NITROGEN BALANCE STUDIES IN THE RICE SOILS OF KERALA

BY

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THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

1986

DECLARATION

I hereby declare that this thesis entitled "Nitrogen balance studies in the rice soils of Kerala" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude and indebtedness to

Sri.P.R. Ramasubramonian, Professor of Soil Science and Agricultural Chemistry and Chairman of the Advisory Committee for suggesting the problem, for his valuable guidance in the planning and execution of this work, for the advice and encouragement given throughout the period of my studies and in the preparation of the thesis.

Dr.R.S.Aiyer, Professor and Head of the Department of Soil Science and Agricultural Chemistry and Member of the Advisory Committee for his valuable advices and encouragement given during the course of my study.

Dr (Mrs) Alice Abraham, Professor of Soil Science and Agricultural Chemistry and Member of the Advisory Committee for the useful suggestions and constant encouragement offered at every stage of the work and for critically going through the manuscript.

Sri.P.Chandrasekharan, Professor of Agronomy and Member of Advisory Committee for his constant encouragement.

Sri.Abdul Hameed, Professor of Soil Science and Agricultural Chemistry, for his valuable help during the chemical analysis and Dr.P.Saraswathy, Professor of Agricultural Statistics for her valuable assistance in the statistical analysis and interpretation of the data.

All other staff members and Post graduate students of the Department of Soil Science and Agricultural Chemistry, for their assistance and kind co-operation.

Dr.M.M.Koshy, Dean i/c College of Agriculture for providing necessary facilities for the work.

Grateful acknowledgement is due to the Kerala Agricultural University for providing the Fellowship for my post-graduate programme.

To my parents, brother, sister and husband who have always inspired me and helped me in several ways throughout the period of this endeavour.

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INTRODUCTION

INTRODUCTION

Nitrogen and water are the two major limiting factors in rice production. They also serve on the key to the realization of yield potential of modern rice varieties. However, suitable and effective use of nitrogen and water to increase rice yield deserves significance not only from the economic view point, but also from the view point of world's energy resources. The efficiency of nitrogen use by rice plants depends on various factors such as soil, variety, water management, source, time and amount of nitrogen application, etc. The analysis of these factors in the rice tracts of Kerala reveals certain evincing facts. Rice cultivation is mainly concentrated in the wet lands of Kerala. But, there exists a lot of heterogeneity in the soil type and variety used by the farmers. The available package of recommendation for rice has not taken into account fully these soil and varietal differences. For example, a general recommendation of 90 kg N/ha and 70 kg N/ha are given for medium and short duration varieties respectively, under all soil types. Similarly, 5 cm level of submergence is generally recommended for all varieties under all situation of wet land rice (Anon, 1986). Hence, there is ample need for undertaking studies on the effect of different soil types, level of submergence and nitrogen application on growth and yield of rice. Analysis of nutrients in soil, plant and plant parts would indicate the effect of soil submergence levels and nitrogen application on growth and yield of rice through influence of nutrients. The effect and the interaction of different factors on the movement and concentration of nutrients in the economic plant parts (grain and straw) can also be inferred from such analysis. The information from these studies will be useful in the formation of separate fertiliser recommendation for different rice soils of Kerala for realizing maximum yield.

Nitrogen balance studies serve as the means by which the influence of various factors on the total nitrogen content can be clearly delineated and monitored. Such studies are many on dryland soils (Allison 1955), and quite meagre on wet land soils in the tropics (Koyama and App, 1979). The information from dryland soils is, however not applicable to wetland soils, due to the difference in the system of cultivation and factors affecting nitrogen use efficiency in the wetlands. Pot culture experiments are considered better than field experiments for nitrogen balance studies due to the added control available in pot cultures against input and outgo pathways (Koyama and App, 1979). Taking into account the paucity of information, nitrogen balance estimation was aimed in the present study with the major rice soil types of Kerala. The information could very well be added to the many more years of data for the construction of a meaningful model of nitrogen balance sheet for a wetland rice crop in the tropics. The nitrogen balance estimates in different soil types can also be compared to see the relative amounts of unaccounted nitrogen losses in different soil types of Kerala. Further, the possible inherent causes for the loss of nitrogen from the soil can also be inferred from the nitrogen balance estimates derived from the pot culture studies.

Considering the aforementioned aspects the present set of investigations was planned with the following objectives:

1. to study the effect of soil types, submergence levels and nitrogen application and their interaction on growth and yield of rice.
2. to assess the effect of soil type, submergence level and nitrogen application and their interaction on NPK content and uptake by rice plants and plant parts.
3. to study nitrogen recovery and nitrogen balance in different soil types of Kerala.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Rice cultivation in Kerala is carried out mainly in lowlands under different soil situations and using varieties of varying duration. Even though different soil types and varieties are involved, a blanket recommendation of 90 or 70 kg N/ha is prescribed for high yielding varieties of paddy without any regard to the nitrogen status of different soils and their ability to supply nitrogen. The information from nitrogen balance studies in different soil types would be helpful in assessing the exact requirement of nitrogen by rice varieties of different duration in different soils and also the residual status of soil. Unfortunately such studies are meagre in wetland rice soil types of tropics. The present investigation is aimed at assessing the availability of nitrogen in different soil types and the rate of recovery of fertilizer nitrogen under varying soil conditions with respect to medium and short duration varieties. Hence in this chapter, the earlier works accumulated on these aspects are reviewed.

I. Effect of nitrogen levels on growth and yield of rice in soil types

a. Height of the plant

Lenka and Behera (1967) observed that increased doses of nitrogen from zero to 120 kg/ha increased plant height in rice significantly. Lenka (1969) again reported that response of height was pronounced and increased progressively with increased nitrogen levels of zero, 40, 80 and 120 kg/ha. Ramanujam and Rao (1971) observed positive correlation in plant height at tillering and flowering stages with the levels of applied nitrogen. Sumbali and Gupta (1972) found that plant height increased with increased levels of nitrogen upto 200 kg/ha, consequently increased the straw yield. In trials at Bangkhan Rice Experiment Station Japan, Koyama and Niamsrichand (1973) observed increase in plant height with increasing levels of nitrogen upto 93 kg/ha. Alexander et al. (1974) and Gunasena et al. (1979) also reported increase in height of plants with increasing rate of applied nitrogen. In an investigation with Jaya cv., at Rice Research Station, Kayamkulam with 45, 60 and 90 kg N/ha Sushamakumari (1981) observed significant increase in height of plants at all levels of nitrogen. In the same location Sobhana (1983) also obtained similar trend on rice variety Mashuri.

In contrast to the above, Sreekumaran (1981) while investigating the fertilizer requirement of Lakshmi variety at the Rice Research Station, Kayamkulam did not observe any significant increase in plant height with different levels of nitrogen. Similar results were reported by Ajit Kumar (1984) based on the investigations carried out at the Rice Research Station, Pattambi with Mashuri variety.

b. Tiller count

According to Kalyanikutty and Morachan (1972), increased doses of nitrogen progressively increased tiller number per hill in dwarf indicas like ADT-27 and CO-33. In pot experiments conducted by Pande and Narkhede (1972), the rice variety Taichung-65 gave increased tiller counts with increasing nitrogen levels upto 90 kg/ha and was higher when it was applied in two instalments rather than three instalments. According to reports by Raju (1979) rice cv., Jaya grown on a sandy clay loam soil gave significant increase in number of tillers per hill with increased nitrogen levels upto 180 kg N/ha. Sushamakumari (1981) observed that nitrogen application had considerable influence on tiller production.

c. Number of productive tillers

Pande and Singh (1970) found that nitrogen increased yields mainly by increasing panicle number per unit area. In a trial on the nitrogen requirement of IR-8 and Taichung (Native)-I Gupta et al. (1970) observed an increase in the number of fertile tillers per plant with nitrogen upto 135 kg/ha. Muthuswamy *et al.* (1972) reported from a trial conducted to assess the fertilizer requirements for three rice varieties, that increase in nitrogen levels increased the productive tillers and that the heighest was for 160 kg N/ha. Subramanian and Kolandaiswamy (1973) observed that the total number of productive tillers per square metre increased with increase in nitrogen levels upto 240 kg/ha. Rethinam (1974) reported that increasing rates of nitrogen from zero to 160 kg/ha produced a linear increase in average number of productive tillers per hill. Gowda and Panicker (1977) obtained increased number of productive tillers per hill with increased nitrogen levels upto 160 kg/ha. Murthy and Murthy (1981) as well as Sree Kumaran (1981) have also obtained similar results.

d. Panicle length

Lenka (1969) observed that the length of panicle increased with the levels of nitrogen, viz. 0, 40, 80 and 120 kg/ha. Singh (1971) reported an increase in panicle length with increase in nitrogen levels from 0 to 160 kg/ha. Subbiah *et al.* (1977) reported that length and weight of panicle increased with increasing rates of nitrogen upto

200 kg/ha. Singh et al (1979) also observed that panicle length increased with nitrogen rates upto 120 kg/ha. Surendran (1985) reported that the length of panicles increased with increase in levels of nitrogen.

e. Thousand grain weight

Pande and Leeuwrik (1972) reported that nitrogen increased thousand grain weight upto 200 kg/ha. According to the results of trials conducted by Sadayappan.et al.(1974) the weight of thousand grains was influenced by nitrogen application, but the treatments with 50 to 200 kg/ha were on par. Positive increase in thousand grain weight due to nitrogen application was also obtained by Gowda and Panicker (1977), Raju (1979) and Surendran (1985).

Contrary to these results Muthuswamy et al. (1972), Natarajan et al. (1974) and Lenka et al. (1976) reported that the weight of thousand grains remained unaffected by nitrogen application. On the other hand, research reports of Shrivastava et al. (1970) and Ramanujam and Rao (1971) indicated that increasing nitrogen application decreased thousand grain weight.

f. Grain yield

Rethinam et al. (1975) observed that the increase in yield was sequential to the graded levels of nitrogen and a maximum yield was obtained with 160 kg N/ha in both tall and dwarf indica rice varieties. Trials conducted by Sahu and Murthy (1975) revealed that grain paddy yield increased with nitrogen levels up to 160 kg/ha. Pillai et al. (1975) observed significant response in grain yield upto 80 kg N/ha.

From experiments conducted in farmers fields, Gowda and Panicker (1977) reported that yield response to nitrogen was linear in varieties Jaya, IR-8 and IR-5. Roy et al. (1977) found that in irrigated trials with long duration rice cultivar, Pankaj, grain yield was highest with 120 kg N/ha applied in four equal split dressings. Murthy and Murthy (1978) observed that rice yields increased with nitrogen rates upto 120 kg/ha and increases were attributed to increase in tillering.

Bhuiya et al. (1979) observed an increase of 600 kg grain per hectare when the level of nitrogen was enhanced from 0 to 60 kg/ha. Gunasena et al. (1979) reported increase in grain yield from 3.63 to 6.52 t/ha, when the level of nitrogen was raised from 0 to 90 kg/ha during wet season in Sree Lanka. Dixit and Singh (1979) observed that grain yield increased from 2.18 t/ha with no nitrogen to 4.19 t/ha with

80 kg N/ha. Pande and Das (1979) observed that increasing the rates of applied nitrogen from 0 to 200 kg/ha increased the average paddy yields from 6.13 to 8.96 t/ha in seven dwarf rice cultivars tried. Raju (1979) reported increases in grain yield with nitrogen doses upto 180 kg/ha. Mengel and Wilson (1981) and Surendran (1985) also reported that grain yield increased with increased nitrogen application.

Ramanujam and Rao (1971), however, recorded decreased paddy yield with the application of more than 90 kg N/ha. Trials conducted by Fagundo et al. (1978) with four nitrogen levels from 0 to 240 kg/ha showed increase in tillering, but had very little effect on final yield.

g. Straw yield

In a trial on the influence of nitrogen supply on growth factors of rice, Ramanujam and Rao (1971) observed that straw yield increased with increase in applied nitrogen upto 180 kg/ha. Muthuswamy et al. (1972) observed a significant increase in straw yield upto 120 kg N/ha. Sumbali and Gupta (1972) reported that straw yield was, increased upto 200 kg N/ha, mainly due to the fact that plant height, number of leaves and effective tillers per hill were increased with increased nitrogen levels. Singh et al. (1974)

noticed considerable increases in straw yield due to increasing doses of nitrogen. According to Rethinam *et al.* (1975), the straw yield in rice varieties, Cauvery and Padma, was influenced by increased doses of nitrogen. Venkateswarlu (1978) reported that straw yields increased upto 200 kg N/ha and beyond this dose it decreased. Sushamakumari (1981) observed that nitrogen at higher levels progressively increased straw yield and the highest straw yield recorded at 90 kg N/ha was significantly superior to 45 or 60 kg levels. Surendran (1985) also observed an increase in straw yield due to increased doses of nitrogen.

II. Changes in the available nitrogen content in different soil types during crop growth

Bhuiyan (1949) reported that the total nitrogen content of the soil was more or less constant throughout the year, the ammonia content remained at a relatively high level soon after waterlogging and then decreased and remained at a low level. Nitrate was absent during waterlogging but began to accumulate after harvest.

From the results of a pot culture experiment conducted with four levels of nitrogen, two levels of phosphorus and potassium using three high yielding varieties, Loganathan and

and Raj (1973) observed that the available nitrogen varied markedly from stage to stage of the rice crop. It was highest at 15 days after transplantation and sharply decreased to a very low value after 30 days, thereafter it recorded a gradual increase. In an experiment at IRRI, Philippines it was reported that mineralization of soil nitrogen appeared to increase with the addition of inorganic nitrogen fertilizer, as reflected in the increased uptake of nitrogen by rice with increased levels of fertilizer nitrogen (Anon., 1974). Sreevastava (1975) reported that alkaline-permanganate-extracted available nitrogen was highly correlated with amino sugar nitrogen, organic matter, hydrolysable nitrogen, total nitrogen and amino acid nitrogen. Mathen et al. (1976) in an assessment of the accumulation of nitrogen in a black soil found that the availability of nitrogen increased substantially over years by increasing the rate of application of nitrogen along with phosphorus. Shiga and Ventura (1976) in a pot culture experiment with Maahas clay and two other soils found that the nitrogen supplied by the soil varied continuously throughout the period of plant growth and this nitrogen played a crucial role in the growth and yield of the rice plant. Mohapatra and Khan (1983) in a study using 21 lowland rice soils of India with a wide pH range found that the mineralisable nitrogen released from soil organic nitrogen formed 0.45% to 4.6% of the total nitrogen content.

From field experiments conducted in Japan it was observed that the amount of extractable organic nitrogen apparently varied with the stage of rice growth. It increased from the transplanting to tillering stage, followed by a decrease until the maximum tillering stage. This was followed by an increase in this form of nitrogen, the maximum being reached at the stage of panicle formation (Highuchi and Uchida, 1984). Keertisinghe (1984) reported that in wet land rice soils highly significant amounts of labelled non-exchangeable ammonia were released and taken up by rice plants and the contribution to rice nutrition in the vermiculite rich soils was estimated to be 20 to 100 kg N/ha.

III. Influence of levels of submergence on the availability of nitrogen in soils

Raymond and Shapiro (1958) while investigating the effect of flooding on availability of phosphorus and nitrogen found that flooding increased the grain yield and nitrogen uptake by rice. But flooding had no apparent effect on the availability of soil nitrogen. Sen and Dasgupta (1969) reported that the rice varieties performed best with the differential supply of water at various stages of growth and development under each season. Under limited water supply greater yield could be obtained by the application of higher dose of nitrogen and under limited application of nitrogen the same effect can be produced by increasing the supply of water to an optimum level.

According to Hukkeri and Sharma (1974) submergence in 4 cm standing water during the tillering and flowering stages only or continuous submergence gave similar paddy yields in the monsoon season. Gorantiwar et al. (1973) reported that in a medium black soil of Jabalpur there was no significant difference between the grain and straw yields under 4 cm and 7 cm of flooding. Yoshida and Padre (1975) observed that the uptake of fertilizer nitrogen by rice plants growing under submerged soil conditions ceased at the vegetative stage of growth because only a small amount of available nitrogen remains in the soil at this time; but the rice plant continued to absorb gradually untagged nitrogen from the soil throughout the reproductive stages of growth. Sharma and De (1976) observed that in field trials with rice cv. Padma given 0-200 kg N/ha, paddy yield was higher under continuous submergence conditions than under alternate wetting and drying conditions. In a field experiment on water management of rice conducted at Pantnagar, it was observed that the total nitrogen content increased with water depth (Sharma and Modgal, 1980). Kupkanachanakul and Vergara (1980) reported that when rice was grown in medium deep water, nitrogen application increased the grain yield from an average of 3.44 to 4.64 t/ha but the harvest index and 1000-grain weight were not affected.

Khind and Ponnamperuma (1981) investigated the effect of water regime on the performance of rice and found that when averaged for soils and nitrogen levels, yields from treatments in which soil drying was began at two and five weeks after transplanting were lower than that from the continuously flooded treatment; but the simple effect of soil drying treatments had adverse effect on the soil which was high in nitrogen content. Soil drying at two and five weeks after transplanting had adverse effect in the soil low in nitrogen. Investigations on the effect of submerging the rice to 75% and 100% of plant height at the active tillering and panicle initiation stages for different periods on the grain yields indicated that at active tillering stage, two days submergence at 75% level recorded the maximum grain yield, which was on par with one day and three days submergence and significantly superior to five days and seven days of submergence. At panicle initiation stage the reduction in yield was significant when the duration of submergence was 5 days or more at 75% level and one day at 100% level (Anon., 1982).

IV. Influence of levels of applied nitrogen on the composition and uptake of nutrients by Paddy.

Thenabadu et al. (1970) based on tracer studies reported that the uptake of nitrogen from fertilizer was greater from early application than from late application. Koyama et al. (1973) in their investigation with ^{15}N found that basal dressing and top dressing at panicle initiation each with 37.5 kg N/ha has resulted in the uptake of 83 kg N/ha, 36% from the fertilizer and 64% from the soil. Of the fertilizer nitrogen absorbed, 33.3% was from basal application and 66.6% from the top dressing. The recovery rate of top dressed nitrogen was 54% and that of basal nitrogen only 27%.

Westerman and Kurtz (1973) examined the priming effect on the uptake of soil nitrogen in two field experiments conducted during 1966 and 1967 on Sorghum using urea and oxamide, each labelled with ^{15}N. They observed that addition of nitrogen fertilizer increased the uptake of soil nitrogen by 17 to 45% in the first experiment and by 8 to 27% in the second experiment. While investigating the response of rice variety IR-8 to increasing rates of nitrogen application in terms of yield and nutrient uptake on four soil types of Gomati and Sai, Khan and Pathak (1976) observed significant progressive increase in yield at all the nitrogen levels in all soil types.

Yoshida and Padre (1977) observed that the nitrogen uptake from fertilizers by the rice crop was much greater when calculated by the difference method than by the isotope method. At fertilizer application rates of 30 ppm nitrogen or more the uptake of fertilizer nitrogen by rice crop increased with increased level of nitrogen application.

Rai and Murthy (1979) reported that the average paddy yields in eight rice cultivars with 40 and 80 kg N/ha were 5.04 and 5 t/ha, respectively under normal conditions and 4 and 4.13 t/ha under water logged conditions. Reddy and Patrick (1980) revealed that yield of grain was closely correlated with total nitrogen uptake in the tops, less closely correlated with soil nitrogen uptake and not significantly correlated with fertilizer nitrogen uptake. However, the increment of yield was positively correlated with fertilizer nitrogen uptake, as compared to yield alone. According to Subbiah and Sachdev (1981) even under the best conditions the amount of fertilizer nitrogen absorbed by the rice crop seldom exceeds 30 to 35% of the total quantity applied. Talha et al. (1981) in lysimeter trials with rice showed that grain and straw yields, 100-grain weight and NPK uptake increased with depth of irrigation water and increase in the nitrogen fertilization rate. Chinchest (1982) in his experiment on the effect of water regimes and nitrogen rates on nitrogen uptake and growth of rice varieties observed that 51 days after sowing nonflood treatment of green house grown rice resulted in greater tiller number, dry weight, nitrogen content and uptake, and leaf number than in plants which were continuously flooded. He has also noticed that in the field, 28 days of deep water treatment resulted in lower grain yield, tiller number, dry weight, nitrogen uptake and decreased height when compared with shallow water treatment.

V. Recovery of nitrogen from applied fertilizer

Abichandani and Patnaik (1958) obtained 40% recovery of applied nitrogen after 42 days of submergence from surface applied ammonium sulphate compared to 88% when the fertilizer was incorporated. Recoveries from ammonium nitrate was 24 and 44%, respectively. Patnaik and Broadbent (1967) reported that utilization of nitrogen within 15 days of application was 18% at tillering and 44% at boot leaf stage. Koyama et al. (1973) reported that the recovery rate of top dressed nitrogen was 54% and that of basal nitrogen was 27%. Based on pot culture experiments using Maahas soil IRRI has reported that at 30, 60 and 90 kg N/ha of applied nitrogen the amounts of fertilizer nitrogen taken up by the rice crop were 35, 39.7 and 40.3%, respectively of the applied fertilizer by the isotope method and 36.3, 65 and 71.8% by the differential method (Anon. 1974). Patrick and Reddy (1976) from their field experiments showed that fertilizer nitrogen recovered in the grain ranged from 30.9 to 37.3 kg N/ha. Recovery of fertilizer nitrogen in the straw ranged from 18.2 to 24.2 kg N/ha and a considerable portion of fertilizer nitrogen remained in the soil after cropping. Yoshida and Padre (1977) found that the recovery of fertilizer nitrogen by the rice plant was low when it was added as basal but the recovery was improved by incorporating it before transplanting and the recovery of fertilizer nitrogen when top dressed at reproduction stage was much higher than when supplied as basal. Houng and Lui (1979) based on pot trials with ^{15}N enriched ammonium sulphate observed 20% recovery from basal application, 40% from top dressing at tillering, 60-90% from top dressing at young panicle stage and 40-60% from application after heading stage. In a field trial where rice cv. MAS 2401 was grown on a sandy loam river levee soil under wet land condition and supplied with 80 kg N/ha by broadcasting or deep placement, only 26% and 35% of applied nitrogen was recovered in the grain and 18% and 29% in the straw with broadcasting and deep placement, respectively (Ayatode, 1980).

VI. Nitrogen Balance studies

Balance sheet for nitrogen and phosphorus was investigated in actual paddy fields in shintone river base in Japan with and without application of fertilizers during 1975-1976. The amounts of both nutrients which were lost from the paddy field were estimated. The annual loss of nitrogen in the fertilized plot amounted to 1.80 kg/10 acres. A considerable amount of nitrogen was lost from the non-fertilized plot, therefore the applied fertilizer loss of nitrogen was estimated to be 0.8 kg/10 ares. The balance was minus 0.37 kg/10 ares, The balance was minus 0.37 kg/10 ares, indicating that the annual uptake of nitrogen by the paddy field exceeded the annual loss (Takamura et al.,1977).

Maeda and Yutaka (1976) based on pot culture experiments using tagged ammonium sulphate found that under flooded condition, applied N balance in cropped soil consisted of nearly 35% of crop recovery, 15-20% of immobilized form and 45% of unknown part - Takamura et al. (1976) investigated the fate and balance sheet of nitrogen in the rice paddy fields with or without application of fertilizers and found that the nutrient concentration in the surface water reached 63 ppm N and 26 ppm P in the paddy field with surface application of fertilizers. About 19.8% of N and 1.8% P of fertilizers added to the field were lost by surface run off, while percolation loss of N was less than 1/3 of its surface run off.

Rao and Sharma (1978) estimated the balance of soil nitrogen in a field experiment, consisting of six cropping sequences and three fertilizer constraints for two years on a sandy loam soil. The study has indicated that the total nitrogen in soil at the end of two years showed a deficit balance of the order of 53 kg N/ha in maize wheat sequence, while other crop sequences particularly those including legumes, built up the nitrogen status of the soil. The highest average gain in soil nitrogen was of the order of 81 kg N/ha which was recorded under maize-potato-green gram sequence. In most of the crop sequences the net gain in soil nitrogen was lower than the lowest dose of fertilizer application: App et al. (1984) based on long term fertility experiments in two sites in the Philippines suggested that the two flooded rice crops grown each year resulted in a positive nitrogen balance equivalent to 79 and 103 kg N/ha/are. In his attempt to measure the accumulation of nitrogen in the surface soil he further observed that plots open to the light accumulated the equivalent of approximately 6-8 kg N/ha in the surface soil between transplanting and heading, as a result of nitrogen fixation by phototropic microorganisms.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation included a well-designed pot culture experiment conducted at the College of Agriculture, Vellayani, during the first crop season of 1984-85.

I. Experimental details

A completely randomized design with two replications was adopted for the study. The treatments consisted of a factorial combination of 5 soil types, two levels of submergence and two fertilizer levels i.e., one with no nitrogen fertilizer and the other with nitrogen applied as per package of practice recommendations of the KAU (Anon. 1986) for short and medium duration rice varieties. The details of the treatments are given below:-

a. Soil types :

S_1 - Riverine alluvium (Kuttanad)
S_2 - Lacustrine alluvium (Kole)
S_3 - Sandy loam (Onattukara)
S_4 - Low level laterite (Pattambi)
S_5 - Black soil (Chittoor)

Surface soil samples upto 6" (15 cm) depth which remained waterlogged after the third crop season were collected from farmers field in bulk quantities. The soils ware air dried, powdered, passed through 2mm sieve and used for subsequent studies. The mechanical composition and chemical characteristics of the soil prior to the experiment were determined using standard procedures (Jackson 1973) and given in Table 1.

b. Rice varieties

R_1 - Jaya

R_2 - Triveni

c. Levels of submergence

W_1 - 5 cm standing water

W_2 - 10 cm -do-

d. Fertilizer dosage

T_0 - No nitrogen

T_1 - 90 kg N/ha for medium duration variety and 70 kg N/ha for short duration variety

Each of the rice varieties had seperate control and were kept without nitrogen.

Total treatments - 20

Replications - 2

The treatment combinations for the two varieties were as follows:

$S_1W_1T_0$	$S_2W_1T_0$	$S_3W_1T_0$	$S_4W_1T_0$	$S_5W_1T_0$
$S_1W_1T_1$	$S_2W_1T_1$	$S_3W_1T_1$	$S_4W_1T_1$	$S_5W_1T_1$
$S_1W_2T_0$	$S_2W_2T_0$	$S_3W_2T_0$	$S_4W_2T_0$	$S_5W_2T_0$
$S_1W_2T_1$	$S_2W_2T_1$	$S_3W_2T_1$	$S_4W_2T_1$	$S_5W_2T_1$

Earthen pots of 12" diameter were used for the study. Before starting the experiment the pots were cleaned and the drainage holes were sealed with cement to prevent the leaching loss.

Exactly 7.5 kg of the five soil type was weighed and filled in each earthern pot. The soil in the pot was flooded and puddled well before the seedlings were transplanted. On the day of planting N, P_2O_5 and K_2O in the form of urea (46% N), superphosphate (18% P_2O_5) and muriate of potash (60% K_2O) were applied at the uniform rate of 90:45:45 and 70:35:35 kg/ha according to the duration of the varieties. Control plots received no nitrogen. Half of the nitrogen and potash and full phosphorus were given as basal dressing. Sprouted seeds of Jaya and Triveni were sown in seperate nurseries. Healthy seedlings of 30 days old Jaya and 18 days old Triveni varieties were transplanted in three hills in each of the respective pot at the rate of two plants per hill. The remaining half of the nitrogen and potash were applied as top dressing at the time of panicle initiation. From the next day after planting, 5 cm and 10 cm levels of water were maintained in the pots by daily irrigation. Irrigation was stopped when the seed setting stage was completed.

The pots were kept free from weeds during the course of the experiment. Ekalux 25% EC spray to control the leaf roller and BHC 50% WP spray to control rice bug were given. There was no serious attack of any disease.

The variety Jaya was harvested 105 days and Triveni 70 days after transplanting. The straw and grain from each pot were collected seperately, dried and weight recorded. The dried samples were ground and used for chemical analysis.

II. Growth and Yield Parameters

The following biometric observations were recorded from each treatment.

1. Plant height at the active tillering, Panicle - initiation, flowering and harvest stages
2. Number of tillers at the above mentioned stages
3. Productive tiller number just before harvest
4. Length of the panicle
5. Weight of grain
6. Weight of straw
7. Thousand grain weight

III. Chemical analysis

a. Periodical Analysis of soil

From each pot wet soil samples were collected periodically at intervals of 24 h, 48 h, 96 h, 1 week, 2, 3, 4, 5, 6, 7 and 8 weeks after fertilizer application and finally at harvest by the funnel method (Abichandani and Patnaik 1957) and with least disturbance to the plants.

i) Available nitrogen:-

Available nitrogen content of the soil was determined by the alkaline permanganate method (Subbiah and Asija,1956).

ii) Available phosphorus:-

Available phosphorus was estimated by extracting the soil with Bray No.1 extractant and thereafter developing chloromolybdic acid blue colour and reading in Klett-Summerson photoelectric colorimeter using red filter (Jackson, 1973).

iii) Exchangeable potassium:-

Exchangeable potassium was estimated by extracting the soil with neutral normal ammonium acetate and the K was read in a EEL-flame photometer (Jackson, 1973).

b. Plant Analysis

i) Nitrogen :-

Nitrogen content of plant samples collected from each treatment at active tillering, panicle initiation and flowering stages and that of grain and straw at harvest were determined by micro-kjeldahl digestion method as suggested by Jackson (1973).

ii) Phosphorus:- Phosphorus concentration of the plant samples at harvest was determined by triple acid digestion and thereafter estimating colorimetrically by vanadomolybdobiphosphoric method using Spectronic 20 at a wavelength of 470 nm (Jackson, 1973).

iii) Potassium:- Potassium concentration of the plant sample at harvest was determined on triple acid extract using an EEL Flame photometer (Jackson, 1973).

iv) Uptake of nitrogen:- The nitrogen uptake was computed from the percentage nitrogen of plant parts and their total dry matter production.

v) Recovery of nitrogen by plants:- The percentage recovery of nitrogen was calculated from the formula $\frac{NF - NC}{R} \times 100$ where, NF is the nitrogen in the plants grown in the fertilized pot, NC is the nitrogen in the plants grown on the control pot and R is the rate of applied nitrogen.

IV. Statistical Analysis

The various data obtained in the study were statistically analysed employing the method of analysis of variance for factorial experiments in completely randomized design. The significant was tested by 'F' test (Cochran and Cox, 1965).

Table 1 Basic data on the soils selected for the study

(a) Physical characteristics

Soils	Mechanical Analysis				Single value constants				
	Coarse sand	Fine sand	Silt	Clay	Bulk density	Particle density	water holding capacity	% pore space	% volume expansion
1. Karapadam (Kuttanad)	26.00	21.25	10.20	42.55	1.058	1.868	50.69	50.21	11.30
2. Kole	11	15	20.85	53.15	1.004	1.984	50.81	49.39	11.90
3. Sandy loam (Onattukara)	50	10	6.45	33.55	1.352	2.170	29.63	37.53	5.02
4. Low level laterite	25.25	22.80	12.00	39.95	0.989	1.742	47.16	43.29	7.69
5. Black soil	32	11.85	10.40	45.75	1.042	1.922	51.82	50.26	12.80

(b) Chemical characteristics

Soils	pH	Organic carbon (%)	CEC	Total N(%)	Total P(%)	Total K (%)	Ava.N (%)	Ava.P (%)	Ava.K (%)	Ava.Ca (%)	Ava.Mg (%)
1. Karapadam (Kuttanad)	4.6	1.40	8.54	0.13	0.06	0.06	0.0110	0.0023	0.012	0.020	0.019
2. Kole	3.8	2.10	10.68	0.16	0.08	0.05	0.0213	0.0020	0.013	0.023	0.010
3. Sandy loam (Onattukara)	5.3	1.12	1.3	0.10	0.04	0.05	0.098	0.0004	0.003	0.011	0.032
4. Low level laterite (Pattambi)	5.0	1.50	6.24	0.15	0.06	0.06	0.0118	0.0040	0.009	0.015	0.059
5. Black soils (Chittoor)	8.0	2.30	7.9	0.19	0.09	0.08	0.0128	0.0046	0.024	0.114	0.140

RESULTS

RESULTS

The present study was carried out to assess the rate of efficiency of field applied nitrogen under varying soil conditions and irrigation levels with respect to short and medium duration varieties of rice viz Jaya and Triveni. The observations recorded were analysed statistically and the salient findings of the experiment are presented below:

I. Growth and yield parameter

(i) Height of the plant

The data on the height of plant at different stages of growth with respect to the two varieties; Jaya and Triveni under different levels of submergence are given in Tables 2(a) to 2(d) and the analysis of variance in Appendix I. it was seen from the table that in both the Jaya and Triveni rice varieties the soil type was found to have significant effect on plant height. At all growth stages, the height varied according to the soil type. The plant height in the Jaya variety was maximum at all growth stages, when grown in the Karapadam soil. Next to karapadam soil was the black soil, where maximum height was recorded at panicle initiation, flowering and harvest stages. At the tillering stage, the

Table 2(a) Plant height (cm) at different stages as affected by different soil types on rice, Jaya & Triveni

Soil type	JAYA				TRIVENI			
	Different growth stages				Different growth stages			
	Tillering	Panicle initiation	Flowering	Harvest	Tillering	Panicle initiation	Flowering	Harvest
Karapadam	35.0	60.5	67.9	74.5	33.1	57.5	66.0	72.1
Kole	34.1	51.1	55.7	60.8	32.6	70.6	78.2	81.7
Sandy loam	26.6	51.4	59.7	62.1	24.8	48.7	59.9	61.5
Low level laterite	32.4	55.8	62.5	68.0	30.6	54.3	60.1	64.4
Black soil	31.5	58.9	65.0	68.9	31.0	55.2	63.2	68.5
C.D.	0.7	0.7	0.6	0.6	0.5	0.7	0.4	0.4

least plant height was recorded in sandy loam soil and at the panicle initiation, flowering and harvest stages in the kole soil. For the short duration variety Triveni, the maximum plant height at tillering was observed in karapadam soil which was on par with kole soil. The kole soil recorded maximum plant height at panicle initiation, flowering and at harvest stages. On the other hand, sandy loam soil has produced the lowest plant height at all stages.

The level of submergence also had significant effect on the plant height at all stages. For Jaya, at tillering stage more height was recorded at 10 cm level of submergence whereas in panicle initiation, flowering and harvest stages 5 cm level of submergence gave more height. As far as Triveni it concerned the 5 cm submergence resulted in significantly increased plant height than 10 cm submergence at all growth stages.

From Table 2(b) it was seen that all treatment interactions had significant influence on plant height. Among the different soil x levels of submergence combinations, Karapadam soil with 5 cm submergence resulted in the highest plant height in the Jaya variety at all stages. The lowest height was noticed in sandy loam soil with 5 cm submergence

Table 2(b) Plant height (cm) in different soil types as affected by level of submergence on rice, Jaya and Triveni

Soil type	Level of submergence (cm)	JAYA: Different stages of growth				TRIVENI: Different stages of growth			
		Tillering	Panicle initiation	Flowering	Harvest	Tillering	Panicle initiation	Flowering	Harvest
Karapadam	5	35.34	60.67	68.10	74.59	33.60	60.00	68.70	73.50
	10	34.60	60.29	67.84	74.37	32.50	54.90	63.20	70.70
Kole	5	33.43	53.80	51.44	56.55	32.70	70.60	78.00	81.80
	10	34.74	53.12	60.02	64.96	32.40	70.50	78.30	81.60
Sandy loam	5	26.44	54.08	62.87	67.43	25.20	50.70	60.70	64.80
	10	26.80	48.77	56.62	56.85	24.30	46.60	59.50	61.60
Low level laterite	5	31.63	56.60	63.92	69.10	31.30	54.80	61.30	65.80
	10	33.15	55.04	61.10	67.18	29.80	53.60	58.80	63.00
Black soil	5	31.22	58.63	65.80	69.33	31.30	55.50	63.70	69.40
	10	31.71	59.13	64.28	68.38	30.60	54.80	62.60	67.60
C.D.		1.01	0.92	0.82	0.80	0.80	1.10	0.60	0.60
Mean for level of submergence	5 cm	31.59	56.76	62.43	67.42	30.82	58.32	66.48	71.06
	10 cm	32.60	55.27	61.97	66.35	29.92	56.08	64.68	68.90
C.D.		0.45	0.41	0.37	0.36	0.34	0.47	0.27	0.27

However, on comparing the levels of submergence alone, there was no significant difference in plant height at tillering stage in the karapadam, sandy loam and black soils. Among the treatment combinations, karapadam soils with 5 cm level of submergence, resulted in the highest plant height. On the other hand, plant height showed the lowest estimates at panicle initiation in sandy loam soil with 10 cm submergence and at flowering and harvest stages in kole soil with 5 cm submergence. The difference in the levels of submergence could indicate significant difference at panicle initiation in sandy loam only. Also, the levels of submergence had significant effect on plant height at flowering and harvest stages in all soils except karapadam soil. For the rice variety Triveni also, the highest plant height at tillering stage was in karapadam soil with 5 cm submergence. At panicle initiation, flowering and harvest stages the plant height was the highest in kole soil with 5 cm submergence.

The data presented in Table 2(c) revealed that the treatment combination of soil x fertilizer nitrogen also had significant influence on the plant height. In the case of Jaya, the maximum plant height at tillering stage was observed for the combination of black soil with nitrogen application at

Table 2(c) Plant height (cm) in different soils as affected by nitrogen application on rice, Jaya and Triveni

Soil type	Nitrogen application	JAYA				TRIVENI			
		Different stages of growth				Different stages of growth			
		Tillering	Panicle initiation	Flowering	Harvest	Tillering	Panicle initiation	Flowering	Harvest
Karapadam	T_0	32.68	50.25	57.21	65.30	31.10	55.70	64.70	71.10
	T_1	37.25	70.71	78.73	83.65	35.00	59.20	67.20	73.10
Kole	T_0	31.29	38.78	46.71	52.48	28.50	66.00	73.70	77.80
	T_1	36.88	58.14	64.75	69.14	36.60	75.10	82.60	88.60
Sandy loam	T_0	25.38	41.49	50.50	53.83	20.80	43.70	52.00	56.30
	T_1	27.86	61.36	69.00	70.45	28.70	53.60	67.20	63.10
Low level laterite	T_0	29.25	49.11	55.75	61.05	26.90	53.80	59.70	64.60
	T_1	35.53	62.53	69.28	75.23	34.20	55.00	60.40	64.30
Black soil	T_0	25.30	48.59	55.35	58.78	25.20	53.20	61.10	66.30
	T_1	37.62	69.18	74.73	78.93	36.80	57.10	65.20	70.70
C.D.		1.01	0.92	0.82	0.80	0.80	1.10	0.60	0.60

90 kg/ha which was closely followed by karapadam and kole soils with nitrogen application. The lowest value was observed for the combination of black soil with no nitrogen application which was on par with sandy loam with no nitrogen. At panicle initiation, flowering and harvest stages, karapadam receiving nitrogen was superior over others and the lowest value was observed in kole soil without nitrogen. In Triveni, at all stages except tillering, kole soil with nitrogen application produced the maximum plant height and sandyloam with no nitrogen produced the minimum plant height. At tillering the maximum plant height was recorded in black soil with nitrogen application which was closely followed by kole soil with nitrogen application and the minimum in sandy loam without nitrogen application.

Data on the effect of treatment combination viz., soil x waterlevel x nitrogen application are presented in Table 2(d). The data revealed that in the case of Jaya, at tillering stage maximum plant height was produced by the combination of black soil with 10 cm submergence and nitrogen application ($S_5W_2T_1$) which was closely followed by the treatment combination of kole soil with 10 cm submergence and nitrogen application ($S_2W_2T_1$). At panicle initiation, flowering

Table 2(d) Plant height (cm) as affected by soil x level of submergence x nitrogen application - -interaction on rice, Jaya and Triveni

Treatment combination	JAYA				TRIVENI			
	Different stages of growth				Different stages of growth			
	Tiller-ing	Panicle initia-tion	Flower-ing	Harvest	Tiller-ing	Panicle initia-tion	Flower-ing	Harvest
$S_1W_1T_0$	32.90	49.17	56.00	64.20	31.80	57.20	63.40	72.00
$S_1W_1T_1$	37.75	72.17	80.21	84.98	35.50	62.90	71.30	75.10
$S_1W_2T_0$	32.45	51.33	58.43	66.40	30.50	54.20	63.10	70.20
$S_1W_2T_1$	36.75	69.25	77.25	82.33	34.60	55.50	66.10	71.10
$S_2W_1T_0$	30.95	35.92	45.25	51.10	28.30	68.10	75.20	80.30
$S_2W_1T_1$	35.90	51.69	57.63	62.20	37.10	77.10	84.40	87.90
$S_2W_2T_0$	31.64	41.65	48.17	53.85	28.70	63.90	72.20	75.30
$S_2W_2T_1$	37.85	64.59	71.87	76.08	36.00	73.10	80.80	83.30
$S_3W_1T_0$	25.70	44.75	53.83	58.65	21.40	47.10	53.30	58.40
$S_3W_1T_1$	27.17	63.42	71.92	76.20	29.00	54.40	68.10	71.20
$S_3W_2T_0$	25.05	38.23	47.17	49.00	20.20	40.40	50.80	54.30
$S_3W_2T_1$	28.55	59.30	66.08	64.70	28.50	52.80	66.30	69.00
$S_4W_1T_0$	28.25	49.64	56.65	61.90	27.40	53.40	60.20	65.40
$S_4W_1T_1$	35.00	63.57	71.30	76.30	35.10	56.20	62.50	66.20
$S_4W_2T_0$	30.25	48.58	54.95	60.20	26.30	53.40	59.20	63.70
$S_4W_2T_1$	36.05	61.50	67.25	74.15	33.30	53.70	58.30	62.40
$S_5W_1T_0$	25.45	47.93	56.30	59.40	25.40	52.90	61.20	66.50
$S_5W_1T_1$	36.98	69.34	75.30	79.25	37.30	58.10	66.30	72.30
$S_5W_2T_0$	25.16	49.25	54.40	58.15	24.90	53.50	61.00	66.10
$S_5W_2T_1$	38.25	69.02	74.15	78.60	36.40	56.10	64.20	69.20
C.D.	1.43	1.30	1.16	1.14	1.10	1.50	0.90	0.90

and harvest stages the combination of karapadam with 5 cm submergence and nitrogen application was superior over others. At panicle initiation stage the lowest value was recorded in kole soil with 5 cm submergence and no nitrogen application and at harvest stage in sandy loam with 10 cm submergence and no nitrogen. In the variety Triveni also, the treatment combination of soil x waterlevel x nitrogen application had considerable influence on the plant height at all stages. However, the maximum plant height at all stages was produced by kole soil with 5 cm submergence and nitrogen application ($S_2W_1T_1$) and the minimum was in sandy loam with 10 cm submergence and no nitrogen application.

(ii) Tiller counts

Data on the mean tiller number/hill at different growth stages are presented in Table 3(a) to 3(d) and their analysis of variance in Appendix II.

From the Table 3(a) it was found that in the case of the medium duration variety Jaya, the mean tiller number differed from soil to soil at all stages. At tillering stage the mean tiller number was the maximum in karapadam soil which was closely followed by kole soil while the value was minimum in sandy loam soil which was on par with that in low-

Table 3(a) Tiller number as influenced by different soil types on rice, Jaya and Triveni

Soil type	J A Y A				T R I V E N I			
	Different stages of growth				Different stages of growth			
	Active tiller-ing stage	Panicle initia-tion	Flower-ing	Harvest	Active tiller-ing stage	Panicle initia-tion	Flower-ing	Harvest
Karapadam	4.91	7.25	6.37	5.67	5.40	7.20	6.90	6.60
Kole	4.50	7.75	6.33	5.46	7.80	10.00	9.20	8.40
Sandy loam	3.50	6.33	4.95	5.41	4.70	7.20	6.00	5.50
Low level laterite	3.91	7.12	5.50	5.29	4.50	8.10	7.60	7.10
Black soil	4.17	7.29	6.50	6.33	5.30	8.00	7.40	7.10
C.D.	0.45	0.54	0.43	0.40	0.90	1.10	0.80	0.70

level laterite soil. At panicle initiation stage, the maximum tiller number was observed in kole soil which was on par with karapadam soil and black soil while the lowest tiller number was noted in sandy loam soil. At flowering and harvest stages the maximum tiller number was observed in black soil which was on par with karapadam and kole soils at flowering. At the harvest stage, the lowest tiller count was observed in low level laterite soil. In the case of Triveni also soil type had significant effect on the mean tiller number. At all stages maximum value was noted in kole soil and the minimum in sandy loam soil.

Data on the mean tiller count as influenced by levels of submergence are presented in Table 3(b). In Jaya, the levels of submergence alone did not have any influence on the mean tiller number, but the soil x level of submergence combination was found to have significant influence on the mean tiller number. For Jaya, at tillering stage, the maximum mean tiller number was produced by karapadam soil at 5 cm submergence which was closely followed by kole soil at 10 cm submergence. At panicle initiation the highest tiller number was noted in kole soil at 5 cm submergence which was the same as that with 10 cm submergence. At flowering the highest

Table 3(b) Mean tiller number in different soil types as affected by level of submergence on rice, Jaya and Triveni

Soil type	Level of submergence (cm)	JAYA				TRIVENI			
		Different growth stages				Different growth stages			
		Active tillering	Panicle initiation	Flowering	Harvest	Active tillering	Panicle initiation	Flowering	Harvest
Karapadam	5	5.31	7.41	6.58	5.58	5.65	6.70	6.50	6.00
	10	4.50	7.08	6.17	5.75	5.10	7.80	7.30	7.10
Kole	5	4.00	7.75	6.41	4.66	7.40	10.20	9.80	8.50
	10	5.00	7.75	6.25	6.25	8.20	9.80	8.60	8.50
Sandy loam	5	3.33	5.92	4.66	5.91	4.30	6.50	6.10	5.70
	10	3.66	6.75	5.25	4.91	5.00	7.90	5.80	5.30
Low level laterite	5	3.49	7.00	5.08	5.08	4.80	8.10	7.50	7.10
	10	4.14	7.25	5.91	5.50	4.20	8.00	7.70	7.10
Black soil	5	4.23	7.25	6.58	6.33	5.70	8.00	7.30	7.10
	10	3.92	7.33	6.42	6.33	4.40	8.00	7.50	7.10
C.D.		0.64	0.77	0.61	0.56	1.40	1.50	1.10	1.00
Mean for level of submergence	5 cm	4.08	7.07	5.86	5.51	5.56	7.90	7.40	6.90
	10 cm	4.24	7.23	6.00	5.75	5.38	8.30	7.40	7.00
C.D.		0.29	0.34	0.27	0.25	0.61	0.68	0.47	0.45

tiller number was noted in karapadam and black soil with 5 cm submergence. At harvest the highest tiller number was produced by black soil at both the levels of submergence. In Triveni karapadam soil at 5 cm submergence increased the tiller number at tillering stage. However, no difference could be noted at panicle initiation, flowering and harvest stages. In kole soil at active tillering and harvest stages higher tiller number was noted at 10 cm submergence. However, at panicle initiation and harvest stages the levels of submergence alone produced no significant difference. In sandy loam soil at active tillering and panicle initiation stages, higher tiller number was noted at 10 cm submergence. However, at flowering and harvest stages the level of submergence alone produced no significant difference. In low level laterite at active tillering and flowering stages, higher tiller number was noted at 10 cm submergence but at panicle initiation and harvest stages there was no significant difference in their tiller number under different levels of submergence. The maximum tiller number at all stages except tillering was noted in kole soil at 5 cm submergence where as at tillering the maximum tiller number was noted in kole soil at 10 cm submergence. The lowest tiller number at active tillering

Table 3(c) Mean tiller number in different soil types as influenced by nitrogen application on rice, Jaya and Triveni

Soil type	Nitrogen application	JAYA				TRIVENI			
		Different stages of growth				Different stages of growth			
		Active tillering	Panicle initiation	Flowering	Harvest	Active tillering	Panicle initiation	Flowering	Harvest
Karapadam	T_0	4.00	5.33	5.08	4.75	3.50	5.90	5.30	5.10
	T_1	5.83	9.16	7.66	6.58	7.20	8.50	8.50	8.00
Kole	T_0	3.50	6.25	5.00	4.58	6.00	8.40	7.50	6.80
	T_1	5.50	9.25	7.66	6.33	9.50	11.50	10.80	9.70
Sandy loam	T_0	3.33	5.50	4.83	4.76	3.40	5.90	4.50	4.30
	T_1	3.66	7.17	5.08	5.00	5.90	8.50	7.40	6.80
Low level laterite	T_0	3.75	6.25	5.25	5.33	4.00	7.50	7.00	6.30
	T_1	3.89	8.00	5.75	5.25	5.00	8.60	8.10	7.80
Black soil	T_0	3.15	6.66	5.33	5.66	5.10	6.90	6.40	6.20
	T_1	5.00	7.91	7.67	7.00	6.10	9.30	8.40	8.00
C.D.		0.64	0.77	0.61	0.56	1.40	1.50	1.10	1.00

and panicle initiation stages was noted in sandy loam at 5 cm submergence, whereas at flowering and harvest stages, sandy loam at 10 cm level of submergence recorded the minimum.

Data on the mean tiller count as influenced by nitrogen application are presented in Table 3(c). The nitrogen application has resulted in significant increase of tiller number in Jaya. For Jaya at flowering and harvest stages, the highest tiller number was given by black soil with applied nitrogen. The lowest tiller number at the tillering stage was observed in black soil without nitrogen application, at panicle initiation stage in karapadam soil without nitrogen, at flowering stage in sandy loam soil with no nitrogen application and at harvest stage in kole soil with no nitrogen application. With Triveni variety at active tillering and flowering stage the soil x nitrogen interaction was found to have significant influence on tiller count. In both stages the nitrogen treated plants produced significantly increased mean tiller number in all soils except low level laterite soil. In low level laterite soil there was no significant increase in the mean tiller count over the control.

In the case of Jaya, the effect of interaction of soil x levels of submergence x nitrogen application on the

Table 3(d) Mean tiller number as affected by soil type, level of submergence and nitrogen application on rice, Jaya and Triveni

Treatment combination	JAYA				TRIVENI			
	Different stages of growth				Different stages of growth			
	Active tiller-ing stage	Panicle initia-tion	Flower-ing	Harvest	Active tiller-ing	Panicle initia-tion	Flower-ing	Harvest
$S_1W_1T_0$	4.33	5.33	5.00	4.50	3.00	4.80	4.50	4.20
$S_1W_1T_1$	6.33	9.50	8.16	6.67	8.10	8.50	8.50	7.80
$S_1W_2T_0$	3.66	5.33	5.17	5.00	3.90	7.00	6.10	6.00
$S_1W_2T_1$	5.33	8.83	7.17	6.50	6.20	8.50	8.50	8.20
$S_2W_1T_0$	3.50	6.17	5.00	3.83	6.20	8.30	7.50	6.80
$S_2W_1T_1$	4.50	9.33	7.83	5.50	8.50	12.00	12.00	10.20
$S_2W_2T_0$	3.50	6.33	5.00	5.33	5.80	8.50	7.50	6.80
$S_2W_2T_1$	6.50	9.17	7.50	7.17	10.50	11.00	9.60	9.10
$S_3W_1T_0$	3.33	5.17	4.33	4.00	3.00	5.00	4.70	4.30
$S_3W_1T_1$	3.33	6.67	5.00	4.83	5.60	8.00	7.50	7.00
$S_3W_2T_0$	3.33	5.83	5.33	5.17	3.70	6.80	4.30	4.20
$S_3W_2T_1$	4.00	7.67	5.16	4.66	6.20	9.00	7.20	6.50
$S_4W_1T_0$	3.50	6.17	5.17	5.00	4.10	7.50	6.80	6.30
$S_4W_1T_1$	3.48	7.83	5.00	5.17	5.40	8.70	8.20	7.80
$S_4W_2T_0$	3.98	6.33	5.33	5.67	3.80	7.50	7.20	6.30
$S_4W_2T_1$	4.30	8.17	6.50	5.33	4.60	8.50	8.00	7.80
$S_5W_1T_0$	3.30	7.00	5.83	5.83	4.90	6.50	6.30	6.20
$S_5W_1T_1$	5.15	7.50	7.73	6.82	6.40	9.50	8.20	8.00
$S_5W_2T_0$	3.00	6.33	4.83	5.50	5.30	7.00	6.50	6.20
$S_5W_2T_1$	4.83	8.32	8.00	7.17	5.80	9.00	8.50	8.00
C.D.	N.S.	N.S.	0.87	0.79	N.S.	N.S.	N.S.	N.S.

tiller count was marked only at flowering and harvesting stage. At flowering the highest tiller number was given by the treatment combination karapadam soil at 5 cm submergence with nitrogen application ($S_1W_1T_1$) which, was closely followed by black soil at 10 cm and 5 cm submergence with nitrogen application, kole soil at 5 cm submergence with nitrogen application and in kole soil at 10 cm submergence with nitrogen application. At harvest stage the highest tiller count was given by kole soil at 10 cm submergence and nitrogen application and black soil at 10 cm submergence and nitrogen application and the lowest tiller number by kole soil at 5 cm submergence and nitrogen application. In the Triveni variety the treatment interaction was found to have no significant effect on tiller number. Kole soil at 5 cm submergence and nitrogen application was found to produce maximum number of tillers at harvest, though not significant.

(iii) Productive tiller number

Data on the productive tiller number as influenced by levels of submergence and nitrogen application in respect of soil types are presented in Table 4 and their analysis of variance in Appendix III.

Table 4 Productive tiller count in different soil types as influenced by level of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application			Level of submergence		Nitrogen application		
	W_1	W_2	T_0	T_1	Mean	W_1	W_2	T_0	T_1	Mean
Karapadam	5.42	5.50	4.67	6.25	5.46	5.75	6.75	4.75	7.75	6.25
Kole	4.25	6.00	4.25	6.00	5.13	8.25	7.75	6.50	9.50	8.00
Sandy loam	5.50	4.50	4.25	5.75	5.00	5.25	4.75	4.00	6.00	5.00
Low level laterite	5.00	5.25	5.00	5.35	5.13	6.75	6.75	6.00	7.50	6.75
Black soil	6.00	6.00	5.25	6.75	6.00	7.00	6.75	6.00	7.75	6.88
Mean	5.23	5.45	5.03	5.65		7.00	6.95	5.85	8.10	

CD for soils = 0.46
CD for soilxlevel of submergence = 0.66
CD for soil x nitrogen application = 0.66
Level of submergence - NS

CD for soils = 0.82
Soil x level of submergence - NS
CD for soil x nitrogen application = 1.17
Level of submergence - NS

In the case of Jaya the productive tiller number was considerably influenced by soil type. The highest productive tiller number was observed in black soil. Karapadam soil recorded the second highest estimate which was on par with kole, and sandy loam soils. In the case of Triveni also, the soil type had significant influence on the productive tiller number. The maximum productive tiller count was seen in kole soil, followed by black soil which was on par with the karapadam and low level laterite soil. The lowest value was given by sandy loam.

In both Jaya and Triveni, the level of submergence alone had no significant influence on the productive tiller count. The treatment combination viz., soil x level of submergence was found to have considerable influence on the productive tiller number in Jaya rice variety. The black soil with 5 cm submergence as well as 10 cm submergence recorded the highest productive tiller number whereas the lowest productive tiller number was in kole soil with 5 cm submergence. In karapadam soil the mean productive tiller count did not show any significant difference between 5 cm and 10 cm submergence. In kole soils 10 cm submergence gave significantly higher productive tiller count than 5 cm submergence.

Sandy loam soil and low level laterite soil were on par at both the levels of submergence. In black soil the productive tiller count at 5 cm and 10 cm submergence were the same. In Triveni, the interaction soil x level of submergence was not significant. In all soil types nitrogen application to Jaya and Triveni resulted in significant increase in productive tiller count over the control. In both Jaya and Triveni, the treatment combination soil x level of submergence x nitrogen application was found to have no significant effect on the productive tiller count.

(iv) Panicle length

The data on the mean panicle length as affected by different treatments are given in Table 5 and the analysis of variance in Appendix III.

For the variety Jaya, the panicle length differed from soil to soil. Maximum panicle length was observed in low level laterite soil which was closely followed by black soil and karapadam soil. The lowest value was observed in sandy loam soil. In the case of Triveni also, panicle length was found to be affected significantly by the soil type. Maximum panicle length was observed with black soil. This was closely followed by karapadam and kole soil. Then followed

Table 5 Panicle length (cm) in different soil types as influenced by level of submergence and nitrogen application

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application			Level of submergence		Nitrogen application		
	W_1	W_2	T_0	T_1	Mean	W_1	W_2	T_0	T_1	Mean
Karapadam	21.84	21.38	18.75	24.78	21.69	17.90	17.96	17.11	18.75	17.93
Kole	20.85	21.20	18.03	24.03	20.98	18.13	17.65	16.94	18.83	17.89
Sandy loam	18.06	18.59	16.95	19.70	18.33	17.08	16.81	15.85	18.04	16.95
Low level laterite	22.70	21.88	19.83	24.70	22.29	16.56	17.00	16.78	16.78	16.78
Black soil	21.59	21.86	19.59	23.86	21.73	17.80	18.77	17.39	19.18	18.14
Mean	21.01	20.98	18.84	23.41		17.49	17.52	16.81	18.32	

CD for soils = 0.17
CD for soil x level of submergence = 0.24
CD for soil x nitrogen application = 0.24
level of submergence - NS

CD for soils = 0.24
CD for soil x level of submergence = 0.33
CD for soil x nitrogen application = 0.33
level of submergence - NS

low level laterite which was on par with sandy loam.

In the case of Jaya and Triveni varieties the different levels of submergence failed to evoke any significant influence on the panicle length.

Nitrogen application also was found to influence the panicle length markedly. In the case of Jaya variety application of fertilizer nitrogen produced significant increase in panicle length in all soils. For Triveni, in all soils except low level laterite soil, nitrogen application resulted in increased panicle length over control. In low level laterite there was no such difference in panicle length.

The soil x level of submergence combination was found to have marked influence on the panicle length. In karapadam soil and low level laterite soil, 5 cm submergence gave significantly higher panicle length than 10 cm submergence in Jaya. However, in all the other soils ie. kole, sandy loam and black soil, 10 cm submergence produced more panicle length. In the case of Triveni, grown in karapadam soil, there was no significant difference in panicle length between 5 cm and 10 cm submergence. But in kole soil 5 cm submergence resulted in significantly increased panicle length than in 10 cm submergence. In sandy loam soil, the panicle at 5 cm and 10 cm levels of submergence were on par. In black soil and low level laterite 10 cm submergence gave significantly increased panicle length than 5 cm submergence. In both varieties, the interaction soil x level of submergence x nitrogen application was found to have significant effect on panicle length. For Jaya, the maximum panicle length was observed with karapadam at 5 cm submergence and nitrogen application which was on par with low level laterite at 5 cm submergence and nitrogen application and the minimum panicle length was noted with sandy loam at 10 cm submergence and no nitrogen. For Triveni the maximum panicle length was noted with black soil at 5 cm submergence and nitrogen application and the minimum panicle length was noted with sandy loam at 10 cm submergence and no nitrogen.

(v) Thousand grain weight

The data on the thousand grain weight of Jaya and Triveni varieties as influenced by different treatment combinations are given in Tables 6 and 9 and their analysis of variance in Appendix VI.

From the results it is observed that for Jaya the soil type had a considerable influence on the thousand grain weight. Maximum thousand grain weight was observed in kole soil which

Table 6 Thousand grain weight (g) in different soil types as influenced by levels of submergence and nitrogen application in rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application			Level of submergence		Nitrogen application		
	W_1	W_2	T_0	T_1	Mean	W_1	W_2	T_0	T_1	Mean
Karapadam	24.03	24.75	24.53	24.25	24.39	21.77	21.64	21.43	21.93	21.71
Kole	24.80	24.48	24.10	25.18	24.64	21.61	21.61	21.09	22.13	21.61
Sandy loam	23.78	24.30	23.78	24.30	23.79	21.25	21.91	20.83	22.33	21.58
Low level laterite	24.63	23.35	25.03	22.95	23.99	22.01	21.64	20.98	22.67	21.83
Black soil	24.60	24.43	24.95	24.08	24.52	21.33	21.55	19.98	22.90	21.44
Mean	24.37	24.26	24.48	24.15		21.59	21.67	20.87	22.39	

CD for soils = 0.50
CD for soil x level of submergence = 0.70
CD for soil x nitrogen application = 0.70
level of submergence - NS

Soil = NS
CD for level of submergence = 0.21
CD for fertilizer nitrogen = 0.21
CD for soil x fertilizer nitrogen = 0.47
level of submergence - NS

was on par with black soil and karapadam soil. The minimum value obtained with sandy loam soil which was on par with the low level laterite soil. In the case of Triveni, soil type was found to have no effect on thousand grain weight.

In both the varieties different levels of submergence alone did not exert any influence, on thousand grain weight. For Jaya the interaction of soil and water level was found to have significant influence on the thousand grain weight. In karapadam soils under 10 cm submergence produced significantly increased thousand grain weight than 5 cm submergence. In kole, sandy loam, low level laterite and black soils, 5 cm submergence gave more thousand grain weight which was statistically on par with the 10 cm submergence. In the case of Triveni, soil x level of submergence interaction had no influence on thousand grain weight.

Among the soil x nitrogen treatment combination for Jaya, in karapadam soil and sandy loam, there was no significant difference in thousand grain weight between the nitrogen applied and without nitrogen soils. In kole soil there was significant increase in thousand grain weight with the application of nitrogen fertilizer whereas in low level laterite the thousand grain weight was more in plants received no nitrogen fertilizer. In the case of Triveni in all soils except karapadam soil there was significant increase in thousand grain weight over the control. In karapadam soil the thousand grain weight of fertilized and control pots were on par.

The interaction effect of soil with level of submergence and nitrogen application also had considerable influence on the thousand grain weight. In the case of Jaya, the maximum value was observed with the treatment of black soil under 5 cm level of submergence and no nitrogen application, which was statistically on par with lowlevel laterite soil at 5 cm level of submergence and nitrogen application. The lowest value was recorded by low level laterite soil at 10 cm submergence and nitrogen application. In the case of Triveni, the highest thousand grain weight was observed with black soil at 5 cm submergence and nitrogen application and the lowest with black soil at 5 cm submergence and no nitrogen application.

(vi) Grain yield

The data regarding the grain yield in g/pot as influenced by different soil types, different levels of submergence, nitrogen application and their combinations are presented in

Table 7 Grain yield (g) in different soil types as influenced by levels of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application		Mean	Level of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	23.00	23.25	21.00	25.25	23.14	20.38	21.05	17.93	23.50	20.72
Kole	25.25	23.25	21.50	27.00	24.25	22.00	22.50	18.90	25.60	22.25
Sandy loam	20.75	20.73	18.10	23.78	20.84	18.75	19.05	16.65	21.15	18.90
Low level laterite	25.00	24.13	22.50	26.63	24.57	21.88	20.05	17.55	24.38	20.97
Black soil	23.25	23.40	21.75	24.90	23.33	22.45	21.78	19.40	24.83	22.12
Mean	23.45	22.95	20.97	25.51		21.09	20.95	18.09	23.89	

Jaya	Triveni
CD for soils = 1.17	CD for soils = 0.92
CD for nitrogen application = 0.79	CD for nitrogen application = 0.58
Level of submergence = NS	Level of submergence - NS

Table 7 and 9 and their analysis of variance in Appendix III.

The result revealed that the soil type had a significant influence on the grain yield. For the variety Jaya low level laterite soil produced maximum grain yield (24.57 g/pot) which was on par with the grain yield from kole soil (24.25 g/pot). This was closely followed by black soil (23.30 g/pot), karapadam soil (23.14 g/pot) and the lowest yield was from sandy loam soil (20.84 g/pot). In the case of Triveni the maximum grain yield was obtained in kole soil (22.25 g/pot) which was on par with black soil (22.12 g/pot). This was followed by low level laterite soil which was on par with karapadam soil. The least value was obtained with sandy loam soil (18.90 g/pot).

In both the varieties the level of submergence was not found to exert any significant influence on the grain yield. The nitrogen application has produced significantly increased yield in all soils. The different treatment combinations also failed to produce any significant influence on the grain yield.

Straw yield

The mean values on the yield of straw as influenced by the treatments are given in tables 8 and 9 and their analysis of variance is Appendix III.

Table 8 Straw yield (g/pot) in different soil types as influenced by levels of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application		Mean	Level of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	29.15	27.03	23.40	32.78	28.09	27.85	24.95	21.78	31.03	26.40
Kole	34.33	30.73	24.83	40.23	32.53	31.43	30.10	24.38	37.15	30.77
Sandy loam	22.93	21.83	18.90	25.85	22.38	23.38	21.98	19.83	25.53	22.68
Low level laterite	30.70	30.90	24.83	36.78	30.80	25.75	24.73	21.65	28.83	25.24
Black soil	32.53	31.03	24.98	38.58	31.78	27.95	27.48	22.98	32.45	27.72
Mean	29.93	28.03	23.38	34.84		27.27	25.85	22.12	31.00	

CD for soils = 1.17

Soil x level of submergence = NS

Soil x nitrogen application = NS

CD for soils = 0.95

Soil x level of submergence = NS

Soil x nitrogen application = NS

CD for level of submergence = 0.70

The results showed that the straw yield was significantly influenced by soil type. In Jaya, the maximum straw yield (32.53 g/pot) was produced by kole soil which was closely followed by black soil (31.78 g/pot). The lowest straw yield was obtained in sandy loam soil (22.38 g/pot). In the case of Triveni the highest yield was noted with kole soil which was followed by black soil. Karapadam soil ranked next and this was followed by low level laterite soil. The minimum yield was obtained from sandy loam soil.

For Jaya, though the level of submergence had marked influence on the straw yield, the straw yield at 5 cm and 10 cm levels of submergence were statistically on par. In the case of Triveni, as is clear from the Table, 5 cm submergence gave higher straw yields than 10 cm submergence.

For both the varieties and in all soils the nitrogen applied plant produced more straw yield than control plants. For both the varieties the soil x level of submergence and soil x fertilizer nitrogen interaction were found to have no significant influence on straw yield. The interaction effect of soil, level of submergence and nitrogen application was found to be significant in both the paddy varieties. For Jaya, the maximum straw yield was recorded by the treatment

Table 9 Interaction effect of soil type levels of submergence, nitrogen, on yield parameters in rice. Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Productive tiller count	Panicle length	Thousand grain weight	Grain yield	Straw yield	Productive tiller count	Panicle length	Thousand grain weight	Grain yield	Straw yield
$S_1W_1T_0$	4.33	18.38	24.90	20.00	23.75	4.00	16.94	21.45	18.25	22.65
$S_1W_1T_1$	6.50	25.30	23.15	26.00	34.55	7.50	18.87	22.09	22.50	33.05
$S_1W_2T_0$	5.00	19.12	24.15	22.00	23.05	5.50	17.28	21.51	17.60	20.90
$S_1W_2T_1$	6.00	23.65	25.35	24.50	31.00	8.00	18.63	21.78	24.50	29.00
$S_2W_1T_0$	3.50	17.50	24.20	21.50	27.35	6.50	17.54	21.05	19.00	24.55
$S_2W_1T_1$	5.00	24.20	25.40	29.00	41.30	10.00	18.73	22.16	25.00	38.30
$S_2W_2T_0$	5.00	18.55	24.00	21.50	22.30	6.50	16.35	21.13	18.80	24.20
$S_2W_2T_1$	7.00	23.85	24.95	25.00	39.15	9.00	18.94	22.10	26.20	36.00
$S_3W_1T_0$	6.50	17.45	23.10	17.80	19.90	4.00	16.15	20.35	17.00	20.60
$S_3W_1T_1$	4.50	18.68	24.45	23.70	25.95	6.50	18.00	22.15	20.50	26.15
$S_3W_2T_0$	5.00	16.45	24.45	18.40	17.90	4.00	15.54	21.31	16.30	19.05
$S_3W_2T_1$	4.00	20.73	24.15	23.05	25.75	5.50	18.08	22.50	21.80	24.90
$S_4W_1T_0$	5.00	20.25	25.40	23.00	24.75	6.00	16.35	21.25	18.25	20.80
$S_4W_1T_1$	5.00	25.15	23.85	27.00	36.65	7.50	16.78	22.78	25.50	30.70
$S_4W_2T_0$	5.50	19.50	24.65	22.00	24.90	6.00	17.22	20.70	16.85	22.50
$S_4W_2T_1$	5.00	24.25	22.05	26.23	36.90	7.50	16.68	22.57	23.25	26.95
$S_5W_1T_0$	5.50	18.63	25.60	21.00	26.05	6.00	16.08	19.30	19.25	22.30
$S_5W_1T_1$	6.50	24.55	23.60	25.50	39.00	8.00	19.52	23.35	25.65	33.60
$S_5W_2T_0$	5.00	20.55	24.30	22.50	23.90	6.00	18.71	20.65	19.55	23.65
$S_5W_2T_1$	7.00	23.18	24.55	24.30	38.15	7.50	18.84	22.45	24.00	31.30
CD	NS	0.33	1.00	NS	2.35	NS	0.47	0.67	NS	1.90

combination of kole soil at 5 cm submergence and nitrogen application which was statistically on par with the treatment combination of kole soil at 10 cm submergence with nitrogen application and black soil at 5 cm submergence with nitrogen application and the lowest yield was produced by the treatment combination of sandy loam at 10 cm submergence and without nitrogen. For Triveni, among the soil x level of submergence x nitrogen application, highest value was observed with kole soil at 5 cm submergence and nitrogen application while the lowest value was noted with sandy loam at 10 cm submergence and without nitrogen application which was on par with sandy loam at 5 cm submergence and no nitrogen fertilizer.

II Plant analysis

(i) Plant nitrogen content at different stages

The data on the nitrogen content of plant determined at five different stages are given in Tables 10(a) to 10(d) and their analysis of variance in Appendix V.

The data relating to the rice variety Jaya indicated that the nitrogen content of plant at different stages was influenced by soil type. At 10 days and 20 days after transplanting, maximum plant nitrogen content was obtained in plants grown in karapadam soil and at 30 days, 60 days and harvest maximum nitrogen content was obtained in plants grown in kole soil. The analysis data after 10 days of transplanting showed that kole soil followed karapadam soil and then black soil followed by low level laterite and least value was on sandy loam soil. At twenty days after transplanting, kole soil and low level laterite were on par with regard to plant nitrogen content and least value was obtained with sandy loam soil. At 30 days of transplanting, second place in plant nitrogen content was rated in karapadam soil and least value was recorded in black soil. At harvest period, plant nitrogen content of karapadam and black soil were on par and least value was noted with sandy loam soil. In the case of Triveni also, the plant nitrogen content at different stages was influenced significantly by soil type. In all stages except at harvest stage maximum plant nitrogen was recorded in kole soil, followed by low level laterite at 10, 20 and 30 days after transplanting and by karapadam at 60th day. At harvest stage maximum plant nitrogen content was noted in black soil which was on par with that from the karapadam soil. The kole, sandy loam and low level laterite were also on par. At harvest stage, plant nitrogen content

Table 10(a) Plant nitrogen (per cent) at different periods as affected by soil type on rice Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Days after transplanting					Days after Transplanting				
	10	20	30	60	Harvest	10	20	30	60	Harvest
Karapadam	3.30	3.30	3.10	3.10	0.85	3.12	3.00	2.80	2.84	0.85
Kole	3.20	3.10	3.80	3.10	0.96	3.51	3.33	3.20	3.09	0.82
Sandy loam	2.60	2.70	2.70	2.40	0.65	3.29	3.15	3.00	2.45	0.79
Low level laterite	3.00	3.10	3.00	2.50	0.70	3.30	3.15	3.05	2.41	0.81
Black soil	3.10	2.80	2.60	2.10	0.85	3.16	3.10	2.71	2.25	0.87
CD	0.05	0.17	0.17	0.16	0.02	0.16	0.03	0.02	0.03	0.02

of karapadam and black soil were on par and the least value was noted with sandy loam soil.

At all periods except at 20 days and 30 days after transplanting, the water level also was found to influence the plant nitrogen content. At 10 cm submergence the plant nitrogen content was found to be higher than that at 5 cm submergence, at all stages except at 20th day of transplanting. In the case of Triveni, at the 10th, 30th and 60th day of planting, 10 cm submergence gave significantly higher plant nitrogen content. However, at harvest stage, analysis showed that plant nitrogen content was more with 5 cm submergence. At 20th day both the levels of submergence were found to give identical, values of plant nitrogen content.

For Jaya, the plant nitrogen content was found to be increased by the nitrogen application. For Triveni also, the fertilized plants gave more nitrogen content than control plants at all the stages.

The soil x levels of submergence interaction was found to influence the plant nitrogen content significantly. In the case of Jaya, in karapadam, kole and low level laterite soils, 10 cm submergence gave more nitrogen content. However, in sandy loam and black soils, 5 cm submergence was found superior.

Table 10(b) Plant nitrogen (per cent) in different soil types as influenced by level of submergence on rice, Jaya and Triveni

Soil type	Level of submergence	JAYA					TRIVENI				
		Days after transplanting					Days after transplanting				
		10	20	30	60	Harvest	10	20	30	60	Harvest
Karapadam	5	3.20	3.30	3.10	3.00	0.80	3.10	3.06	2.72	2.80	0.85
	10	3.30	3.30	3.10	3.10	0.90	3.16	2.92	2.87	2.87	0.85
Kole	5	3.00	2.90	3.30	3.10	1.00	3.52	3.38	3.14	2.96	0.86
	10	3.30	3.20	4.00	3.20	0.90	3.52	3.24	3.25	3.20	0.82
Sandy loam	5	2.60	2.80	2.80	2.40	0.70	2.85	2.73	2.98	2.44	0.79
	10	2.60	2.70	2.60	2.30	0.60	3.69	3.58	3.02	2.46	0.77
Low level laterite	5	2.90	3.10	3.00	2.10	0.60	3.34	3.23	2.96	2.68	0.82
	10	3.10	3.00	3.00	2.90	0.80	3.25	3.08	3.15	2.16	0.83
Black soil	5	3.10	2.90	2.80	2.00	0.80	3.14	3.31	2.57	1.91	0.92
	10	3.00	2.60	2.30	2.10	0.90	3.20	2.89	2.85	2.59	0.86
C.D.		0.07	0.25	0.20	0.20	0.03	0.20	0.05	0.03	0.04	0.03
Mean for level of submergence	5cm	2.96	3.00	3.00	2.52	0.78	3.19	3.14	2.87	2.56	0.85
	10cm	3.06	2.96	3.00	2.72	0.82	3.36	3.14	3.03	2.66	0.83
C.D.		0.10	0.05	0.01	0.02	0.02	0.10	0.02	0.01	0.02	0.02

For Triveni, among the soil x levels of submergence combination at 10th and 20th day after transplanting sandy loam at 10 cm submergence showed highest plant nitrogen per cent which was on par with kole soil at 5 cm level of submergence and kole soil at 10 cm submergence. At 30th day, highest plant nitrogen content was observed with kole soil at 10 cm submergence and the lowest plant nitrogen content was with black soil at 5 cm submergence. At 60th day also, the highest plant nitrogen content was noted with kole soil at 10 cm submergence which was closely followed by kole soil at 5 cm submergence. The lowest value was observed with black soil at 5 cm submergence. At harvest highest value was given by black soil at 5 cm submergence. For both the varieties the soil x nitrogen interaction was significant at all stages. At all stages the application of nitrogen fertilizer increased the plant nitrogen content. The soil x level of submergence nitrogen application was also found significant for both varieties at all stages. The maximum plant nitrogen content in the case of Jaya at 10th day was noted with black soil at 5 cm submergence and nitrogen application, whereas at 20th day the maximum was noted with karapadam soil at 5 cm submergence and nitrogen application. At 30th, 60th and harvest stages, the maximum value was noted

Table 10(c) Plant nitrogen (per cent) content of different soil types as influenced by nitrogen application on rice, Jaya and Triveni

Soil type	Nitrogen application	JAYA Days after Transplanting					TRIVENI Days after Transplanting				
		10	20	30	60	Harvest	10	20	30	60	Harvest
Karapadam	T_0	2.70	2.70	2.70	2.60	0.80	2.50	2.40	2.40	2.50	0.80
	T_1	3.80	3.80	3.50	3.50	0.90	3.70	3.60	3.20	3.20	0.90
Kole	T_0	3.00	2.80	3.30	2.40	0.80	3.60	3.40	3.00	2.40	0.70
	T_1	3.30	3.30	4.10	3.90	1.20	3.40	3.30	3.40	3.30	0.90
Sandy loam	T_0	2.60	2.60	2.60	2.20	0.60	2.90	2.80	2.50	2.20	0.70
	T_1	2.60	2.80	2.90	2.60	0.70	2.70	3.50	3.50	2.70	0.90
Low level laterite	T_0	2.90	2.70	2.60	2.60	0.70	2.80	2.70	2.40	2.30	0.70
	T_1	3.10	3.50	3.40	2.40	0.70	3.80	3.60	3.70	2.50	0.90
Black soil	T_0	3.10	2.20	2.30	2.00	0.80	2.90	2.70	2.60	2.10	0.80
	T_1	3.00	3.40	2.80	2.10	0.80	3.40	3.50	2.80	2.40	1.00
C.D.		0.07	0.25	0.20	0.20	0.03	0.20	0.05	0.03	0.04	0.03

Table 10(d) Plant nitrogen content (per cent) as influenced by soil type, level of submergence and nitrogen application on rice, Jaya and Triveni

Treatment combinations	JAYA					TRIVENI				
	Days after transplanting					Days after transplanting				
	10	20	30	60	Harvest	10	20	30	60	Harvest
$S_1W_1T_0$	2.54	2.51	2.61	2.47	0.75	2.53	2.51	2.22	2.23	0.77
$S_1W_1T_1$	3.88	3.93	3.57	3.48	0.91	3.68	3.61	3.22	3.37	0.93
$S_1W_2T_0$	2.95	2.92	2.85	2.71	0.79	2.50	2.33	2.52	2.79	0.79
$S_1W_2T_1$	3.71	3.67	3.41	3.52	0.96	3.81	3.52	3.22	2.96	0.91
$S_2W_1T_0$	2.57	2.51	2.57	2.20	0.82	3.71	3.52	2.95	2.81	0.76
$S_2W_1T_1$	3.42	3.31	4.03	3.97	1.21	3.34	3.25	3.33	3.11	0.96
$S_2W_2T_0$	3.14	3.09	3.94	2.63	0.79	3.52	3.22	2.99	2.94	0.74
$S_2W_2T_1$	3.41	3.34	4.09	3.85	1.11	3.52	3.27	3.51	3.47	0.91
$S_3W_1T_0$	2.63	2.60	2.66	2.24	0.69	2.18	2.06	2.55	2.23	0.69
$S_3W_1T_1$	2.57	2.81	2.91	2.66	0.76	3.52	3.41	3.42	2.65	0.89
$S_3W_2T_0$	2.56	2.63	2.47	2.13	0.53	3.57	3.32	2.52	2.08	0.69
$S_3W_2T_1$	2.56	2.74	2.83	2.51	0.71	3.81	3.65	3.52	2.85	0.85
$S_4W_1T_0$	2.97	2.91	2.81	2.31	0.60	2.71	2.65	2.41	2.74	0.74
$S_3W_1T_1$	2.92	3.34	3.28	1.94	0.71	3.96	3.81	3.52	2.61	0.89
$S_4W_2T_0$	2.61	2.41	2.47	2.93	0.83	2.96	2.82	2.44	1.96	0.72
$S_4W_2T_1$	3.63	3.61	3.52	2.80	0.70	3.54	3.35	3.87	2.37	0.94
$S_5W_1T_0$	2.33	2.08	2.51	1.94	0.72	2.96	2.93	2.64	1.64	0.79
$S_5W_1T_1$	3.91	3.81	3.04	3.03	0.79	3.31	3.69	2.51	2.19	1.05
$S_5W_2T_0$	2.40	2.32	2.07	2.05	0.85	2.89	2.38	2.61	2.48	0.76
$S_5W_2T_1$	3.51	2.93	2.08	2.13	0.91	3.52	3.41	3.08	2.71	0.97
C.D.	0.10	0.10	0.20	0.07	0.03	0.33	0.06	0.04	0.05	0.04

with kole soil at 5 cm submergence and nitrogen application. In the case of Triveni at 10th & 20th day, the maximum content was noted with low level laterite at 5 cm submergence and nitrogen application. At 30th day low level laterite at 10 cm submergence and nitrogen application recorded the maximum value. At 60th day, kole soil at 10 cm submergence and nitrogen application was found superior, whereas at harvest black soil at 5 cm submergence and nitrogen application was found superior.

(ii) Nitrogen content of grain

Data on the nitrogen content of grain is presented in Tables 11 and 13 and their analysis of variance in Appendix VII.

The nitrogen content of grain differed from soil to soil. For Jaya, the maximum grain nitrogen was seen with black soil followed by kole soil, sandy loam, low level laterite and karapadam soil. In the case of Triveni, the highest value for grain nitrogen was observed in plants grown in black soil, followed by kole soil and the least value was with low level laterite soil.

In the case of Jaya, the grain nitrogen content was found more with 5 cm submergence while in Triveni variety, the levels of submergence had no effect.

Table 11 Nitrogen content of grain (per cent) in different soil types as influenced by level of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application		Mean	Level of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	1.10	1.09	1.10	1.10	1.10	1.19	1.13	1.22	1.10	1.16
Kole	1.19	1.25	1.26	1.18	1.22	1.17	1.23	1.25	1.14	1.20
Sandy loam	1.23	1.06	1.17	1.12	1.15	1.11	1.10	1.13	1.08	1.11
Low level laterite	1.19	1.05	1.12	1.13	1.12	1.03	1.03	1.07	0.99	1.03
Black soil	1.30	1.21	1.31	1.20	1.26	1.35	1.25	1.39	1.21	1.30
Mean	1.20	1.13	1.19	1.15						

CD for soils = 0.02
CD for level of submergence = 0.01
CD for soil x nitrogen application = 0.025
CD for soil x level of submergence = 0.025

CD for soils = 0.07
Level of submergence - NS
Soil x level of submergence - NS
CD for soil x nitrogen application = 0.10
CD for nitrogen application = 0.05

Nitrogen fertilizer application was found to have no significant influence on the grain nitrogen content in Jaya, whereas in the case of Triveni, fertilizer nitrogen application was found to result in a significant decrease over the control.

In the case of Jaya, the soil x level of submergence interaction was found to influence the grain nitrogen significantly. Maximum grain nitrogen content was recorded in black soil with 5 cm submergence, followed by kole soil at 10 cm submergence, sandy loam at 5 cm submergence and black soil at 10 cm submergence which were on par. The lowest value was given by low level laterite at 10 cm which was on par with sandy loam at 10 cm submergence karapadam at 5 cm submergence and karapadam at 10 cm submergence were on par. So also, kole soil at 5 cm submergence and low level laterite at 5 cm submergence were on par. In the case of Triveni, the soil x level of submergence interaction was found to have no significant effect on grain nitrogen content. In both the rice varieties, the soil x nitrogen application and soil x level of submergence x nitrogen interaction were found not to influence the grain nitrogen content.

(iii) Nitrogen content of straw

The data on the nitrogen content of straw are presented

Table 12 Nitrogen content of straw (per cent) in different soil types as influenced by level of submergence and nitrogen application in rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application		Mean	Level of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	0.58	0.56	0.59	0.55	0.57	0.57	0.50	0.50	0.49	0.50
Kole	0.53	0.54	0.56	0.51	0.54	0.53	0.55	0.55	0.53	0.54
Sandy loam	0.54	0.56	0.57	0.53	0.55	0.62	0.62	0.63	0.61	0.62
Low level laterite	0.79	0.64	0.73	0.70	0.72	0.69	0.84	0.80	0.72	0.76
Black soil	0.83	0.83	0.85	0.82	0.83	0.56	0.63	0.60	0.59	0.60
Mean	0.65	0.63	0.66	0.62		0.58	0.63	0.62	0.59	

CD for soils = 0.02
CD for soil x level of submergence = 0.03
CD for soil x nitrogen application = 0.03
CD for nitrogen application = 0.01
CD for level of submergence = 0.01

CD for soils = 0.03
CD for soil x level of submergence = 0.05
CD for soil x nitrogen application = 0.05
CD for level of submergence = 0.02

in Tables 12 & 13 and the analysis of variance in Appendix VII.

From the results it is found that the nitrogen content of straw differed from soil to soil. In the case of Jaya, the maximum nitrogen content of straw was found in black soil, which was followed by low level laterite, karapadam, sandy loam and kole soils. In the case of Triveni, nitrogen content of the straw was found significantly higher when it was grown in low level laterite soil. Next to this was sandy loam, which was on par with black soil, least value was found in karapadam soil.

In the case of Jaya, the nitrogen content of straw was more at 5 cm submergence than at 10 cm submergence. For Triveni, the straw nitrogen content was higher at 10 cm submergence than at 5 cm submergence.

In both Jaya and Triveni varieties, the straw nitrogen content was found decreased by the nitrogen treatment.

The soil x level of submergence interaction was found to have significant effect on straw nitrogen content. For Jaya, the highest value was noted with black soil at 5 cm submergence, which was identical with black soil at 10 cm submergence, followed by low level laterite soil at 5 cm submergence and the least value was with kole soil at 5 cm submergence. In the case of Triveni, the maximum straw nitrogen content was observed with low level laterite at 10 cm submer-

Table 13 Nitrogen content (per cent) of grain and straw as influenced by soil x levels of submergence x nitrogen application on rice: Jaya and Triveni

Treatment combination	JAYA		TRIVENI	
	Nitrogen content of grain	Nitrogen content of straw	Nitrogen content of grain	Nitrogen content of straw
$S_1W_1T_0$	1.07	0.61	1.20	0.50
$S_1W_1T_1$	1.14	0.55	1.14	0.49
$S_1W_2T_0$	1.12	0.57	1.17	0.50
$S_1W_2T_1$	1.06	0.55	1.12	0.48
$S_2W_1T_0$	1.23	0.55	1.21	0.53
$S_2W_1T_1$	1.16	0.51	1.15	0.54
$S_2W_2T_0$	1.30	0.56	1.24	0.58
$S_2W_2T_1$	1.20	0.51	1.18	0.52
$S_3W_1T_0$	1.29	0.56	1.12	0.63
$S_3W_1T_1$	1.18	0.53	1.10	0.61
$S_3W_2T_0$	1.06	0.59	1.12	0.64
$S_3W_2T_1$	1.07	0.53	1.09	0.61
$S_4W_1T_0$	1.24	0.82	1.05	0.74
$S_4W_1T_1$	1.15	0.76	1.01	0.64
$S_4W_2T_0$	1.00	0.65	1.05	0.87
$S_4W_2T_1$	1.11	0.63	1.01	0.81
$S_5W_1T_0$	1.40	0.85	1.37	0.55
$S_5W_1T_1$	1.20	0.82	1.28	0.57
$S_5W_2T_0$	1.22	0.85	1.32	0.65
$S_5W_2T_1$	1.20	0.82	1.23	0.62
CD	NS	NS	NS	NS

gence, followed by the same soil type at 5 cm submergence and black soil at 10 cm submergence, Sandy loam at 5 cm submergence and sandy loam at 10 cm submergence were identical. The other treatment combinations were found to have no marked influence on the straw nitrogen content.

(iv) Phosphorus content of grain

The data on mean phosphorus content of grain as affected by the treatments are given in Tables 14 and 18 and the analysis of variance in Appendix VII.

In the variety Jaya, the maximum grain phosphorus was observed in black soil followed by karapadam soil, sandy loam, kole and low level laterite soil. In the case of Triveni, this followed the order: kole, karapadam, black soil, low level laterite and sandy loam soil.

The water levels had no significant influence on the grain phosphorus content.

The nitrogen fertilizer application had resulted in significant increase of grain phosphorus content in both the rice varieties.

Among the soil x level of submergence interaction, maximum value for Jaya variety was noted with black soil at 10 cm submergence which was on par with all other treatments

Table 14 Phosphorus content of grain (per cent) in different soil types as influenced by level of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application		Mean	Level of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	0.24	0.24	0.23	0.25	0.24	0.25	0.24	0.23	0.26	0.25
Kole	0.23	0.23	0.22	0.24	0.23	0.25	0.25	0.24	0.25	0.25
Sandy loam	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.22	0.24	0.23
Low level laterite	0.22	0.22	0.21	0.23	0.22	0.23	0.24	0.24	0.24	0.24
Black soil	0.24	0.25	0.24	0.25	0.25	0.23	0.24	0.23	0.25	0.24
Mean	0.23	0.23	0.23	0.24		0.24	0.24	0.23	0.25	

CD for soils = 0.002
CD for soil x level of submergence = 0.07
CD for soil x nitrogen application - NS
Level of submergence - NS
CD for nitrogen application - 0.005

CD for soils = 0.005
CD for level of submergence - NS
CD for nitrogen application = 0.01
CD for soil x level of submergence = 0.01
CD for soil x nitrogen application = 0.01

For Triveni, among the soil x level of submergence combinations karapadam soil at 5 cm submergence, kole soil at 5 cm as well as 10 cm submergence were equal and gave the maximum value. For Jaya, the soil x nitrogen fertilizer interaction was found to have no marked influence on the grain phosphorus content. For Triveni, among the soil x nitrogen fertiliser interactions fertilizer nitrogen applied to karapadam soil gave the maximum content followed by nitrogen applied to black soil and kole soil. The soil x level of submergence x nitrogen fertilizer interactions was found to exert marked influence on the phosphorus content of the grain. In the case of Jaya, the maximum grain phosphorus content was observed with karapadam soil at 5 cm submergence and fertilizer nitrogen application and the black soil at 10 cm submergence and fertilizer nitrogen which was closely followed by karapadam soil at 10 cm submergence and nitrogen fertilizer application and kole soil at 5 cm submergence and fertilizer nitrogen application. The lowest value was observed by the treatments, low level laterite soil at 10 cm submergence and without nitrogen fertilizer application and kole soil at 5 cm submergence and without nitrogen application. In the case of Triveni, there was no significant influence.

Table 15 Phosphorus content of straw (per cent) in different soil types as influenced by level of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application		Mean	Level of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	0.12	0.15	0.13	0.14	0.14	0.12	0.12	0.12	0.12	0.12
Kole	0.15	0.14	0.15	0.14	0.15	0.12	0.13	0.12	0.13	0.13
Sandy loam	0.13	0.11	0.11	0.12	0.12	0.12	0.11	0.11	0.12	0.12
Low level laterite	0.13	0.13	0.12	0.15	0.13	0.12	0.12	0.11	0.13	0.12
Black soil	0.12	0.13	0.13	0.12	0.13	0.12	0.11	0.11	0.12	0.12
Mean	0.13	0.13	0.13	0.13		0.12	0.12	0.11	0.12	

Jaya:
CD for soils = 0.01
CD for nitrogen application - 0.004
CD for soil x level of submergence = 0.01
CD for soil x nitrogen application = 0.01

Triveni:
CD for soils = 0.01
CD for nitrogen application = 0.004
CD for soil x level of submergence - 0.009

(v) Phosphorus content of straw

The data on the percentage phosphorus content of straw are presented in Tables 15 and 18 and their analysis of variance in Appendix VII.

In the case of Jaya, the phosphorus content of straw was found maximum in kole soil followed by karapadam soil which was on par with low level laterite and black soil. The least value was observed with the sandy loam soil. In the case of Triveni, the maximum phosphorus content of straw was noted with kole soil karapadam low level laterite sandy loam and black soil were on par.

In the case of Jaya and Triveni, the level of submergence alone did not exert any significant influence on the phosphorus content of the straw.

In both the rice varieties, the nitrogen applied plants registered significantly increased phosphorus content over the control.

The interaction of soil and level of submergence was found to exert significant influence on the phosphorus content of straw. In the case of Jaya, in karapadam and black soil 10 cm level of submergence gave significantly increased straw phosphorus than 5 cm level of submergence. However, in kole and sandy loam soils 5 cm level of submergence gave significantly higher phosphorus content than 10 cm level of submergence. In low level laterite soil, the same amount of phosphorus content could be observed at both 5 cm and 10 cm levels of submergence. In the case of Triveni, maximum straw phosphorus content was noted with kole soil at 10 cm submergence and the minimum with sandy loam at 10 cm submergence and black soil at 10 cm submergence. The interaction of soil and fertilizer nitrogen application also had marked influence on the straw phosphorus content in Jaya. In all soils except black soil, the phosphorus content was significantly increased by the fertilizer nitrogen application. In black soil, the control treatment recorded significantly increased phosphorus content of straw over the nitrogen fertilizer applied treatment. In the case of Jaya, the interaction of soil x level of submergence x fertilizer nitrogen application was found to influence the phosphorus content. The maximum straw phosphorus content was observed with the treatment combination of karapadam soil at 10 cm submergence and nitrogen application. Sandy loam soil at 10 cm level of submergence with and without nitrogen application recorded the least value. In Triveni, there was no significant influence.

(vi) Potassium content of grain

Data regarding the potassium content of grain as affected by soil type, level of submergence and nitrogen application are given in Tables 16 and 18 and their analysis of variance in Appendix VII.

As far as the Jaya variety is concerned, the potassium content of grain differed from soil to soil. The maximum grain potassium content was noted with black soil followed by low level laterite, kole, sandy loam and karapadam soils in order. For Triveni, the maximum grain potassium was noted with black soil, followed by low level laterite soil, sandy loam and kole and least with karapadam soil.

In both the varieties, the level of submergence did not exert any influence on the grain potassium content. The potassium content of grain in plants which received fertilizer nitrogen was found higher than that in the control plants.

The soil x level of submergence had significant influence on the grain potassium content. For Jaya, in karapadam and low level laterite soils, more grain potassium content was attained with 5 cm submergence. In kole soil significantly more potassium content was attained with 10 cm

Table 16 Potassium content of grain (per cent) as affected by levels of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application		Mean	Level of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	0.57	0.56	0.51	0.62	0.57	0.58	0.57	0.52	0.63	0.58
Kole	0.62	0.65	0.54	0.73	0.64	0.59	0.61	0.52	0.68	0.60
Sandy loam	0.58	0.58	0.49	0.66	0.58	0.60	0.64	0.51	0.73	0.62
Low level laterite	0.65	0.64	0.58	0.72	0.65	0.69	0.66	0.62	0.72	0.67
Black soil	0.70	0.71	0.59	0.82	0.71	0.73	0.72	0.62	0.83	0.73
Mean	0.63	0.63	0.54	0.71		0.64	0.64	0.56	0.72	

CD for soils = 0.017

CD for soil x level of-submergence = 0.024

CD for soil x nitrogen application = 0.024

CD for soils = 0.02

CD for nitrogen application = 0.01

submergence. In sandy loam and black soil, 5 cm and 10 cm submergence were on par. For Triveni, in kole soil and sandy loam 10 cm submergence gave more potassium content in grains. However, in low level laterite soil 5 cm submergence gave more potassium content while in karapadam and black soil 5 cm and 10 cm submergence were on par. As far as the interaction of soil and fertilizer nitrogen application is concerned, all the soil types which received nitrogen fertilizer resulted in significant increase of grain potassium content. The interaction effect of soil x level of submergence x fertilizer nitrogen application also was found to have significant influence on the grain potassium content, in both varieties.

(vii) Potassium content of straw

Data regarding the potassium content of straw as influenced by soil type, level of submergence and nitrogen application are given in Tables 17 and 18 and their analysis of variance in Appendix VII.

The results revealed that soil type had significant influence on the straw potassium content. In the case of Jaya the maximum potassium content was noted in the straw of plants grown in kole soil which was on par with those

Table 17 Potassium content of straw (per cent) in different soils as influenced by level of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Levels of submergence		Nitrogen application		Mean	Levels of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	1.42	1.39	1.20	1.61	1.41	1.39	1.30	1.05	1.63	1.34
Kole	1.48	1.63	1.62	1.49	1.56	1.69	1.65	1.65	1.69	1.67
Sandy loam	1.59	1.20	1.50	1.29	1.40	1.51	1.33	1.57	1.27	1.42
Low level laterite	1.44	1.24	1.17	1.51	1.34	1.70	1.49	1.31	1.88	1.60
Black soil	1.49	1.58	1.44	1.64	1.54	1.04	1.55	1.41	1.18	1.30
Mean	1.48	1.15	1.39	1.51		1.46	1.46	1.40	1.57	

CD between soils = 0.05
CD between levels of submergence = 0.03
CD between soil x level of-submergence = 0.07
CD between soil x nitrogen-application = 0.07

CD between soils = 0.02
CD for nitrogen application = 0.01
CD for soil x level of-submergence = 0.02
CD for soil x nitrogen-application = 0.02

Table 18 Phosphorus and potassium contents (per cent) of grain and straw as influenced by soil type, levels of submergence and nitrogen application on rice, Jaya and Triveni

Treatment combinations	JAYA				TRIVENI			
	Phosphorus content		Potassium content		Phosphorus content		Potassium content	
	grain	straw	grain	straw	grain	straw	grain	straw
$S_1W_1T_0$	0.22	0.12	0.55	1.28	0.24	0.12	0.54	1.25
$S_1W_1T_1$	0.26	0.13	0.60	1.55	0.27	0.11	0.62	1.51
$S_1W_2T_0$	0.24	0.14	0.48	1.11	0.23	0.11	0.50	0.85
$S_1W_2T_1$	0.25	0.16	0.64	1.66	0.26	0.13	0.65	1.75
$S_2W_1T_0$	0.21	0.15	0.52	1.57	0.24	0.11	0.54	1.67
$S_2W_1T_1$	0.25	0.15	0.71	1.38	0.25	0.12	0.65	1.71
$S_2W_2T_0$	0.22	0.15	0.55	1.66	0.24	0.13	0.51	1.63
$S_2W_2T_1$	0.24	0.14	0.76	1.60	0.25	0.14	0.71	1.67
$S_3W_1T_0$	0.23	0.12	0.51	1.45	0.23	0.11	0.49	1.51
$S_3W_1T_1$	0.24	0.13	0.65	1.73	0.24	0.13	0.72	1.51
$S_3W_2T_0$	0.23	0.11	0.48	1.55	0.22	0.12	0.53	1.63
$S_3W_2T_1$	0.23	0.11	0.67	0.84	0.24	0.11	0.75	1.02
$S_4W_1T_0$	0.21	0.12	0.62	1.37	0.23	0.11	0.65	1.63
$S_4W_1T_1$	0.23	0.14	0.71	1.51	0.23	0.14	0.73	1.76
$S_4W_2T_0$	0.22	0.11	0.54	0.97	0.24	0.12	0.60	0.98
$S_4W_2T_1$	0.22	0.14	0.73	1.51	0.25	0.13	0.71	1.99
$S_5W_1T_0$	0.24	0.13	0.59	1.32	0.23	0.12	0.65	1.28
$S_5W_1T_1$	0.24	0.11	0.81	1.66	0.24	0.12	0.82	0.81
$S_5W_2T_0$	0.24	0.12	0.59	1.55	0.23	0.11	0.59	1.55
$S_5W_2T_1$	0.26	0.14	0.84	1.61	0.25	0.11	0.84	1.55
CD	0.09	0.01	-	0.03	NS	NS	0.03	0.03

grown in black soil karapadam and sandy loam were on par. Least value was found in the straw of plants grown in low level laterite soil. In the case of Triveni, the highest potassium content of straw was with kole soil which was followed by low level laterite, sandy loam, karapadam and black soil. It was found that in Jaya 5 cm submergence had a significant effect on the straw potassium content over the 10 cm level. In the case of Triveni, both the levels of submergence had the same effect.

In both the rice varieties nitrogen application was found to exert significant influence on the straw potassium content.

The effect of interaction soil x level of submergence was significant in both varieties. In the case of Jaya, the maximum straw potassium content was observed in kole soil at 10 cm submergence, which was on par with sandy loam at 5 cm submergence and the least value was observed in sandy loam at 10 cm submergence. In the case of Triveni, the maximum straw nitrogen content was observed in low level laterite at 5 cm submergence which was on par with kole soil at 5 cm submergence. The least value was observed in black soil at 5 cm submergence. In both the rice varieties, the soil x nitrogen application and soil x level of submergence x nitrogen interaction were found to have significant influence on straw potassium content.

III Soil analysis

(i) Available nitrogen content of soil

Data on the available nitrogen content of soil at different periods are presented in Tables 19 to 22 and their analysis of variance in Appendix IV.

In the case of Jaya the results showed that available nitrogen content of soils varied in different soil types. The maximum available nitrogen content was obtained in kole soil, followed by low level laterite and the minimum value was obtained with the sandy loam. In the case of Triveni, at all periods the maximum available nitrogen content was noted with kole soil followed by low level laterite, karapadam, black soil and sandy loam soil.

In the case of Jaya, more available nitrogen content was noted with 5 cm submergence at all periods. So also in the case of Triveni, more available nitrogen content was noted with 5 cm submergence than 10 cm submergence. In both the cases the soil which relieved fertilizer nitrogen gave more available nitrogen than control.

FIG. 1. AVAILABLE NITROGEN CONTENT OF SOILS AT DIFFERENT PERIODS IN JAYA

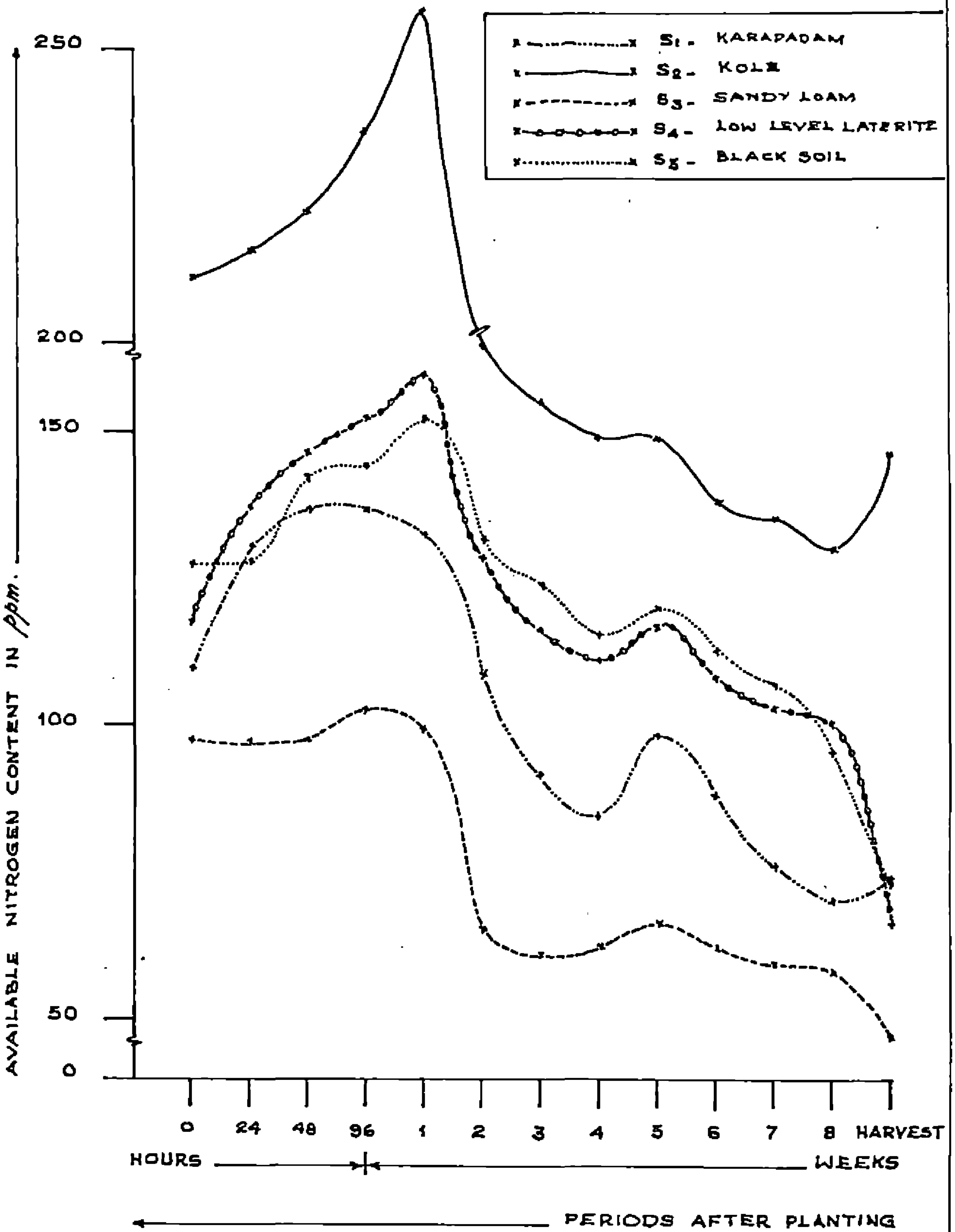


Table 19(a) Mean available nitrogen content (ppm) at different periods in different soils for rice, Jaya

	Periods after transplanting												
	0h	24h	48h	96h	1week	2week	3week	4week	5week	6week	7week	8week	Harvest
Karapadam	110	131	137	137	133	109	92	85	99	89	77	70	74
Kole	212	216	222	236	257	164	155	149	149	138	135	130	146
Sandy loam	98	98	98	103	100	66	62	63	67	63	60	59	48
Low level laterite	118	137	147	152	160	129	117	112	117	109	104	101	67
Black soil	128	128	143	144	152	131	124	116	120	113	107	96	73
CD		1.36	2.4	1.7	1.4	1.5	1.7	1.2	3.8	1.1	1.9	2.5	6.2

FIG. 2. AVAILABLE NITROGEN CONTENT OF SOILS AT DIFFERENT PERIODS IN TRIVENI

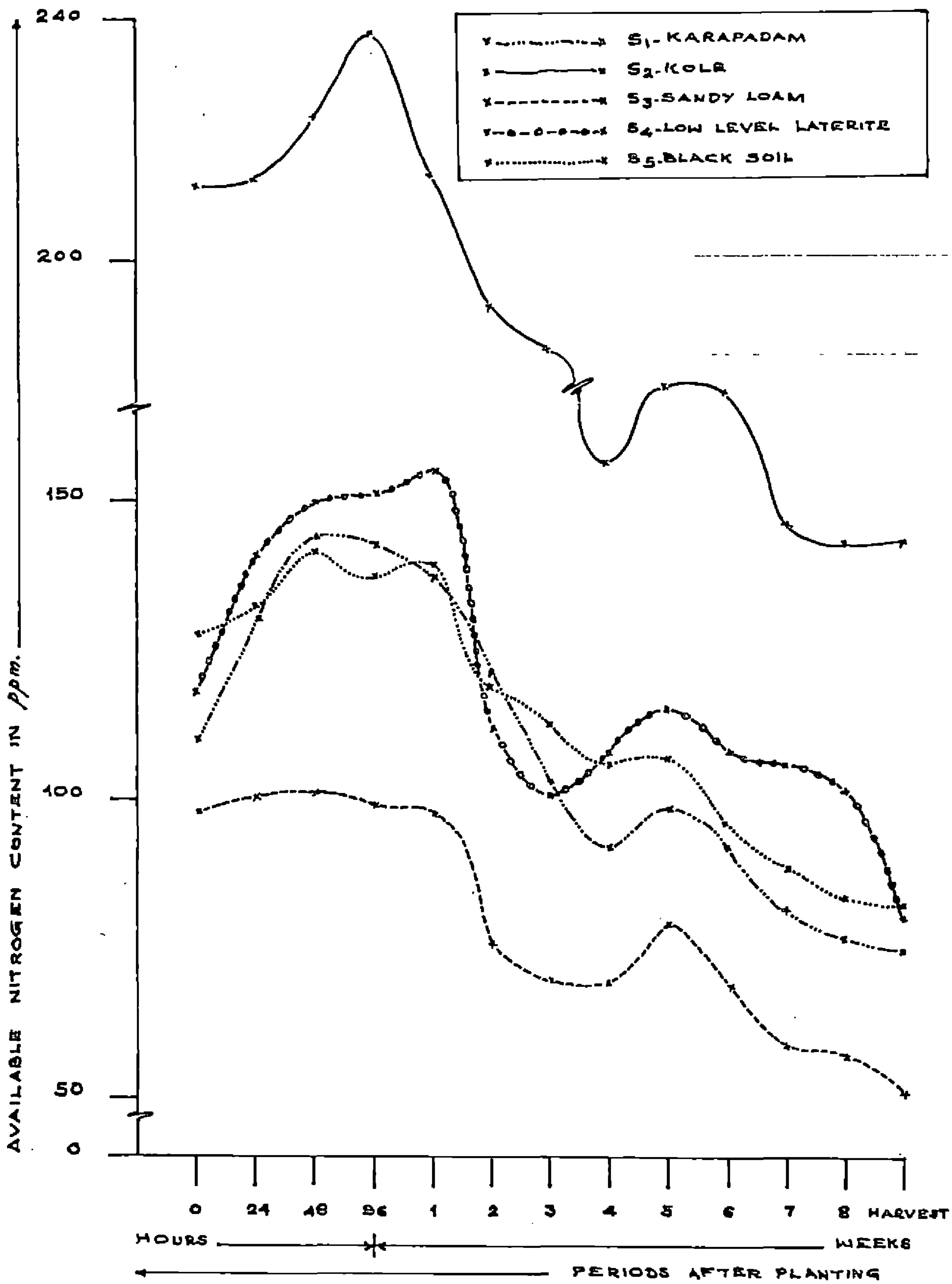


Table 19(b) Mean available nitrogen content (ppm) at different periods in different soils for rice, Triveni

	Periods after transplanting												
	0h	24h	48h	96h	1week	2week	3week	4week	5week	6week	7week	8week	Harvest
Karapadam	110	130	144	143	138	121	103	93	99	93	82	77	75
Kole	212	213	224	238	214	192	185	156	169	168	146	143	143
Sandy loam	98	101	101	99	98	76	70	69	79	69	59	57	51
Low level laterite	118	141	150	151	155	112	101	95	115	108	106	102	81
Black soil	128	132	142	137	139	119	112	106	107	96	89	84	82
CD		2.4	2.3	3.0	2.6	2.7	2.1	1.9	2.7	2.5	3.8	4.3	7.0

In the case of Jaya, among the soil x levels of submergence interaction, in all soils and at all periods the kole soil at 5 cm submergence gave the maximum available nitrogen content followed by kole soil at 10 cm submergence, followed by low level laterite at 5 cm and 10 cm submergence and black soil at 5 cm and 10 cm submergence. The least content was recorded in sandy loam at 10 cm submergence. In the case of Triveni, except at harvest stage the available nitrogen content of soils was markedly affected by soil x levels of submergence interaction. At all periods except 96 hours, 2 and 4 weeks, the highest available nitrogen content was reported in kole soil with 5 cm submergence, while at 96 hours, 2 and 4 weeks, the highest available nitrogen content was found in kole soil with 10 cm submergence among the different combinations. The lowest available nitrogen content was noted with sandy loam with 5 cm submergence at period of 24 hour, whereas at all other periods sandy loam with 10 cm submergence had lowest. In all soils, when the level of submergence alone is considered except at a few periods, the 5 cm submergence registered higher available nitrogen content.

For Jaya, among the soil x nitrogen fertilizer treatment interaction, in all soils and at all periods the ferti-

Table 20(a) Available nitrogen content (ppm) in different soil types as influenced by level of submergence on rice, Jaya and Triveni

Soil type	Level of submergence (cm)	Periods after transplanting												
		0h	24h	48h	96h	1week	2week	3week	4week	5week	6week	7week	8week	Harvest
Karapadam	5	110	135	142	142	139	114	94	89	104	93	81	74	74
	10	110	128	132	131	128	104	90	80	80	84	72	67	74
Kole	5	212	216	223	240	264	171	164	157	157	148	144	138	153
	10	212	215	220	232	250	156	147	140	141	128	126	122	138
Sandy loam	5	98	97	99	105	107	69	64	63	69	65	62	60	52
	10	98	100	97	101	93	63	60	56	65	61	58	57	46
Low level laterite	5	118	139	149	154	160	130	120	114	118	111	106	103	67
	10	118	135	144	149	161	128	114	109	116	106	102	99	67
Black	5	128	130	147	147	157	135	129	120	122	116	109	104	73
	10	128	126	139	140	148	126	118	111	117	110	104	76	72
CD			1.92	3.33	2.39	1.95	2.18	1.70	1.67	5.30	1.54	1.68	2.98	8.7
Mean for 5 cm submergence			143	152	158	165	124	114	109	114	107	100	96	84
10 cm			141	146	151	156	115	106	99	106	98	92	84	79
CD			0.86	1.49	1.07	0.87	0.97	0.80	0.75	2.37	0.69	0.75	0.58	3.93

Table 20(b) Available nitrogen content (ppm) at different periods as influenced by soil type level of submergence on rice var. Triveni

Soil type	Levels of submergence (cm)	Periods after transplanting												
		0h	24h	48h	96h	1week	2week	3week	4week	5week	6week	7week	8week	Harvest
Karapadam	5	110	140	151	143	131	105	95	98	92	92	83	77	70
	10	110	120	136	133	133	110	100	91	99	93	80	76	73
Kole	5	212	215	225	238	216	186	188	153	169	176	150	146	146
	10	212	211	221	250	211	198	182	159	169	169	142	140	140
Sandy loam	5	98	100	101	97	99	81	76	71	81	66	63	58	52
	10	98	102	102	101	96	70	63	66	77	72	56	54	49
Low level laterite	5	118	138	152	155	158	115	102	94	117	112	119	115	82
	10	118	143	147	146	151	109	100	96	119	111	108	105	79
Black soil	5	128	138	154	143	146	124	113	107	112	100	94	90	80
	10	128	125	134	130	132	114	110	110	115	96	90	85	83
CD			1.7	1.7	2.1	1.8	1.9	1.5	1.3	1.9	1.8	2.7	3.0	NS
Mean for 5 cm		..	146.2	156	157	152	127	117	99	111	103	96	92	79
,, 10 cm			140	148	152	145	120	111	104	112	104	91	88	78
CD			0.76	0.74	0.95	0.81	0.84	0.65	0.59	0.85	0.80	1.21	1.36	2.21

Table 21(a) Available nitrogen content (ppm) at different periods as affected by soil type and fertilizer nitrogen application on rice, Jaya

Soil type	Nitrogen application	Periods after transplanting												
		0h	24h	48h	96h	1week	2week	3week	4week	5week	6week	7 week	8week	Harvest
Karapadam	T_0	110	114	119	114	99.2	86	82	78	75	68	65	59	60
	T_1	110	148	155	160	167	133	102	91	122	109	88	81	88
Kole	T_0	212	211	218	231	246	149	143	139	134	130	125	120	134
	T_1	212	220	226	241	268	178	167	158	163	147	145	140	158
Sandy loam	T_0	98	94	91	94	79	55	53	51	47	44	42	38	28
	T_1	98	103	105	112	121	77	71	68	87	82	79	79	66
Low level laterite	T_0	118	109	118	125	132	118	100	93	88	84	79	74	49
	T_1	118	165	175	178	188	140	133	131	145	133	130	128	86
Black soil	T_0	128	117	123	121	128	112	105	93	97	91	86	82	61
	T_1	128	139	163	167	176	149	142	138	143	135	127	122	84
CD			1.92	3.33	2.40	1.95	2.18	1.70	1.67	5.30	1.54	1.68	2.98	8.79

Table 21(b) Available nitrogen content (ppm) at different periods as influenced by soil type and nitrogen application on rice, var. Triveni

Soil type	Nitrogen application	Periods after transplanting												
		0h	24h	48h	96h	1week	2week	3week	4week	5week	6week	7week	8week	Harvest
Karapadam	T_0	110	117	126	122	101	91	76	70	66	62	60	58	63
	T_1	110	143	161	163	107	150	129	116	131	124	103	95	87
Kole	T_0	212	209	222	224	175	149	143	135	132	131	130	129	131
	T_1	212	217	229	240	252	236	226	176	206	197	155	157	155
Sandy loam	T_0	98	95	90	81	71	66	59	58	53	50	47	44	42
	T_1	98	106	112	118	124	85	80	79	104	88	71	70	59
Low level laterite	T_0	118	124	133	132	138	105	94	91	91	84	81	78	70
	T_1	118	157	166	169	171	120	108	99	131	124	116	108	91
Black soil	T_0	128	115	117	110	107	88	76	73	69	63	61	58	69
	T_1	128	148	161	163	171	150	147	134	140	124	109	104	94
CD			1.7	1.7	2.1	1.8	1.9	1.5	1.3	1.9	1.8	2.7	3.0	6.3

Table 22(a) Mean available nitrogen content (ppm) at different periods as influenced by soil type, level of submergence and nitrogen application on rice, var. Jaya

Treatment combinations	Periods after transplanting												
	0h	24h	48h	96h	1week	2week	3week	4week	5week	6week	7week	8week	Harvest
$S_1W_1T_0$	110	111	115	112	101	92	87	85	80	74	72	65	61
$S_1W_1T_1$	110	159	169	173	176	138	100	93	129	111	91	83	86
$S_1W_2T_0$	110	117	123	116	97	80	76	71	64	62	59	53	58
$S_1W_2T_1$	110	138	142	147	159	128	104	89	116	106	85	80	90
$S_2W_1T_0$	212	212	221	237	253	155	149	145	140	137	129	125	138
$S_2W_1T_1$	212	220	227	246	275	188	179	169	174	160	159	151	167
$S_2W_2T_0$	212	211	216	226	239	144	137	133	129	123	121	116	129
$S_2W_2T_1$	212	219	225	239	262	169	156	147	153	134	131	129	148
$S_3W_1T_0$	98	95	91	95	86	59	55	53	50	47	45	41	36
$S_3W_1T_1$	98	99	107	116	128	80	73	73	88	82	80	80	68
$S_3W_2T_0$	98	93	91	94	73	52	50	49	44	41	39	36	30
$S_3W_2T_1$	98	107	104	109	114	73	70	63	87	82	78	78	62
$S_4W_1T_0$	118	111	121	129	136	119	103	96	91	87	81	77	49
$S_4W_1T_1$	118	168	178	180	184	141	137	132	145	135	132	130	84
$S_4W_2T_0$	118	108	115	121	129	117	97	89	85	81	78	72	49
$S_4W_2T_1$	118	163	173	176	193	139	139	130	146	131	127	126	88
$S_5W_1T_0$	128	118	125	123	131	114	107	95	94	90	85	81	59
$S_5W_1T_1$	128	141	170	172	183	155	151	144	150	141	133	127	86
$S_5W_2T_0$	128	110	121	119	127	109	103	92	99	91	87	82	62
$S_5W_2T_1$	128	136	157	161	170	142	133	131	136	130	121	117	82
CD		2.79	4.84	3.48	2.83	3.16	2.46	2.43	7.5	2.19	2.37	2.10	2.43

Table 22(b) Available nitrogen content (ppm) at different periods as influenced by soil type, levels of submergence and nitrogen application on rice, var. Triveni

Treatment combination	Periods after transplanting												
	0h	24h	48h	96h	1week	2week	3week	4week	5week	6week	7week	8week	Harvest
$S_1W_1T_0$	110	115	121	124	104	94	74	68	65	61	58	56	64
$S_1W_1T_1$	110	165	180	279	182	168	136	122	131	124	107	97	85
$S_1W_2T_0$	110	120	131	119	98	89	78	72	67	63	62	59	62
$S_1W_2T_1$	110	121	142	147	170	132	122	111	131	124	99	94	88
$S_2W_1T_0$	212	210	227	230	181	155	142	140	136	134	134	131	132
$S_2W_2T_1$	212	220	233	246	251	231	221	165	202	206	166	161	159
$S_2W_2T_0$	212	207	217	217	170	156	132	130	128	128	126	127	130
$S_2W_2T_1$	212	214	224	233	253	241	232	188	210	205	158	153	150
$S_3W_1T_0$	98	96	91	81	77	71	66	61	57	54	51	46	42
$S_3W_1T_1$	98	103	111	114	121	91	86	81	104	79	75	73	62
$S_3W_2T_0$	98	94	90	81	86	61	53	55	49	47	44	43	41
$S_3W_2T_1$	98	109	114	122	127	80	73	77	105	98	68	67	56
$S_4W_1T_0$	118	122	136	139	141	106	96	92	92	86	83	79	72
$S_4W_1T_1$	118	153	168	171	174	125	109	97	128	122	114	105	92
$S_4W_2T_0$	118	125	130	125	135	104	93	90	90	82	80	77	68
$S_4W_2T_1$	118	161	164	167	168	115	107	101	134	126	113	111	90
$S_5W_1T_0$	128	121	124	119	115	95	76	75	68	61	59	56	70
$S_5W_1T_1$	128	155	183	167	177	153	149	138	139	120	109	105	90
$S_5W_2T_0$	128	108	110	101	99	81	76	71	69	65	62	60	68
$S_5W_2T_1$	128	142	159	159	166	147	145	130	140	127	109	104	98
CD		2.4	2.3	3.0	2.6	2.7	2.1	1.9	2.7	2.5	3.8	4.3	7.0

lizer nitrogen application had increased the available nitrogen content. In the case of Triveni, among the soil x nitrogen application combination, the highest available nitrogen content was noted in kole soil with nitrogen application at all periods and the lowest content was noted in sandy loam without applied nitrogen.

The effect of soil x level of submergence x nitrogen application interaction on available nitrogen was more in kole soil at 5 cm and 10 cm submergence levels with nitrogen. Lowest value was recorded in sandy loam soil at 10 cm submergence without nitrogen for both varieties.

Available phosphorus content of soil

Data on the available phosphorus content of the soils are given in Tables 23 and 25 and the analysis of variance in Appendix VII.

In the case of Jaya the soil type had no significant influence on the available phosphorus content. In the case of Triveni, soil type was found to have significant influence on the available phosphorus content of soils. The maximum value was noted in low level laterite soil. All other soils registered the same values of available phosphorus.

The level of submergence was found to have significant

Table 23 Available phosphorus content (ppm) of the soils after harvest as affected by levels of submergence and fertilizer nitrogen on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Level of submergence		Nitrogen application		Mean	Level of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	11.00	12.00	11.00	12.00	11.50	11.00	12.00	11.00	12.00	11.50
Kole	11.00	14.00	13.00	11.00	12.25	10.00	13.00	12.00	11.00	11.50
Sandy loam	12.00	12.00	13.00	12.00	12.25	12.00	11.00	11.00	12.00	11.50
Low level laterite	12.00	13.00	13.00	11.00	12.25	12.00	14.00	12.00	14.00	13.00
Black soil	11.00	12.00	9.00	14.00	11.50	11.00	12.00	12.00	11.00	11.50
Mean	11.10	12.50	11.65	11.95		11.20	12.40	11.60	12.00	

CD for soils = 0.81
CD for soil x level of-submergence = 1.14
CD for level of submergence = 0.51

CD for soils = 0.52
CD for level of submergence = 0.33
CD for nitrogen application = 0.33
CD for soil x level of-submergence = 0.74
CD for soil x nitrogen-application =

influence on the available phosphorus in both varieties, where 10 cm submergence gave more available phosphorus content. The nitrogen application was found to have no significant influence on the available phosphorus content.

All treatment combinations were found to have significant influence on the available phosphorus content. Among the soil x level of submergence interaction, Jaya variety grown in kole soil under 10 cm submergence registered maximum available phosphorus. Minimum value was noted in kole soil at 5 cm submergence karapadam at 5 cm submergence and black soil at 5 cm submergence. For Triveni, the maximum available phosphorus content was noted with low level laterite at 10 cm submergence and the minimum content was noted at kole soil at 5 cm submergence.

Among the soil x fertilizer nitrogen interaction, for Jaya, black soil with fertilizer nitrogen registered the maximum available phosphorus while the minimum was noted in black soil with no applied nitrogen. For Triveni, the maximum available phosphorus content was noted in low level laterite with nitrogen application and the minimum content was noted in sandy loam soil and karapadam soil both without nitrogen application and kole and black soils with nitrogen application. Among the S x W x T combination for Jaya, the maximum available phosphorus content was noted with black soil at 10 cm submergence and nitrogen application and kole soil at 10 cm submergence and without fertilizer nitrogen application. The least content was noticed in karapadam soil at 5 cm submergence and receiving no applied nitrogen. For Triveni, the maximum available phosphorus content was noted with the treatment combination of low level laterite at 10 cm submergence and nitrogen application and the minimum value was noted with kole soil at 5 cm submergence and nitrogen application.

Exchangeable potassium content of soils

The data on the exchangeable potassium content of soils are given in Tables 24 and 25 and analysis of variance in Appendix VII.

The soil type was found to have significant influence on the exchangeable potassium content in both the rice varieties, wherein black soil recorded the maximum content and sandy loam minimum.

The level of submergence was significant only in the case of Jaya. For Jaya 10 cm submergence was found good regarding the exchangeable potassium content.

Table 24 Exchangeable potassium (ppm) of the soils after harvest as affected by levels of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Levels of submergence		Nitrogen application			Levels of submergence		Nitrogen application		
	W_1	W_2	T_0	T_1	Mean	W_1	W_2	T_0	T_1	Mean
Karapadam	30	28	25	33	29	29	28	27	30	29
Kole	26	28	22	32	27	25	26	22	29	26
Sandy loam	23	25	23	26	24	25	25	23	27	25
Low level laterite	25	26	22	29	26	27	28	24	31	28
Black soil	47	49	43	53	48	48	49	44	52	48
Mean	30.20	31.20	27.00	34.60		31	31	28	34	

CD for soils = 1.71
CD for soil x level of-submergence = 1.21
CD for soil x nitrogen-application = 1.21
Level of submergence = 0.54

CD for soils = 0.7
CD between level of-submergence = 0.4
CD between soil x fertilizer-treatment = 0.9

Table 25 Available phosphorus and potassium content (ppm) of the soils at harvest as affected by levels of submergence and nitrogen application on rice, Jaya and Triveni

Treatment combination	JAYA		TRIVENI	
	Available phosphorus	Exchangeable potassium	Available phosphorus	Exchangeable potassium
$S_1W_1T_0$	8	27	10	28
$S_1W_1T_1$	13	34	12	30
$S_1W_2T_0$	14	24	13	25
$S_1W_2T_1$	11	32	11	31
$S_2W_1T_0$	11	22	11	23
$S_2W_1T_1$	10	30	9	28
$S_2W_2T_0$	16	21	14	21
$S_2W_2T_1$	13	34	13	30
$S_3W_1T_0$	12	22	13	24
$S_3W_1T_1$	13	25	12	27
$S_3W_2T_0$	13	24	10	22
$S_3W_2T_1$	11	27	13	28
$S_4W_1T_0$	13	22	11	23
$S_4W_1T_1$	11	29	13	30
$S_4W_2T_0$	14	22	14	24
$S_4W_2T_1$	12	30	15	32
$S_5W_1T_0$	9	39	12	42
$S_5W_1T_1$	13	55	10	54
$S_5W_2T_0$	9	47	12	46
$S_5W_2T_1$	16	50	11	51
CD	1.61	1.71	1.21	1.32

For both varieties the nitrogen application was found to have a significant increase in the exchangeable potassium content of soils.

Between the soil x level of submergence interaction for the two varieties, black soil at 10 cm submergence produced the highest exchangeable potassium content while the minimum was noticed in sandy loam at 5 cm submergence.

Between the soil x fertilizer nitrogen interaction, for the two varieties, the highest value was noted in black soil with nitrogen application. For Jaya, the lowest content was found in kole and low level laterite without nitrogen application and for Triveni, the lowest content was noted in sandy loam without nitrogen application.

As far as the S x W x T interaction is concerned, for both varieties the maximum exchangeable potassium content was found with the treatment combination of black soil at 5 cm submergence and nitrogen application and the minimum found with kole soil at 10 cm submergence and no nitrogen application.

IV Nitrogen uptake

(i) Nitrogen uptake by grain

The data on the nitrogen uptake by grain are presented

Table 26 Nitrogen uptake by grain (g/pot) in different soil types as influenced by levels of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Levels of submergence		Nitrogen application		Mean	Levels of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	0.260	0.270	0.240	0.290	0.265	0.230	0.226	0.206	0.250	0.228
Kole	0.300	0.290	0.270	0.320	0.295	0.254	0.273	0.235	0.292	0.264
Sandy loam	0.260	0.220	0.210	0.260	0.238	0.208	0.209	0.187	0.229	0.208
Low level laterite	0.300	0.260	0.250	0.300	0.278	0.218	0.205	0.187	0.236	0.212
Black soil	0.300	0.290	0.290	0.300	0.295	0.299	0.264	0.268	0.295	0.282
Mean	0.284	0.266	0.252	0.294		0.242				

CD for soils = 0.018

CD forlevel of submergence = 0.011

CD for nitrogen application = 0.011

CD for soils = 0.015

CD for soil x level of-submergence = 0.022

CD for nitrogen application = 0.01

in Table 26 and 29 and the analysis of variance in Appendix VI.

The nitrogen uptake by grain was maximum and identical with black soil and kole soil. This was followed by low level laterite karapadam and sandy loam. In the case of the variety Triveni, maximum uptake was noted with black soil followed by kole soil, karapadam, low level laterite and sandy loam. Sandy loam and low level laterite were on par.

In the case of Jaya, the nitrogen uptake was found to be more at 5 cm submergence than at 10 cm submergence. In the case of Triveni, 5 cm submergence recorded a higher nitrogen uptake but there was no significant influence.

For both the varieties, the fertilizer nitrogen application had resulted in more uptake.

In the case of Jaya, the treatment combinations soil x level of submergence and soil x fertilizer had no influence on the nitrogen uptake. For Triveni soil x level of submergence interaction was found to have significant influence in the nitrogen uptake. Maximum uptake was noted with the treatment combination black soil at 5 cm submergence, followed by kole soil at 10 cm submergence and the least uptake was in sandy loam at 10 cm submergence. The soil x fertilizer nitrogen interaction was found to have no influence in the uptake of nitrogen in Triveni also.

The soil x level of submergence x fertilizer application interaction was found to influence the nitrogen uptake in Jaya. However, in Triveni, there was no such influence.

(ii) Nitrogen uptake by straw

The data on the nitrogen uptake by straw are given in Table 27 and 29 and the analysis of variance in Appendix VI.

The nitrogen uptake by straw was maximum in black soil followed by low level laterite, kole, karapadam and sandy soil. In the case of the variety, Triveni, the maximum uptake of nitrogen was observed in low level laterite soil followed by kole soil, black soil, sandy loam and karapadam soil.

In the case of Jaya, the nitrogen uptake by straw was more at 5 cm submergence than at 10 cm submergence. In the case of Triveni, more nitrogen uptake was at 10 cm submergence than at 5 cm submergence. In both varieties, the nitrogen application resulted in increased uptake of nitrogen.

Table 27 Nitrogen uptake by straw (g/pot) in different soil types as influenced by levels of submergence and nitrogen application on rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Levels of submergence		Nitrogen application		Mean	Levels of submergence		Nitrogen application		Mean
	W_1	W_2	T_0	T_1		W_1	W_2	T_0	T_1	
Karapadam	0.170	0.150	0.140	0.180	0.160	0.138	0.121	0.108	0.151	0.130
Kole	0.190	0.180	0.150	0.220	0.185	0.161	0.172	0.139	0.195	0.167
Sandy loam	0.140	0.130	0.110	0.160	0.135	0.147	0.138	0.128	0.156	0.142
Low level laterite	0.240	0.200	0.190	0.260	0.223	0.172	0.204	0.172	0.203	0.188
Black soil	0.270	0.260	0.220	0.320	0.268	0.156	0.172	0.137	0.191	0.164
Mean	0.202	0.184	0.162	0.228		0.155	0.161	0.137	0.179	

CD for soils = 0.014
Soil x level of submergence = NS
CD for soil x nitrogen-application = 0.02
CD for level of submergence = 0.009

CD for soils = 0.010
CD for soil x levels of submergence = 0.013
CD for nitrogen application = 0.013
CD for level of submergence = 0.006

In the case of Jaya, the soil x level of submergence interaction was found to have no significant influence on the nitrogen uptake. In the case of Triveni, there was significant influence. Maximum uptake was noted with low-land laterite at 10 cm submergence. Kole at 10 cm submergence, low land laterite at 5 cm submergence and black soil at 10 cm submergence were identical. This was followed by kole soil at 5 cm submergence. The minimum value was noted with karapadam at 10 cm submergence.

In the case of Jaya, soil x fertilizer nitrogen interaction resulted in the maximum uptake in black soil with nitrogen application. This was followed by low level laterite with nitrogen. Kole soil with nitrogen and black soil without nitrogen were equal. The least value was given by sandy loam without nitrogen. In the case of Triveni, the maximum nitrogen uptake by straw was noted with low level laterite soil with applied nitrogen and the minimum uptake was found in karapadam soil without applied nitrogen. The other treatment combinations were found to have no significant influence on the nitrogen uptake by straw.

(iii) Total Nitrogen uptake by the plant

The data on the total nitrogen uptake were presented

Table 28 Total nitrogen uptake by plant (g/pot) as influenced by levels of submergence and nitrogen application in rice, Jaya and Triveni

Soil type	JAYA					TRIVENI				
	Levels of submergence		Nitrogen application			Levels of submergence		Nitrogen application		
	W_1	W_2	T_0	T_1	Mean	W_1	W_2	T_0	T_1	Mean
Karapadam	0.428	0.410	0.368	0.470	0.419	0.365	0.358	0.314	0.408	0.361
Kole	0.490	0.465	0.420	0.535	0.478	0.416	0.445	0.374	0.487	0.431
Sandy loam	0.394	0.351	0.322	0.423	0.373	0.352	0.345	0.313	0.384	0.349
Low level laterite	0.536	0.456	0.432	0.560	0.496	0.390	0.409	0.360	0.439	0.400
Black soil	0.569	0.540	0.496	0.613	0.555	0.455	0.437	0.405	0.486	0.446
Mean	0.483	0.444	0.408	0.520		0.396	0.399	0.353	0.441	

CD for soils = 0.02

CD for level of submergence = 0.01

CD for soil x level of-submergence = 0.029

CD for soils = 0.01

CD for soil x level of-submergence = 0.015

CD for soil x nitrogen-application = 0.015

in Tables 28 and 29 and the analysis of variance in Appendix VI.

The maximum uptake in the case of Jaya was noted with black soil followed by low level laterite soil, kole soil and the least value was noted with sandy loam soil. In the case of Triveni, the maximum uptake was in the black soil followed by kole, low level laterite, karapadam and sandy loam soil.

In the case of Jaya, the uptake was more at 5 cm submergence than at 10 cm submergence. In the case of Triveni the level of submergence was found to have no significant influence on the total nitrogen uptake.

In the case of Jaya, the soil x water level interaction had resulted in the maximum uptake with black soil at 5 cm submergence followed by black soil at 10 cm submergence, low level laterite at 5 cm submergence and the least value was noted with sandy loam at 10 cm submergence. In the case of Triveni, the maximum uptake was noted with black soil at 5 cm submergence, followed by kole soil at 10 cm submergence, black soil at 10 cm submergence and the least with sandy loam at 10 cm submergence.

In the case of Jaya, the soil x nitrogen application

FIG. 3. TOTAL UPTAKE OF NITROGEN IN DIFFERENT SOILS BY JAYA

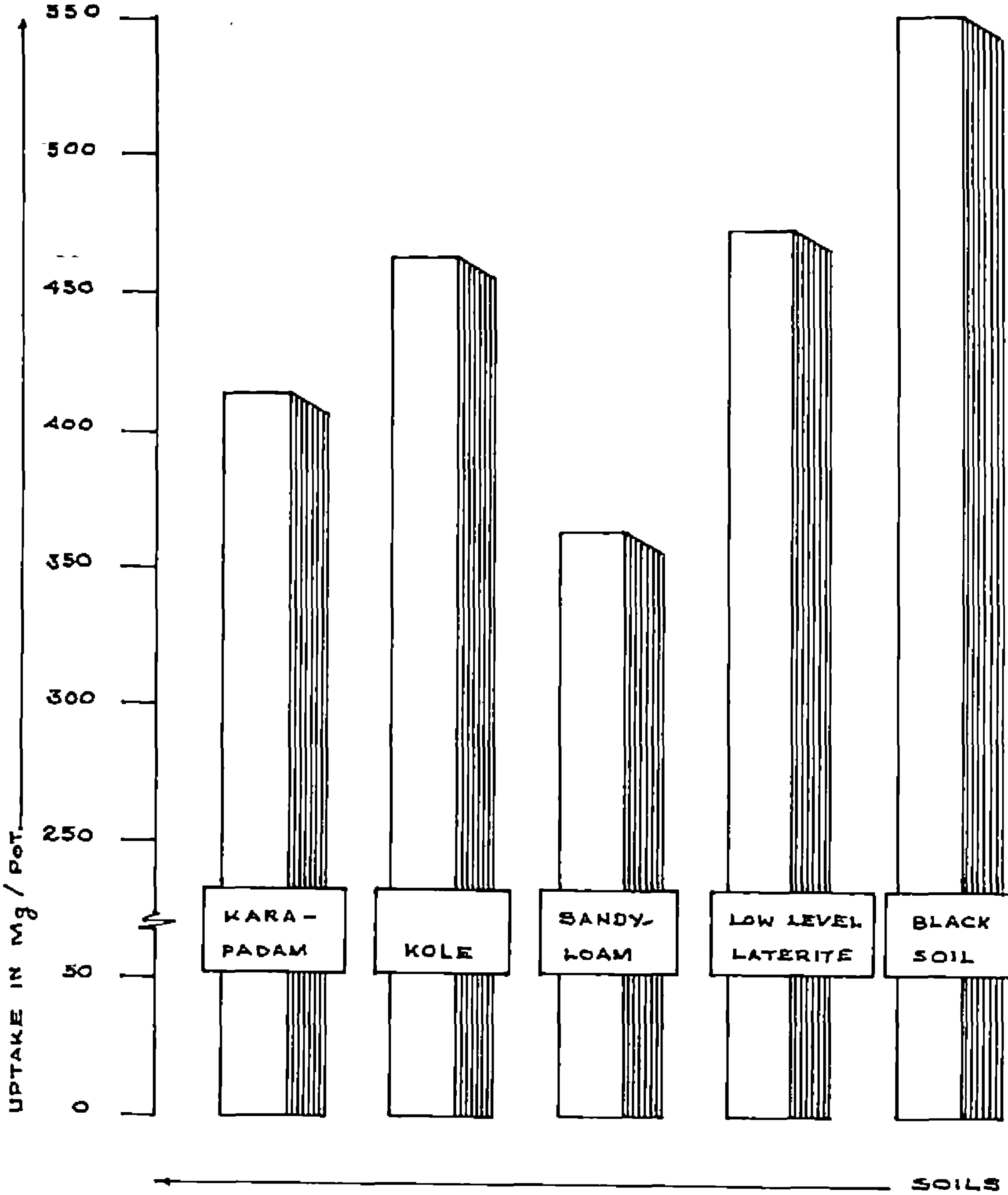
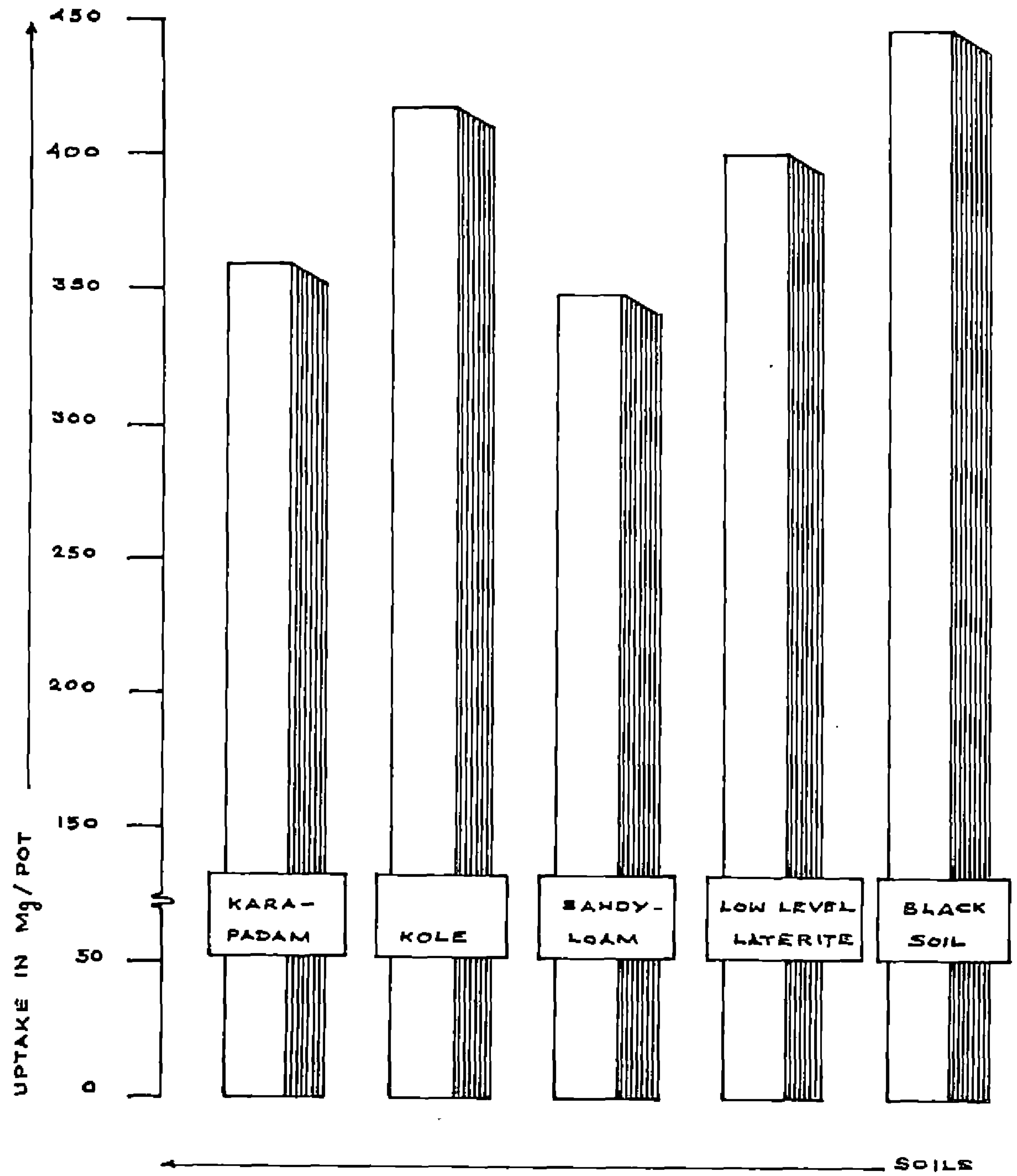


Table 29 Uptake of nitrogen (g/pot) as influenced by soil type, level of submergence and nitrogen interaction on rice, Jaya and Triveni

Treatment combinations	JAYA			TRIVENI		
	Grain uptake	Straw uptake	Total uptake	Grain uptake	Straw uptake	Total uptake
$S_1W_1T_0$	0.218	0.145	0.363	0.205	0.113	0.318
$S_1W_1T_1$	0.294	0.190	0.494	0.256	0.162	0.413
$S_1W_2T_0$	0.262	0.132	0.374	0.208	0.104	0.311
$S_1W_2T_1$	0.277	0.169	0.446	0.244	0.140	0.404
$S_2W_1T_0$	0.262	0.160	0.424	0.228	0.130	0.354
$S_2W_1T_1$	0.337	0.219	0.556	0.281	0.193	0.474
$S_2W_2T_0$	0.280	0.136	0.415	0.243	0.148	0.391
$S_2W_2T_1$	0.299	0.215	0.514	0.304	0.196	0.500
$S_3W_1T_0$	0.224	0.111	0.335	0.194	0.135	0.324
$S_3W_1T_1$	0.280	0.163	0.452	0.221	0.158	0.379
$S_3W_2T_0$	0.205	0.105	0.309	0.181	0.121	0.302
$S_3W_2T_1$	0.246	0.148	0.394	0.237	0.155	0.389
$S_4W_1T_0$	0.284	0.202	0.484	0.198	0.153	0.351
$S_4W_1T_1$	0.310	0.278	0.588	0.239	0.190	0.429
$S_4W_2T_0$	0.219	0.162	0.381	0.177	0.191	0.369
$S_4W_2T_1$	0.298	0.233	0.531	0.233	0.217	0.450
$S_5W_1T_0$	0.293	0.222	0.515	0.283	0.122	0.403
$S_5W_1T_1$	0.306	0.318	0.623	0.316	0.190	0.506
$S_5W_2T_0$	0.275	0.202	0.477	0.255	0.153	0.407
$S_5W_2T_1$	0.291	0.313	0.603	0.274	0.193	0.466
	0.03	0.29	0.041	NS	NS	0.02

FIG. 4. TOTAL UPTAKE OF NITROGEN IN DIFFERENT SOILS BY TRIVENI



was found to have no influence on nitrogen uptake. In Triveni the maximum uptake was noted with kole soil with nitrogen which was significant. This was closely followed by black soil with nitrogen. The least value was recorded in sandy loam without nitrogen and this was on par with karapadam with no nitrogen. The soil x level of submergence x nitrogen application interaction was also found to have significant influence on the total nitrogen uptake. The total nitrogen uptake was maximum in black soil at 5 cm submergence and with nitrogen application which was followed by black soil at 10 cm submergence with nitrogen application. The lowest value of the uptake was noted with sandy loam at 10 cm submergence and without nitrogen.

V Recovery of nitrogen

Data on the recovery of fertilizer nitrogen are given in Table 30 and their analysis of variance in Appendix VIII.

In the case of Jaya, recovery of nitrogen differed from soil to soil. The recovery of fertilizer nitrogen was highest at low level laterite soil which was on par with black soil and kole soil. Karapadam soil was on par with kole. The lowest recovery was from sandy loam soil. In the case of Triveni, the recovery was highest with kole soil followed by karapadam soil. The low level laterite, black soil and sandy loam were on par.

Table 30 Recovery of applied nitrogen (per cent) as influenced by soil type and level of submergence for rice, Jaya and Triveni

Soil type	JAYA			TRIVENI		
	Levels of submergence			Levels of submergence		
	W_1	W_2	Mean	W_1	W_2	Mean
Karapadam	38.68	21.32	30.00	36.19	35.43	35.81
Kole	38.83	29.12	33.98	44.57	41.73	43.15
Sandy loam	34.41	24.85	29.63	20.95	33.14	27.05
Low level laterite	30.73	44.26	37.50	26.17	30.86	28.52
Black soil	31.91	37.21	34.56	34.64	22.48	28.56
Mean	34.91	31.35		32.50	32.73	

CD for soils = 4.39

CD for soil x level of-submergence = 6.21

CD for level of-submergence = 2.78

CD for soils = 4.03

CD for s x w = 5.70

CD for level of-submergence = 2.50

In the case of Jaya, 5 cm level of submergence gave significantly higher recovery than 10 cm submergence while in Triveni the values were on par. Among the soil x level of submergence interaction, highest recovery was by low level laterite soil at 10 cm submergence, which was on par with the karapadam soil at 5 cm submergence and kole soil at 5 cm submergence. S_1W_1, S_2W_1, S_3W_1 and S_5W_2 were on par. The lowest recovery rate was given by karapadam soil at 10 cm submergence which was on par with sandy loam at 10 cm submergence. In the case of Triveni, among the soil x level of submergence interaction the highest recovery was given by kole soil at 5 cm level of submergence, which was on par with kole soil at 10 cm submergence. S_1W_1, S_1W_2, S_3W_2 and S_5W_1 were on par. The lowest recovery was given by sandy loam at 5 cm submergence.

DISCUSSION

DISCUSSION

In Kerala, rice is grown under different soil conditions and under varying water regimes. Several high yielding varieties have also been brought under cultivation during the recent years. However, only general recommendations of 90 kg N and 70 kg N/ha are given for medium duration and short duration varieties, respectively without considering soil type and water regimes. The information on the ability of the different soil types in the utilization of water for plant growth and its productivity is also not enough, except that a general recommendation of 5 cm level of water for rice during its active growth periods. It is quite reasonable that the availability of nutrients especially nitrogen would be influenced largely by soil type and irrigation levels. Hence, the present set of investigation on the nitrogen balance of the different soil types of Kerala was conducted to decide on the extent of utilization of nitrogen by two rice varieties of differing duration under varying soil types and irrigation levels. The individual effect as well as the cumulative effect of all these three factors viz. soil type, irrigation level and nitrogen on growth and productivity of each of medium duration and short duration rice varieties are discussed.

I Influence of soil type submergence level and nitrogen application on growth and yield of rice

1. Plant height

Plant height in rice is influenced primarily by genetic and environmental factors. Hence within a single variety, the effect of soil, nitrogen and irrigation could be realised. In the present study, soil type was found to influence the growth of rice plants (Table 2(a). Maximum plant height at all stages in Jaya and at tillering stage in Triveni was observed in karapadam soil. However, in Triveni, kole soil has produced the maximum plant height at panicle initiation, flowering and harvest stages. Both karapadam and kole soils have recorded inherently higher nitrogen status than other soils as was evidenced by the initial soil analysis. As nitrogen has a major role in influencing the vegetative growth of rice, probably high initial nitrogen content of karapadam and kole soils might have augmented the plant height in these soils. (Ramamoorthy and Velayudham 1976). In the case of Triveni, kole soil showed its superiority in the later stages after tillering. Sandy loam soil has produced minimum plant height at tillering in Jaya and at all stages in Triveni. Compared to all other soils, sandy loam is poor in most of the nutrients and the minimum height thus recorded is in agreement with the poor productivity of the soil.

Irrigation levels also influenced the vegetative growth of rice. In the medium duration variety Jaya, 10 cm level resulted in maximum height at tillering and panicle initiation stages whereas 5 cm level produced maximum height at flowering and harvest stages. However, in the case of Triveni, 5 cm level was superior over 10 cm level at all stages in increasing plant height. Vamadevan (1971) has indicated that at lower atmospheric temperature, increased waterdepth gave taller plants in rice. Increased vegetative growth due to deep submergence has also been reported by Senewiratne and Mikkelsen (1961). On the contrary shallow submergence of 5 - 7.5 cm was found superior by Ghidiyal and Jana (1967).

The present investigation also revealed certain interaction effects of soil type and irrigation level on plant height. Karapadam soil with 5 cm water level was found to produce maximum plant height at all stages in Jaya, variety. But in Triveni, only at tillering stage, karapadam with 5 cm level was superior; at panicle initiation, flowering and harvest stages, kole soil with 5 cm level was better than others in increasing plant height. The inferior nutrient status effect of sandy loam soil in the minimum plant height was also expressed in interaction of soil type and irrigation levels.

Nitrogen fertilization has been established to influence the vegetative growth of rice plants (Alexander et al 1974, Gunasena et al 1979; Sushamakumari, 1981). In the present investigation also, positive effect of N fertilization on plant height was noticed. Among different soil x fertilizer combinations in Jaya, black soil, karapadam and kole soil receiving 90 kg N, resulted in more plant height at tillering and black soil receiving 90 kg N, resulted in more plant height at tillering and black soil receiving no nitrogen produced the shortest plants. In Triveni the superiority of black soil with nitrogen utilization was also noticed at tillering stage.

When we consider cumulative effect of soil type, irrigation and nitrogen levels together on plant height black soil and kole soil with 10 cm irrigation level and nitrogen application resulted in more plant height at tillering stage than rest of the combinations in Jaya variety. However, at panicle initiation, flowering and harvest stages, karapadam soil receiving 5 cm irrigation and nitrogen produced the maximum height, it is thus clear that in karapadam soil, increase in plant height at later stages was more than in other soils including black soil and kole soil. In the case of Triveni, kole soil with 5 cm irrigation level and nitrogen application resulted in the maximum plant height than other combinations at all stages. Usefulness of deep submergence on vegetative growth was emphasized by Senewiratne and Mikkelsen (1961). Internode elongation in response to increasing water depth was also reported by IRRI (1968). On the contrary, Ghildiyal and Jana (1967), Singh and Pande (1973) reported shallow submergence 5 to 7.5 cm to be superior to deep submergence. In all soil types, nitrogen application was found to result in higher plant heights than with no nitrogen application.

2. Tiller count

Soil type has also influenced the growth characters ie., total tiller counts. It was found that in the variety Jaya all the three heavy soils viz. karapadam, kole and black soils produced maximum tiller counts at all stages. On the other hand, sandy loam and low level laterite soils were poor in tiller production which may be attributed to their poor nitrogen status. In the case of Triveni also, heavy soils have produced maximum tiller counts, kole soil occupying the first position in mean tiller number. Here again, sandy loam has produced the lowest tiller count. The better growth of rice plants grown in these soils may be due to the high nitrogen content associated with these soils. In addition, submergence generally causes an increase in the pH of the soil (Ponnamperuma 1972). The increased pH resulting from submergence might also have contributed towards the increased tiller count. The lesser tiller count observed in sandy loam and low level laterite in Jaya and sandy loam in Triveni has to be attributed to the inherently poor productivity and fertility status association with these soils. The findings are in agreement with the results of Venugopal and Koshy (1976).

Whereas the levels of submergence did not affect the tiller count, soil x level of submergence combination has influenced this character in rice. This was also reported by Sivanappan et al (1974) Sahu and Misra (1974). However, the effect of interaction varied in different soils and at different stages of plant growth. In fact in both Jaya and

Triveni rice varieties, all the heavy soils in combination with 5 cm or 10 cm levels of submergence produced the maximum tiller number at different growth stages. The results indicated that the influence of water on tiller count depends on soil type and stage of growth of plant. Hence the optimum amount of water for different soil types have to be worked out by programming detailed investigation on these lines.

Nitrogen application significantly influence the production of tillers in Jaya and Triveni varieties of rice. Black soil with applied nitrogen has produced the maximum tiller count at flowering and harvest stage in Jaya. In both stages nitrogen applied plant recorded more tiller count. For Triveni, significant effect of soil x nitrogen was noticed at tillering and flowering stages. However, in low level laterite soil, there was no significant difference between nitrogen applied and not applied plants.

Interaction of soil x level of submergence x nitrogen application was pronounced only in Jaya and that too at flowering and harvesting stages. Karapadam and black soils with 5 cm level of submergence and nitrogen application produced increased tiller counts at flowering stage. At harvesting stage, kole and black soil with 10 cm level of submergence and with N application recorded the maximum tiller count. Incidently kole and black soil at 10 cm submergence recorded the highest recovery and uptake of nitrogen by the plant.

3. Productive tiller count

For Jaya, the maximum productive tiller count was noted in black soil, and while for Triveni, the kole soil recorded the highest productive tiller count. This may be due to the high nitrogen supplying capacity of these soils. The nitrogen supplying capacity of black soil & kole soils seems to be relatively larger than other soils. It may be due to the presence of high clay (montmorilonite type) and organic matter content. It is also rich in all other major nutrients (Table 1). For both the varieties, the lowest productive tiller count was recorded in sandy loam soils. The sandy loam is poor in nutrient supplying capacity and nutrient status (Table 1).

The submergence levels has got no significant influence on productive tiller count. Similar results are reported by Shanmugasundaram and Morachan (1974) and Mane & Dastane (1971). Among the soil x level of submergence interaction black soil at 5 cm submergence recorded the highest productive tiller count. This can be attributed to more availability of nitrogen at 5 cm submergence in black soil. At panicle initiation stage available nitrogen content of black soil at 5 cm was found to be 104 ppm while for 10 cm submergence it is only 76 ppm. In all soils, the nitrogen application has resulted in increased productive tiller count. This was in agreement with the findings of Muthuswamy (1972), Subramonian and Kolandaiswamy (1973), Murthy & Murthy (1981). For, both the varieties the treatment combination soil x level of submergence x nitrogen application was found to have no significant effect on the productive tiller count. The significant effect of soil type and applied nitrogen on the productive tiller count and the non-significance of level of submergence have already been reported. It was also seen that level of submergence x applied nitrogen interaction was not affecting productive tiller count. These want of significance may be responsible for absence of influence of soil type x level of submergence x nitrogen application interaction.

4. Panicle length

In the case of Jaya, the maximum panicle length was noted in low level laterite which was followed by black soil and karapadam soil and the minimum panicle length was noticed in sandy loam soil. Though the available nitrogen content of low level laterite is comparatively less than that of kole soil, the recovery of nitrogen was the highest in low level laterite. In the case of Triveni the highest panicle length was noticed in kole soil. This can be attributed to the highest available nitrogen content and the largest recovery of nitrogen in the kole soil. The lowest panicle length was noticed in sandy loam. The nitrogen content was also the lowest in sandy loam. The submergence has got no significant influence on panicle length. Among the soil x level of submergence interaction, the maximum panicle length was noted in low level laterite at 5 cm submergence for Jaya, while for Triveni it was kole soil at 5 cm. For Jaya, low level laterite recorded the highest recovery of nitrogen while for Triveni, kole soil recorded the highest recovery. For both the varieties the minimum panicle length was noted in sandy loam at 5 cm submergence. This can be attributed to the lowest available nitrogen status of sandy loam soil. From the results it is observed that in all soils, the nitrogen application has contributed to panicle length. This had been previously reported by many other workers like Lenka (1969) Singh (1971), Subbiah et al (1979). The interaction of the soil x level of submergence x nitrogen application was found to have no effect on panicle length in both the varieties. This may be due to the insignificant response of level of submergence.

Thousand grain weight

Thousand grain weight in Jaya variety was found to be influenced by different treatments and their combinations. The soil type was found to have significant influence on the thousand grain weight in Jaya while there was no influence in Triveni. In Jaya, the maximum was observed in kole soil which was on par with black soil and karapadam soil and the minimum was noted in sandy loam and low level laterite soil. Thousand grain weight in kole soil was high due to high available nitrogen in the soil. Also the nitrogen uptake by grain and recovery of nitrogen were high in kole, black and karapadam soils. This might have contributed to higher thousand grain weight. The submergence levels had no effect on the thousand grain weight in both the varieties. Similar results were obtained by Sivanappan _et al_ (1974).

5. Grain yield

In the case of Jaya the maximum grain yield was noted in low level laterite and kole soil while for Triveni, the maximum yield was in kole soil. In both cases, the productive tiller count, panicle length and thousand grain weight were high which has naturally resulted in increased grain weight. For both Jaya and Triveni, the minimum grain yield was obtained in sandy loam soil. The yield contributing characters were also minimum in sandy loam soil, which may account for the low yield in sandy loam soil. Level of submergence as in the case of other yield attributes, failed to show any significant effect on the grain yield. The non-response of irrigation levels on yield has been reported by many other workers viz; Sivanappan (1974), Sahu and Misra (1974) and Jha and Asthana (1978). The different treatment combinations were also found to have no significant effect on the grain yield. Nitrogen fertilizer application increased grain yield in rice considerably. This finding is in agreement with the findings of Bhuiya _et al_. (1979) and Gunasena _et al_ (1979) Kupukanachanakul and Vergera (1980).

6. Straw yield

Yield of straw which is one of the economic vegetative characters in rice, was influenced by soil type, level of submergence and nitrogen application. Among the soil types tried, kole soil followed by black soil produced the maximum yield of straw in Jaya variety. However, in Triveni variety, kole followed by black and karapadam resulted in increased straw production. In both the varieties, sandy loam soil has produced the lowest straw yield. Among the levels of submergence, superiority of 5 cm level was observed over 10 cm level in the increased production of straw was observed only in the Triveni variety. Nitrogen application in both varieties produced significant difference in straw yield over no nitrogen application. Venkateswaralu (1978), Sushamakumari (1981) and Surendran (1985) have observed positive response to nitrogen application on straw yield in rice. Analysis of effect of treatment combination also showed some interesting results. Kole soil with 5 and 10 cm levels of submergence and nitrogen application and black soil with 5 cm level of submergence and nitrogen application recorded maximum straw yield in Jaya. In Triveni, kole soil with 5 cm level of submergence and nitrogen application was the best over other combinations. The interaction effects clearly indicate the relative importance of different management practices (Irrigation levels and nitrogen application) to be adopted under different soil types. Probably in kole and black soils, inherent content of various nutrients and utilization ability might have augmented the straw yield of rice in contrast to sandy soil.

II Influence of soil type, submergence level and nitrogen application on nitrogen content of soil and plant

a. Available nitrogen in the soil

Shiga and Ventura (1976) have mentioned that available nitrogen in the soil plays a crucial role in growth and yield of rice plants. Also the available nitrogen in the soil is an indication of mineralization of soil nitrogen (Anon, 1974). In the present study, analysis of different soil types for their nitrogen content revealed varying trends in the nitrogen content of the soil during the growth stages of rice plant. It was found that during the first week of rice growth, increase in available nitrogen was noticed. Thereafter in the second week a decrease in nitrogen content was observed and this decrease continued till the end of fourth week. Again, during the fifth week of planting increasing trend in available nitrogen content was observed which was followed by a continued decrease till the harvest stage. The initial increase in available nitrogen during the first week and during the fifth week can be attributed to the application of nitrogen fertilizers as basal dressing at the time of planting and as top dressing at the panicle initiation stage respectively. The above mentioned varied trend in nitrogen availability partially agrees with the reports of Loganathan and Rao (1973) and Highuchi and Uchida (1984). The variations noticed can be due to the difference in the soil type and varieties of rice used in the present study.

Comparison of available nitrogen in different periods of plant growth, revealed the inherent superiority of certain soil types of Kerala over others. For both the varieties kole soil followed by low level laterite recorded the higher available nitrogen content. Sandy loam soil was poor in available nitrogen content with respect to both varieties. The purpose of water management in rice is to ensure a good growing environment near the root zone and to control the supply of soil nitrogen. Positive and negative influences of water on the nitrogen mineralization of rice soils have been reported, eventhough the product of mineralization in flood water is ammonium ion. In this study recommended practice of 5 cm submergence was found to be better with regard to nitrogen availability than 10 cm level for both varieties. Probably 5 cm level would be better for increased mineralization of nitrogen than 10 cm or 10 cm has some adverse effect on the availability of nitrogen (Broadbent, 1979). Nitrogen application also increased the available nitrogen content of soil for both varieties. In this event, nitrogen application had a better effect in increasing the available nitrogen content than no nitrogen situation (Westerman and Kurtz, 1973, Mathen et al 1976).

Among the treatment combination effects, kole soil with 5 cm level of submergence and nitrogen application recorded the highest available nitrogen content as compared to others and sandy loam soil with 10 cm level of submergence and without nitrogen application recorded the lowest. The inherent superiority of kole soil coupled with increased mineralization must have resulted in the increased nitrogen content.

b. Plant nitrogen content at different periods

Analysis of plant nitrogen content at different periods of rice growth showed some varied results. For Jaya variety karapadam soil showed the highest estimates in 10 days and 20 days after planting. However, at 30 days, 60 days after planting and at harvest time, maximum content was analysed in kole soil, whereas in Triveni, kole soil showed the highest plant nitrogen content at 10, 20, 30 and 60 days after planting, karapadam and black soil recorded the highest estimates at harvest. All these three soils are inherantly rich in nutrient status which may be responsible for these results. The varied influence noticed may be due to the difference in the nutrient availability and nitrogen mineralization of soil types. The interaction of soil, level of submergence and nitrogen application was also significant on plant nitrogen content and this indicate their cumulative effect on nitrogen use efficiency. Nitrogen application alone also showed significant effect on plant nitrogen content and total nitrogen uptake as compared to no application of nitrogen, and this effect is quite expected in rice where inorganic fertilization contributes sizeably to the nitrogen content in plants. Khan and Pathak (1976) Yoshida and Padre (1977) Rai and Murthy (1979) and Talha *et al* (1981) have reported similar findings.

c. Nitrogen content and uptake of grain

Analysis of nitrogen content as well as nitrogen uptake in grain has shown some indications on the role of nitrogen in grain yield, under varying soils, water levels and nitrogen application. In both rice varieties, black and kole soils showed higher estimates for nitrogen content and nitrogen uptake of grain. However, only kole soil has resulted in higher yield of grain, which indicates that nitrogen alone may not be solely responsible for the increase in grain yield.

Only in Jaya variety, level of submergence showed some influence viz., 5 cm level having better effect than 10 cm level on the nitrogen content and uptake of grain.

Fertilizer nitrogen application has been reported to increase the nitrogen uptake by rice grain (Khan and Pathak, 1976 Talha et al 1981). In the present investigation also such a trend was observed in the grain uptake of nitrogen. However, nitrogen application did not show any significance on the nitrogen content of grain in Jaya variety and also showed a inverse relationship in Triveni variety. Here the nitrogen application resulted in a significant increase of yield than the control. Since is the control, the yield was low, the nitrogen take up got accumulated in that limited portion and had resulted in an high content of nitrogen. This can be explained on the basis of inverse nitrogen yield concept which says that the yield of a crop is inversely proportional to its nitrogen content (Wilcox, 1954). Since nitrogen uptake is obtained by multiplying the nitrogen content with yield, even if nitrogen content is low or at the same level a high yield would result in a high nitrogen uptake.

d. Nitrogen content and uptake of straw

Straw nitrogen content and uptake were also influenced by soil type, submergence level and nitrogen application. In the case of Jaya, black and low level laterite and in the case of Triveni, low level laterite resulted in the increased nitrogen content of straw. These soil types also produced corresponding results for nitrogen uptake by straw. Incidently these soil types have produced higher yield of straw also.

In Jaya variety 5 cm level of submergence resulted in higher nitrogen content of straw whereas in Triveni 10 cm level was better for increasing the straw nitrogen content.

A similar trend was observed for nitrogen uptake by straw as influenced by submergence level. Probably, the difference in the duration of two varieties, Jaya and Triveni, may be responsible for this varied influence of submergence level. The effect of nitrogen application on nitrogen content of straw and nitrogen uptake by straw was almost similar to grain nitrogen content and grain uptake. Nitrogen application resulted in less nitrogen content of straw than control in both varieties. On the other hand, nitrogen uptake in both varieties increased with nitrogen application. This was mainly because of the part that nitrogen application has increased the straw yield. In the control the dry matter production was less than the treated. So the nitrogen taken up got accumulated in those parts and resulted in a high nitrogen content of straw. But in the case of treated plants the yield was high, so the nitrogen content was low. This may be explained by the inverse - nitrogen yield concept which says that the yield of a crop is inversely proportional to its nitrogen content (Wilcox 1954). Since uptake is the product of nitrogen content and yield, a high yield could have resulted in increased uptake of nitrogen by straw. Nitrogen content and uptake of nitrogen by straw in both varieties was also influenced by soil type x level of submergence interaction which indicates their cumulative effect on the nitrogen absorption by straw.

e. Recovery of nitrogen by rice

The mean recovery of fertilizer nitrogen by rice plants ranged from 20 to 45 per cent among different treatments. These estimates are found to be within the range reported by earlier workers (Patnaik and Broadbent, 1967; Koyama, 1973; Ayatode 1980). Soil type, level of submergence and their interaction have influenced the nitrogen recovery. Among the soil types, low level laterite, black and kole soils were on par with regard to the variety of nitrogen by Jaya variety. However, in Triveni, kole was the first, showing maximum recovery. Level of submergence influenced the recovery of nitrogen only on Jaya variety, 5 cm level being better than 10 cm level. In the treatment combination in Jaya, the mean recovery was found to range between 29.63 to 37.3 per cent. Maximum recovery of nitrogen of 44.26 per cent was observed in low level laterite at 10 cm submergence level followed by karapadam and kole soils each at 5 cm submergence. Least nitrogen recovery was recorded in sandy loam at 10 cm submergence. However, the Triveni variety, the mean recovery of nitrogen ranged from 28.56 to 43.15 per cent. The maximum recovery of 44.57 per cent was noted in the kole soil at 5 cm submergence followed by karapadam soil and the least value of 20.95 per cent was noted in sandy loam at 5 cm submergence. All these results indicate the inherent superiority of certain soil types and irrigation levels on the nitrogen recovery by rice plants, which should be given importance in the management practices involving such combinations.

III Influence of soil type, submergence level and nitrogen application on Phosphorus and Potassium content of grain and straw

Analysis of phosphorus content in grain and straw under different treatments has shown some indications on the influence of soil type and nitrogen fertilization on the phosphorus content. In the case of Jaya, black and kole soils resulted in the highest content of phosphorus in grain and straw respectively. But in Triveni variety, kole soil resulted in the highest phosphorus content of grain and straw. All these soil types are having more phosphorus content and capacity to supply to the plants, probably due to less fixation than other soil types.

Inorganic nitrogen application affected the phosphorus content of grain and straw positively. It has been reported that the presence of high concentration of rapidly absorbable cations like NH_4^+ increases the phosphorus uptake by plants (Ramamoorthy & Velayudham 1976). In the present study also, nitrogen fertilization of rice plants might be increasing the NH_4^+ ion concentration in the submerged conditions, thereby increasing the phosphorus uptake and higher content of phosphorus in grain and straw.

Grain and straw potassium were also influenced by soil and nitrogen fertilizer and their interaction. Black and kole soils have recorded higher grain and straw potassium contents. These soils have higher potassium content in them than other soils and under optimum potassium fertilization they would be supplying the plants with enough potassium resulting in higher content of potassium in grain and straw. Nitrogen fertilization also resulted in increasing the potassium content of grain and straw. It has been reported that if the supply of available potassium is low, the use of nitrogen or phosphorus might produce potassium deficiency symptoms (Ramamoorthy and Velayudham 1976). But since recommended potassium fertilization has been done in the present study such a trend can not be expected. On the contrary, nitrogen fertilization has augumented the potassium content of grain and straw, indicating a positive interaction between nitrogen and potassium.

Balance sheet of nitrogen

Quantitative data relating to the nitrogen resources of the soil after nitrogen fertilizer application, the extent of nitrogen consumed by the plant and the balance of nitrogen left over in the soil after harvest are presented in Table

Table 31(a)

Balance sheet for the utilization of applied nitrogen in different soils at different levels of submergence in Jaya (mg/pot)

Particulars	Karapadam		Kole		Sandy loam		Low level laterite		Black soil	
	5 cm	10 cm	5 cm	10 cm	5 cm	10 cm	5 cm	10 cm	5 cm	10 cm
Initial total nitrogen	9750	9750	12000	12000	7500	7500	11250	11250	14250	14250
Fertilizer nitrogen added	338	338	338	338	338	338	338	338	338	338
Total (A)	10088	10088	12338	12338	7838	7838	11588	11588	14588	14588
Residual nitrogen in the soil at harvest	9584	9628	11741	11780	7372	7427	10983	11033	13944	13957
Crop uptake	494	446	556	514	452	394	588	531	623	603
Total (B)	10078	10074	12297	12294	7824	7821	11571	11564	14567	14560
Unaccounted loss	10	14	41	44	14	17	17	24	21	28
(A-B)	(3%)	(4.14%)	(12.1%)	(13%)	(4.14%)	(5%)	(5%)	(7.1%)	(6.2%)	(8.3%)

The difference between the total nitrogen content of the soil and the nitrogen content of the plant parts including the grain nitrogen is given in the Table as unaccounted loss of nitrogen. These data were computed to assess the rate of efficiency of applied nitrogen under varying soil conditions and submergence levels with respect to short duration (Triveni) and medium duration (Jaya) rice varieties. The data revealed that the unaccounted losses of nitrogen for the Jaya variety varied from 44 mg and 10 mg per pot, while the value for Triveni ranged between 32 mg and 6 mg per pot. Among the five soils used kole soil showed the highest nitrogen loss in both the rice varieties. Between the two levels of submergence 10 cm submergence resulted in more loss of nitrogen than 5 cm level. It is seen from Table that kole soil under 10 cm level of submergence experienced maximum loss of 44 mg nitrogen per pot (13 per cent of applied nitrogen) for the Jaya variety while the same soil under 10 cm level of submergence indicated maximum loss of 32 mg nitrogen per pot (12.2 per cent of applied nitrogen) for the Triveni variety. Minimum loss of 10 mg nitrogen per pot (3 per cent of of applied nitrogen) was noted for Jaya variety grown in the karapadam soil under 5 cm submergence and 6 mg (2 per cent

Table 31(b)

Balance sheet for utilization of applied nitrogen in different soils at different levels of submergence in Triveni (mg/pot)

Particulars	Karapadam		Kole		Sandy loam		Low level laterite		Black soil	
	5 cm	10 cm	5 cm	10 cm	5 cm	10cm	5 cm	10 cm	5 cm	10 cm
Initial total nitrogen	9750	9750	12000	12000	7500	7500	11250	11250	14250	14250
Fertilizdr nitrogen added	263	263	263	263	263	263	263	263	263	263
Total (A)	10013	10013	12263	12263	7763	7763	11513	11513	14513	14513
Residual nitrogen in the soil at harvest	9589	9596	11768	11731	7378	7354	11073	11048	13731	13766
Group uptake	413	404	474	500	379	398	429	449	506	466
Total (B)	10002	10000	12242	12231	7757	7752	11502	11497	14237	14232
Unaccounted loss (A-B)	11 (4.2%)	13 (4.9%)	21 (8%)	32 (12.2%)	6 (2%)	11 (4.2%)	11 (4.2%)	16 (6.1%)	13 (4.9%)	18 (6.8%)

of applied nitrogen) nitrogen per pot for Triveni grown in the sandy loam soil under 5 cm submergence. This unaccounted nitrogen loss which does not confer any nutritional benefit on the rice plant, might in all probabilities be due to ammonia volatilization and denitrification resulting from anaerobic conditions of submergence. Since the holes at the bottom of the pots used in the experiment were closed in order to prevent drainage, leaching loss can not be considered here. The reports by Blasco and Cornfield (1966); Duplessis and Kroontje (1964), Volk (1951) and MacRae and Ancajas (1970) showed that even in acid soils there could be a loss of NH_3 through volatilization. The nature of ammoniacal nitrogen source affects the rate of NH_3 loss and larger losses have been observed with urea. The nitrogen lost by ammonia volatilization can be as high as 19 per cent of the applied nitrogen (MacRae and Ancajas, 1970). Denitrification loss of nitrogen from fertilized submerged soils have been reported by Crasswell and Vlek (1979). Based on the indications from the present study, further investigations can be undertaken on the processes and estimation of loss of nitrogen from different soil types.

SUMMARY

SUMMARY AND CONCLUSION

Nitrogen balance studies were carried out to assess the rate of efficiency of applied nitrogen under varying soil conditions and irrigation levels with respect to short and medium duration varieties of rice. A pot culture experiment in CRD was carried out with five soil types namely, karapadam, kole, sandy loam, low level laterite and black soil, under two irrigation levels namely 5 cm and 10 cm and with and without nitrogen application on two varieties of different durations viz., Jaya and Triveni, for this purpose. The effect of soil type, submergence levels and nitrogen application on growth and yield of rice, N P K content and uptake of nitrogen by rice grain and other plant parts, and nitrogen recovery and its loss was investigated. The important findings are summarized below.

1. Soil type and irrigation levels were found to influence the growth characters in rice significantly. Karapadam soil with 5 cm level of submergence was found to produce maximum plant height at all growth stages in Jaya rice variety. In the case of Triveni variety, karapadam soil at 5 cm submergence at the tillering stage and kole soil at 5 cm submergence at the subsequent stages produced maximum plant height.

2. Growth characters in rice were influenced also by interaction of soil type x nitrogen application in Jaya and Triveni varieties. Among the different soil x nitrogen interactions, nitrogen application produced higher plant height in all soils. Black soil with nitrogen application was found superior for Jaya while for Triveni kole soil with nitrogen application was found superior.

3. The interaction effect of soil x levels of submergence x nitrogen was found to have significant influence on the growth characters but was found varying between varieties and growth stages.

4. Significant influence was noticed with regard to soil type on grain yield and yield attributes. In the case of Jaya, low level laterite and kole soils have been found to be superior with regard to grain yield as compared to kole soils in Triveni variety.

5. The soil x level of submergence interactional effect had no influence on grain yield in rice, but had influence over the other yield attributes though to varying levels. Yield and yield attributes in rice were positively influenced by nitrogen application to all soils.

6. The soil type had significant influence on its available nitrogen content. Among the different soil types, kole soil recorded the highest available nitrogen content and sandy loam recorded the lowest content, in the case of both rice varieties at different periods.

7. In the case of both rice varieties the available nitrogen content followed a definite pattern through out the growth period. During the first week of planting seedlings an increase in available nitrogen content was noticed in all soils, which showed a decrease during the second week and continued till the fourth week and thereafter again an increase during the fifth week, which was followed by a continuous decrease till harvest stage.

8. Level of submergence had significant effect on the availability of nitrogen. The 5 cm submergence was found to be superior with regard to available nitrogen content in both varieties. Among the soil x levels of submergence interaction kole soil with 5 cm submergence was found superior.

9. The nitrogen application was found to increase the available nitrogen content of soil with both the rice varieties.

10. The treatment combination of soil x level of submergence x nitrogen application had significant influence on the available nitrogen content. Among different combinations kole soil with 5 cm level of submergence and nitrogen application recorded the highest available nitrogen content and sandy soil with 10 cm submergence and no applied nitrogen recorded the lowest available nitrogen content in all the periods.

11. Soil type had significant influence on the plant nitrogen content but its influence was found to varying at different stages.

12. The effect of submergence and the interaction effect due to soil and level of submergence combination were found to have significant influence on the plant nitrogen content and total uptake of nitrogen in both the varieties.

13. Nitrogen application resulted in increased nitrogen content and total uptake of nitrogen in both rice varieties.

14. The interactional effect due to soil, level of submergence and nitrogen was found to have significant influence on plant nitrogen content in both the rice varieties.

15. The nitrogen content and its uptake by grain were significantly influenced by the soil type. In both varieties, black and kole soils showed higher estimates for nitrogen content and nitrogen uptake by grain.

16. Levels of submergence indicated significant influence on nitrogen content and uptake by grain in Jaya variety while, there was no such effect in Triveni. In Jaya 5 cm submergence was found better.

17. Soil type was found to have significant influence on the recovery of nitrogen by the rice plant. In Jaya, low level laterite, black and kole soils produced higher recoveries while, for Triveni kole soil produced the highest nitrogen recovery.

18. Levels of submergence was found to have significant influence on the recovery of nitrogen with regard to Jaya variety, but had no influence on Triveni. In Jaya, 5 cm level of submergence was found to be better than 10 cm. The soil x level of submergence interaction also had significant influence on recovery of nitrogen.

19. The soil type, level of submergence, applied nitrogen and their interaction were found to have significant influence on the phosphorus and potassium contents of grain and straw.

20. In the case of Jaya, the unaccounted losses of nitrogen in different soil types ranged from 10 mg/pot to 44 mg/pot in nitrogen applied soils. In the case of Triveni, the unaccounted losses ranged from 6 mg/pot to 32 mg/pot in nitrogen applied soils.

In the case of both varieties kole soil registered the maximum unaccounted loss while low level laterite registered the minimum loss.

The results of the present set of investigations have clearly brought out the superiority of certain soil types of Kerala in rice grain production. Levels of submergence were found to have significant influence on straw yield. Nitrogen fertilizer application had definite advantage on the growth and productivity of rice. Both grain yield and straw yield were positively influenced by nitrogen application. Soil type, levels of submergence and nitrogen application have influenced the uptake and content of nitrogen, phosphorus and potassium of grain and straw. Balance sheet of nitrogen application indicated unaccounted loss of nitrogen from different soil types, and this loss is probably through ammonia volatalization and denitrification.

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*original not seen

APPENDICES

Analysis of variance

Appendix - I

Plant height at different stages

Source	df	Mean square							
		Tillering		Panicle initiation		Flowering		Harvest	
		Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
Total	39								
Soil	4	84.97**	88.01**	202.65**	485.89**	178.73**	421.98**	245.09**	344.75**
Submergence	1	3.54*	7.73**	2.64*	51.73**	2.09*	73.23**	11.47**	61.27**
Nitrogen application	1	390.06**	603.72**	3511.13**	310.78**	3309.09**	279.36**	2955.97**	263.72**
Soil x submergence	4	1.60*	0.34	58.30**	10.02**	60.98**	11.66**	82.92**	5.79**
Soil x nitrogen-application	4	27.04**	15.25**	18.13**	26.70**	17.19**	33.52**	9.91**	45.34**
Submergence x nitrogen	1	1.12	0.26	0.34	1.45	2.58*	0.22	2.09*	2.03*
Soil x submergence x nitrogen applica-cation	4	0.89	0.36	10.74**	15.43**	19.90**	14.93**	18.38**	13.51**
Error	20	0.47	0.26	0.39	0.51	0.31	0.17	0.30	0.17

** - Significant at 1% level

* - Significant at 5% level

Analysis of variance

Appendix - II

Tiller number at different stages of growth

Source	df	Mean square							
		Tillering		Panicle initiation		Flowering		Harvest	
		Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
Total	39								
Soils	4	2.49**	12.12**	2.11**	8.21**	3.63**	5.72**	1.37**	3.13**
Submergence	1	0.28	0.45	0.28	0.09	0.18	0.22	0.54	0.02
Nitrogen fertilizer	1	15.18**	61.60**	52.90**	55.93**	27.76**	55.70**	4.89**	49.78**
Soil x submergence	4	1.09*	0.77	0.37	0.84	0.58	1.29	1.72**	1.02
submerg. ~~Soil~~ x nitrogen fertilizer	1	0.70	1.19	0.10	2.86	0.04	2.60*	0.18	1.44
Soil x Nitrogen fertilizer	4	1.65**	3.65*	2.32**	1.10	2.83**	1.68*	3.77**	0.81
Soil x submergence x Nitrogen fertilizer	4	0.41	1.81	0.34	0.25	0.83**	0.50	0.45*	0.24
Error	20	0.19	0.86	0.27	1.06	0.17	0.52	0.14	0.46

** - Significant at 1% level

* - Significant at 5% level

Analysis of variance

Appendix III

Yield characters of rice

Source	df	Productive tillers		Panicle length		Thousand grain weight		Grain yield		Straw yield	
		Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
Total	39										
Soils	4	1.32**	3.27**	19.42**	3.52**	0.67*	0.16	18.09**	14.59**	136.05**	71.72**
Submergence	1	0.47	0.02	0.10	0.20	0.12	0.06	2.50	0.42	26.41**	20.31**
Nitrogen fertilizer	1	3.81**	50.63**	222.41**	22.45**	1.06*	23.16**	198.92**	336.98**	1312.17**	787.66**
Soil x submergence	4	1.95**	0.77	0.68**	0.67**	1.25**	0.30	1.80	2.19	3.07*	1.62
Submergence x Nitrogen fertilizer	1	0.07	1.23	1.75**	0.71**	0.50	0.91**	12.54**	1.06	1.06	17.02**
Soil x Nitrogen-fertilizer	4	4.12**	1.60	3.37**	1.50**	3.02**	1.69**	1.81	1.87	22.41**	14.34**
Soil x submergence x nitrogen fertilizer	4	0.47	0.10	3.05**	1.62**	2.08**	0.49**	1.51	1.92	2.42	2.27
Error	20	0.20	0.63	0.03	0.05	0.23	0.10	1.43	0.78	1.37	0.83

** - Significant at 1% level

* - Significant at 5% level

Analysis of variance

Appendix IV

Available nitrogen status at different periods

Source	df	24 hr		48 hr		96 hr	
		Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
Total							
Soils	4	15216.39*	19643.91*	16246.94*	26071.53*	19444.36*	24180.19*
Submergence	1	63.38*	245.06*	63.41*	336.44*	511.19*	525.56*
Nitrogen fertilizer	1	6543.38*	18105.00*	9709.38*	16402.50*	11881.69*	19228.19*
Soil x submergence	4	31.45**	193.27*	27.80*	59.02**	12.54**	134.20*
Submergence x Nitrogen fertilizer	1	51.19**	189.25**	174.81**	115.56**	90.13**	4.31
Soil x Nitrogen-fertilizer	4	777.55*	1950.66*	193.98*	505.25*	759.03**	156.05**
Soil x submergence x Nitrogen fertilizer	4	95.94*	281.47*	118.89*	262.11**	104.03**	148.02**
Error	20	1.70	1.33	5.10	1.25	2.64	2.08

** - Significant at 1% level

* - Significant at 5% level

Appendix IV contd.

1 week		2 week		3 week		4 week	
Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
27582.81**	14226.78**	10274.64**	14405.65**	9808.63**	14621.42**	9306.92**	5773.02**
844.69**	403.19**	743.06**	366.08**	719.09**	216.25**	802.81**	136.90**
22146.50**	37393.19**	9797.00**	24255.63*	7118.09**	24059.06**	7409.05**	16321.59**
71.33*	18.11*	46.17*	273.27*	67.89**	70.03**	44.99**	328.14**
6.94	42.13**	19.56*	207.00*	10.25*	0.63	13.63**	8.09**
574.22**	682-48**	244.31**	1923.75**	130.19**	2038.93**	379.41**	1272.73**
63.42**	62.63**	9.34*	77.03*	62.10**	214.29**	38.98**	39.85**
1.75	1.53	2.18	1.63	1.33	0.98	1.29	0.80

** - Significant at 1% level

* - Significant at 5% level

Appendix IV contd.

5 weeks		6 weeks		7 weeks		8 weeks		Harvest	
Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
7310.68**	6123.36**	6369.13**	6570.36**	6739.31**	5110.40**	6762.55**	4542.91**	10987.65**	9342.58**
766.41**	34.25**	777.00**	13.25**	729.34**	270.41**	797.41**	93.03**	129.60**	688.91**
18640.72**	43230.69**	14051.28**	35105.66**	11303.13**	21436.91**	11978.44**	24059.03**	8410.00**	23039.97**
67.14**	184.09**	86.20**	33.09**	72.09**	27.65**	38.39**	46.21**	85.85**	11.83
6.75	7.18*	3.06	5.59	44.91**	313.59**	14.66*	378.22**	3.6	48.41*
214.17**	103.98**	293.46**	1238.74**	306.17**	700.52**	353.48**	958.34**	64.25**	1283.07**
32.71	63.36**	38.52**	297.75**	56.65**	141.98**	37.95**	151.54**	25.85**	128.71**
12.96	1.68	1.10	1.48	1.30	3.40	5.75	4.22	4.9	11.25

** Significant at 1% level

* Significant at 5% level

Analysis of Variance

Appendix V

Plant nitrogen content at different stages

Source	df	10 days		20 days		30 days		60 days		Harvest	
		Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
Total											
Soil	4	0.54**	0.19**	0.03**	0.107**	50.71**	0.31**	1.77**	0.92**	12251**	0.34*
Submergence	1	0.05	0.30**	0.04**	0.0009	0.005	0.23**	0.41**	0.11**	0.004**	0.004*
Nitrogen fertilizer	1	4.62**	4.19**	4.06**	4.94**	3.96**	5.43**	2.78**	1.92**	195992**	0.34*
Soil x submergence	4	0.06	0.28*	0.38**	0.48**	0.37**	0.15**	0.20**	0.37**	0.02**	0.01
Submergence x Nitrogen fertilizer	1	0.02	0.08	0.09**	0.13**	0.11**	0.07**	0.31**	0.003	0.004**	0.0009
Soil x Nitrogen-fertilizer	4	0.57**	0.58**	0.40**	0.45**	0.09**	0.37**	0.95**	0.08**	0.037**	0.004**
Soil x Submergence x Nitrogen-fertilizer	4	0.25**	0.21**	0.19**	0.22**	0.25**	0.05**	4.23**	0.19**	0.0085**	0.0093**
Error	20	0.02	0.02	0.004	0.009	0.02	0.004	0.02	0.007	0.0003	0.0005

** - Significant at 1% level

* - Significant at 5% level

Analysis of Variance

Appendix VI

Uptake of nutrients

Source	df	Nitrogen uptake by grain		Nitrogen uptake by straw		Total Nitrogen uptake	
		Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
Total							
Soils	4	0.004**	0.008**	0.02**	0.004**	0.04**	0.01**
Submergence	1	0.002**	0.0004	0.003**	0.0005**	0.01**	0.0001
Nitrogen fertilizer	1	0.01*	0.02**	0.04**	0.02**	0.13**	0.08**
Soil x submergence	4	0.0007	0.0008*	0.0003	0.0008**	0.001**	0.0008**
Submergence x nitrogen fertilizer	1	0.0005	0.00004	0.00002	0.0003**	0.0004	0.00003
Soil x nitrogen-fertilizer	4	0.0004	0.0003	0.001**	0.0003**	0.0002	0.0005**
Soil x submergence x nitrogen fertilizer	4	0.001	0.0002	0.00009	0.0001	0.0009	0.0004*
Error	20	0.0002	0.0002	0.0002	0.00009	0.0004	0.0001

** - Significant at 1% level

* - Significant at 5% level

Analysis of Variance

Appendix VII

Composition of grain and straw

Source	df	Mean squares: Nitrogen content grain		Nitrogen content straw		Phosphorus content grain		Phosphorus content straw		Potassium content grain		Potassium content straw	
		Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
Total	39												
Soils	4	0.04**	0.03**	0.13**	0.08**	0.0007**	0.0004**	0.0009**	0.002**	0.02**	0.03**	0.07**	0.20**
Submergence	1	0.05**	0.002	0.009**	0.02**	0.00002	0.00002	0.00002	0.00002	0.00002	0.00001	0.059**	0.00006
Nitrogen fertilizer	1	0.02*	0.008**	0.02**	0.009**	0.002**	0.002**	0.0004**	0.001**	0.25**	0.28**	0.101**	0.17**
Soil x submergence	4	0.02*	0.002	0.009**	0.009**	0.00009	0.0002**	0.0004**	0.002**	0.001**	0.001*	0.14**	0.17**
Submergence x Nitrogen fertilizer	1	0.01	0.0009	0.0002	0.0009	0.0003**	0.00006	0.001	0.00006	0.006*	0.009**	0.06**	0.19**
Soil x Nitrogen-fertilizer	4	0.005	0.0001	0.00008	0.002*	0.0002**	0.0002**	0.0003**	0.0001	0.006*	0.005**	0.01**	0.36**
Soil x Submergence x Nitrogen fertilizer	4	0.01	0.009	0.0004	0.0009	0.0002**	0.00006	0.0002**	0.0003**	0.0008*	0.0009*	0.16**	0.17**
Error	20	0.006	0.001	0.0004	0.001	0.00003	0.00003	0.00004	0.00004	0.0002	0.0003	0.002	0.0003

** - Significant at 1% level

* - Significant at 5% level

Analysis of Variance

Appendix VIII

Recovery of nitrogen

Source	df	Mean square	
		Recovery of Nitrogen	Recovery of Nitrogen
		Jaya	Triveni
Total	19		
Soil	4	42.34*	183.43**
Submergence	1	63.33*	0.25
Interaction	4	160.16**	81.74**
Error	10	7.83	6.60

** - Significant at 1% level

* - Significant at 5% level

NITROGEN BALANCE STUDIES IN THE RICE SOILS OF KERALA

BY

MEERA, K.

ABSTRACT OF A THESIS
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REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
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1986

ABSTRACT

Nitrogen balance studies were carried out under pot culture conditions in CRD to assess the rate of efficiency of applied nitrogen in five different soil types viz., karapadam, kole, sandy loam, low level laterite and black soils and two irrigation levels, viz., 5 and 10 cm with respect to short and medium duration varieties of rice viz., Triveni and Jaya. The effect of soil type, submergence levels and fertiliser nitrogen application on growth and yield of rice, nitrogen uptake and NPK content in soil, plant, grain and straw were studied and the recovery and loss of nitrogen were computed.

Soil type was found to influence the growth and yield characters in rice significantly. In Jaya, black soil, low level laterite and kole soils were found superior for grain yield, while in Triveni, kole soil alone turned out superior. Karapadam and kole soils produced higher plant height, tiller count and straw yield in both the varieties. Soil type also influenced the available nitrogen content in soil, uptake and content of nitrogen in straw and grain. Eventhough level of submergence failed to show any effect on grain yield and

yield attributes in both rice varieties, significant effect was noticed on their growth characters, available nitrogen content of soil, uptake and content of nitrogen in plant, straw and grain. However, 5 cm submergence was better than 10 cm, with regard to available nitrogen content of the soil in both varieties. Fertilizer nitrogen application influenced all the growth characters and yield attributes in both varieties of rice as compared to control. Available nitrogen content of soil, nitrogen content and its uptake by grain and straw were also influenced by applied nitrogen. Interaction effect of soil and level of submergence was noticed on different growth characters and yield attributes except on grain yield and NPK content of grain and straw in both varieties. The combined effect of soil and nitrogen application was quite pronounced on all characters studied and soil and plant nutrients analysed. Soil type, level of submergence, nitrogen application and their interaction influenced the phosphorus and potassium contents of grain and straw. Three way interaction of soil, level of submergence and nitrogen application was significant on the growth and yield characters but found varying between varieties and their characters. Maximum nitrogen recovery by Jaya variety was in low level laterite soil under 10 cm submergence and was found to be 44.26 per cent of the applied nitrogen and that in Triveni variety was in kole soil under 5 cm submergence and was 44.57 per cent. Nitrogen balance estimates indicated loss of nitrogen from all the soil types studied, probably by ammonia volatilization and denitrification.