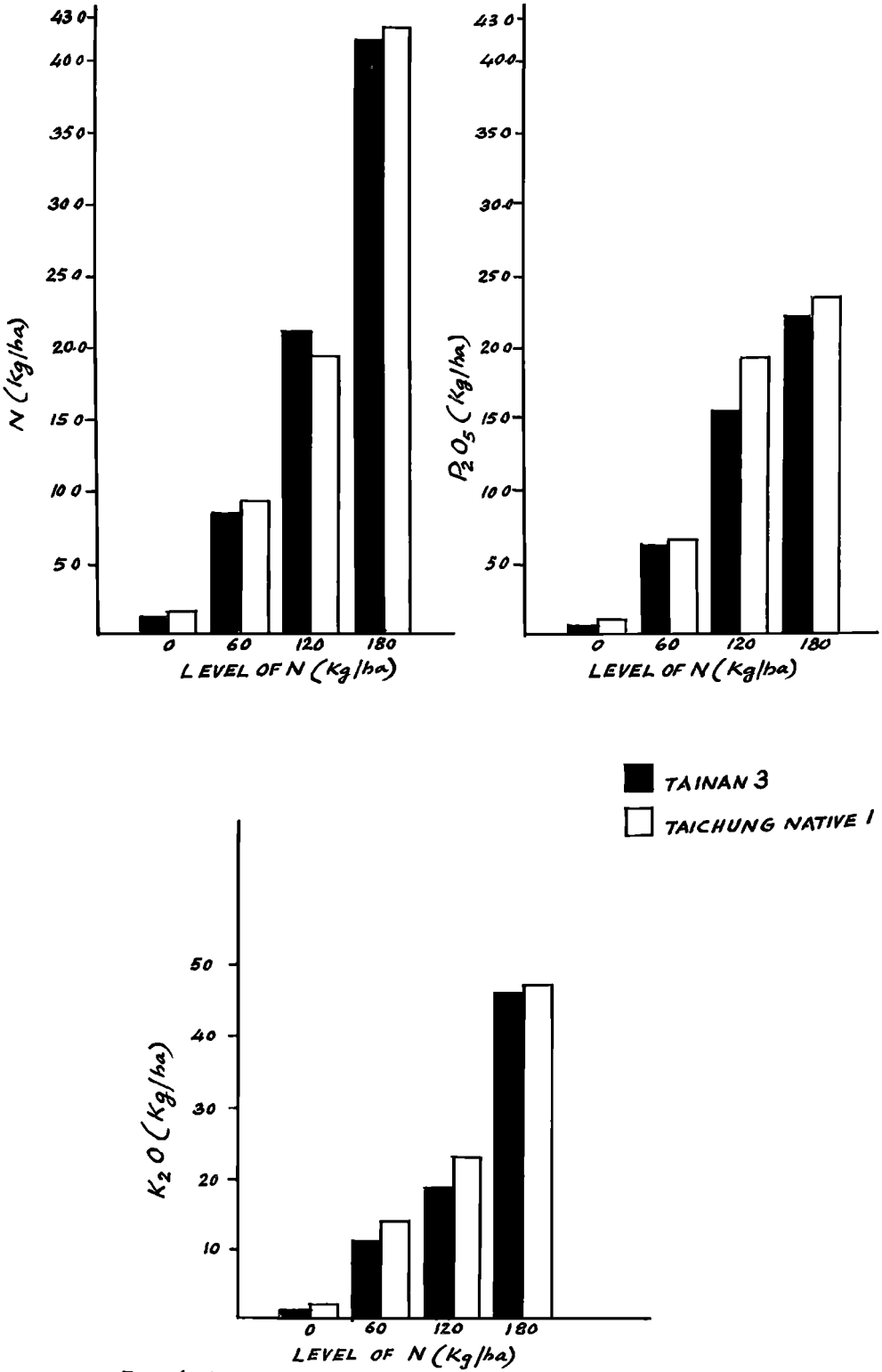


FIG 4 HISTOGRAMS SHOWING NUTRIENT REMOVAL IN RICE GRAIN FOR DIFFERENT NITROGEN TREATMENTS

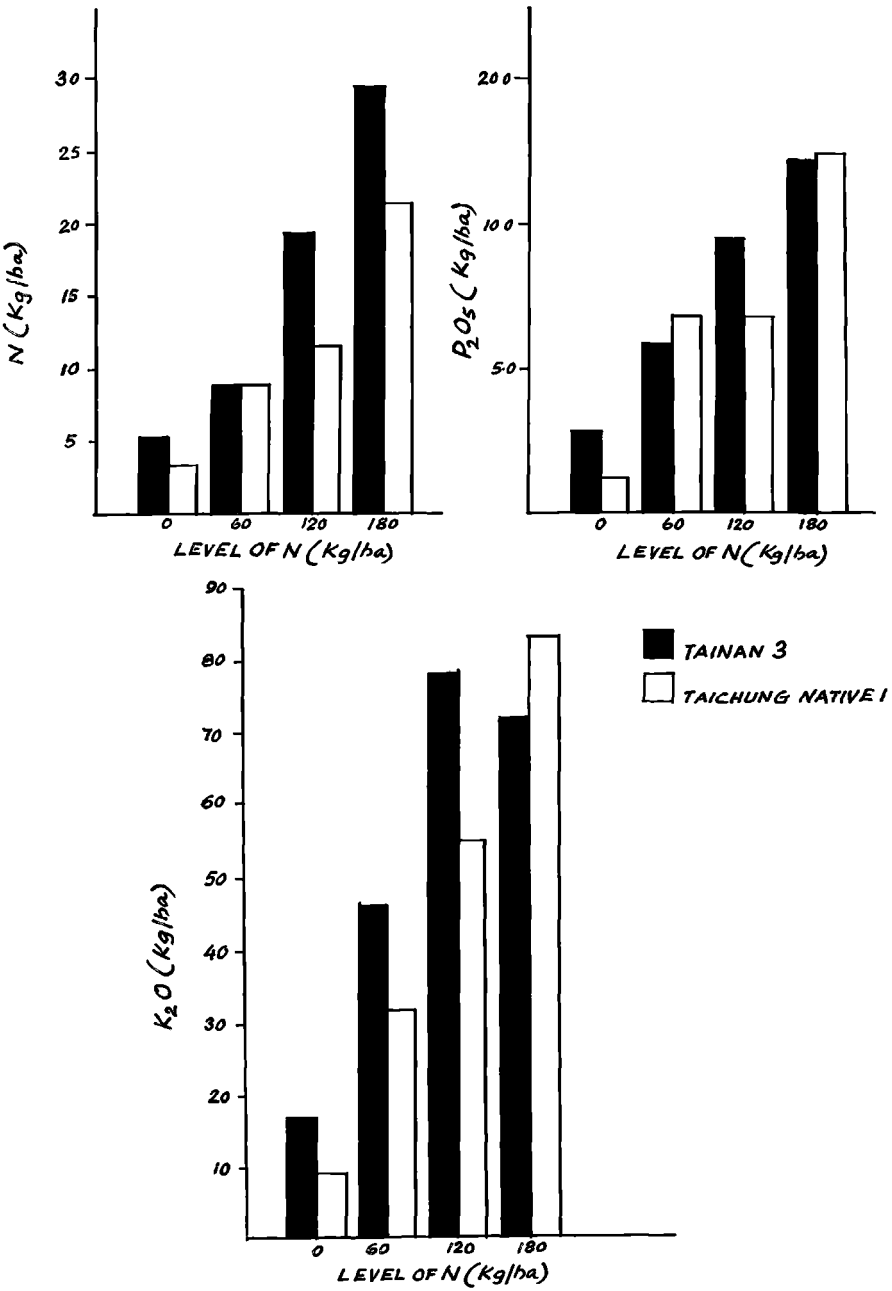


FIG 5 HISTOGRAMS SHOWING NUTRIENT REMOVAL IN STRAW FOR DIFFERENT NITROGEN TREATMENTS

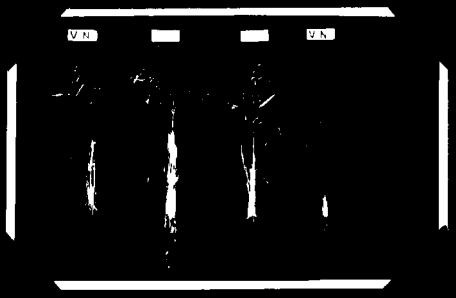


Fig.6. Effect of different levels of nitrogen on the growth of Tainan-3.

Fig.7. Effect of different levels of nitrogen on the growth of Taichung Native-1.