

STUDIES ON EFFICIENCY OF UREA BASED N FERTILIZERS IN RELATION TO THEIR MODES OF APPLICATION TO RICE

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BY

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1994**

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**DEDICATED TO
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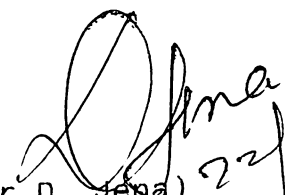


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April, 22, 1995.

C E R T I F I C A T E - I

Certified that the thesis entitled "STUDIES ON EFFICIENCY OF UREA BASED N FERTILIZERS IN RELATION TO THEIR MODES OF APPLICATION TO RICE" submitted in partial fulfilment of the requirements for the award of the degree of MASTER OF SCIENCE IN AGRICULTURE (AGRICULTURAL CHEMISTRY, SOIL SCIENCE AND BIOCHEMISTRY) to the Orissa university of Agriculture and Techonology, Bhubaneswar, is a faithful record of bonafied research work carried out by Sri Gobinda chandra Sahoo under my guidance and supervision during the academic year 1994. No part of the thesis has been submitted for the award of any other degree or diploma. It is further certified that all possible help and source of information availed of during the course of this investigation have been duly acknowledged by him.


(Dr D. Jena) 22/4/95

CERTIFICATE - II

This is to certify that the thesis entitled "STUDIES ON EFFICIENCY OF UREA BASED N FERTILIZERS IN RELATION TO THEIR MODES OF APPLICATION TO RICE" submitted by Gobinda Chandra Sahoo in partial fulfilment of requirements for the award of Degree of MASTER OF SCIENCE IN AGRICULTURE (AGRICULTURAL CHEMISTRY, SOIL SCIENCE AND BIOCHEMISTRY) to the Orissa University of Agriculture and Technology, Bhubaneswar has been approved by the advisory committee after an oral examination on the same in collaboration with external examiner.

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ABSTRACT

Field experiments were laid out during 1994 Kharif season under medium and low land situation of Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar, in order to understand the efficiency of different modes of application of PU and USG to kharif rice as well as the transformation patterns in the crop root zone. Flood water samples and soil solution samples from 10cm soil depth were collected and analysed for amide-N and ammonium -N. Laboratory study with ^{15}N PU were also made to determine the percent nitrogen retained in soil columns after 24 hours of leaching.

The soil of the experimental site is classified as a member of fine loamy mixed hyperthermic family of a haplaquept. The research results show that the grain yield of rice due to application of 58kg N/ha as USG/PU is significantly higher than that from 76kg N/ha applied through USG/PU. The observed non significant difference between PU and USG during the present investigation(1994 kharif) may have been due to high intensity of rain fall received during transplanting to panicle initiation stage.

The efficiency of nitrogen to kharif rice can be increased when 2/3rd of N is applied as USG at 7DAT and 1/3rd of N as PU at panicle initiation stage. The values for agronomic efficiency, relative efficiency and apparent N recovery(%) parameters in USG treatments are appreciably higher than that for equivalent dose of PU(@ 58kg N/ha) applied in three splits.

The rate of urea hydrolysis can be higher under PU than that under USG as inferred from the amide N distribution data in flood water and soil solution. Lateral seepage of amide N in flood water from upper reaches /treated plots does occur in the rice fields during kharif season. The down ward movement of amide N or ammonium N in USG treatment is higher than upward movement.

Recovery percent of applied nitrogen in soil columns was found higher than the applied amount might be due to priming effect resulting from ammonification from organic source.

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CHAPTER I

INTRODUCTION

INTRODUCTION

1.1. IMPORTANCE OF FERTILIZER NITROGEN RESEARCH.

Nitrogen is the single plant nutrient most frequently limiting yield of the major food crops. More and more researchers and farmers are finding that efficient use of nitrogen requires its addition to be closely associated with other effective management practices. Stangel (1979) examined yield parameters of the leading rice producing countries of the world and found that high national average yields of rice positively correlate with good water control, fertilizer responsive modern varieties and heavy doses of fertilizer nitrogen. Most notably, average nitrogen rates were frequently above the agronomic optimum recommended by research workers.

1.2 FERTILIZER NITROGEN USE EFFICIENCY

One characteristic of high yield technology is the heavy addition of chemical fertilizers particularly nitrogen fertilizer. Data on the response of field crops to nitrogen are available from thousands of field experiments of agricultural experiment stations and on farmers fields

conducted all over the country. Though it is found that the economics of N application to cereals is fairly good (FAO, 1980), the recovery of applied N from conventional fertilizer is quite low, 10 - 50 % for rice.

The poor utilization of N fertilizer is thought to be largely caused by losses of N from the soil-plant system through volatilization, denitrification and leaching. Many researchers have shown that farmers of Asia benefit only a fraction of the fertilizer nitrogen applied (De Datta and Craswell 1980). It is reported that farmers benefit from only about one out of three bags of chemical nitrogen that they apply to the rice crop. The remaining two bags are lost because of the present practice of broadcasting nitrogen fertilizer directly into the paddy water. Losses are more severe when urea is used. These losses can be cut to half if the nitrogen fertilizer is either placed 7-10cm into the reduced zone of rice field.

1.3. ENVIRONMENTAL HAZARD

It is well known that the consumption of high nitrate water leads to infantile methemoglobinemia. Ingested nitrate is converted to nitrite leading to this malady.

In developed countries, application of heavy

doses of nitrogen fertilizers leads to environmental pollution. In course of time one may expect such type of hazard in developing countries. Therefore, it is important that the rates, method of application as well as its rates of hydrolysis / mineralization to NH_4^+ or NO_3^- should be determined for different soils.

1.4. OBJECTIVES

The objectives of the present investigation have been

- * to study the relative efficiency of PU and USG under different modes of application and land situation.

- * to determine the temporal variation of concentration of $\text{NH}_2\text{-N}$, $\text{NH}_4^+\text{-N}$ and $\text{NO}_3^-\text{-N}$ in flood water and soil solution following application of PU and USG.

- * to study the fate of left over nitrogen in soil after the harvest of kharif rice.

- * to study the extent of formation of $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ during the leaching of ^{15}N PU, in different soil columns.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

2.1 HYDROLYSIS OF UREA

2.1.1 Activity of urease enzyme in soil and flood water

Urease (Urea amido hydrolase) is an enzyme that catalyzes the hydrolysis of urea to ammonium carbonate. This enzyme is important in the process of rapid urea hydrolysis leading to appreciable losses of fertiliser N through ammonia volatilization and leaching. This urease, in soil, is a microbial extracellular enzyme (Paulson and Kurtz 1969; Tarafdar and Chhonkar 1982) that accumulates through release from living or dead microbial cells or plants. The soil urease activity is increased by increase in urea concentration (Douglas and Bremner 1971; Pal and Chhonkar 1979) and organic matter (Balasubramanian et al. 1972 ; pal and Chhonkar 1981), decreased by increase in water level (Dalal 1975; Sankhayan and Shukla 1974) and has no effect with oxygen (Delaune and Patrick 1970; Zantua and Bremner 1976).

Reddy and Chhonkar (1991) reported that urease activity in soil and flood water increased significantly due to organic matter but decreased due to flooding and application of inhibitors. Urease activity is dynamic in

soil and it is found in unfiltered flood water but not in filtered flood water.

They have also reported that urease activity changes with crop growth. In non crop soils, its activity is low due to absence of rhizosphere resulting lower ureolytic microbial population.

They have reported that urease activity is largely associated with soil colloids. Filtered flood water exhibits no urease activity. Thus it appears that urea, that remains in flood water following fertilization, is hydrolysed in the flood water itself due to presence of particulate matter in it. Sahrawat (1980) has also reported the similar findings.

Kumar and Wagnet (1984) observed that increasing the moisture content from 25% to 100% of field capacity, the urease activity is increased by 15, 29 and 46% in Kilburn, Dagore and Nibley soils, respectively. As the moisture content was further increased to flooding, however urease activity decreased. A similar relationship was observed by Myers and McGarity (1968). This reduction in urease activity may be attributed to reduction in aeration (Reddy and Chhonkar, 1991).

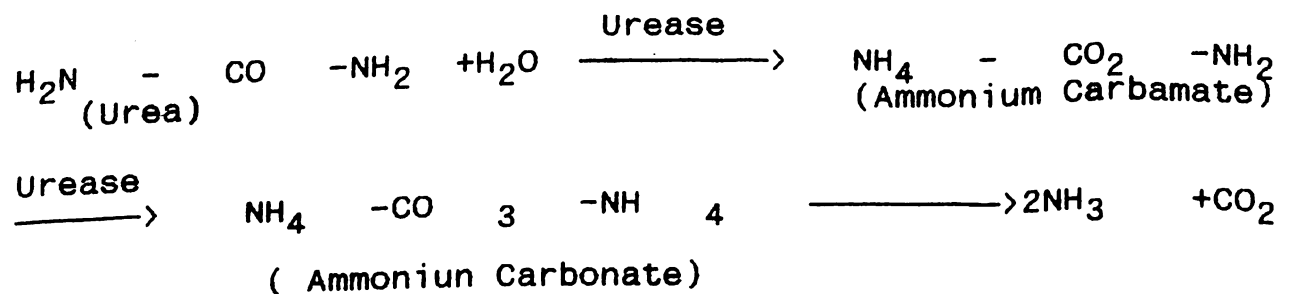
Zantua et al. (1977) observed a negative relationship between CaCO_3 content of natural soils and soil urease activity. Kumar and Wagnet (1984) observed that

addition of 2.4 and 8% amorphous CaCO_3 decrease the urease activity in all the 3 soils (i.e. Kiburn, Dagore and Nibley) they studied.

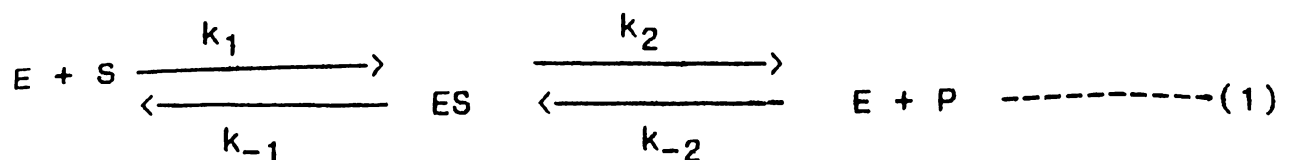
Kumar and Wagnet (1984) found that urease activity increased linearly with temp. from 5° to 35° C in all soils though from 35° to 45° the linear relationship did not hold good.

2.1.2 Kinetics of Urea hydrolysis

Biochemical reaction representing Urea hydrolysis :



The Kinetics of a simple enzyme catalysed reaction may be represented as follows.:-



where, E = enzyme

S = substrate

P = product

ES = Enzyme substrate complex.

k_1, k_{-1}, k_2, k_{-2} are the relevant rate constants

The reaction rate can be shown , based on Michaelis Menton treatment, to be

$$v = \frac{ds}{dt} = k_2 \frac{E_0 + S}{k_m + S} \quad (2)$$

The following treatment of eq (2) is essentially given by Misra et al. (1973). If the concentration of the enzyme is isnearly independent of substrate concentration, eq (2) may be integrated to,

$$- k_2 E_0 t = k_m \ln \frac{S}{S_0} + (S - S_0) \quad (3)$$

Where S_0 = Concentration of substrate at $t = 0$

If the value of initial concentration of substrate S_0 is small which is also the condition for a nearly constant enzyme concentration and the value of k_m is relatively large, the second term of right side of eq(3) may be neglected to yield,

$$\begin{aligned} - k_2 E_0 t &= k_m \ln (S/S_0) \\ \text{or } \ln (S/S_0) &= - (k_2 / k_m) E_0 t = -kt \\ \text{or } S &= S_0 e^{(-kt)} \quad (4) \end{aligned}$$

Where $k = k_2 (E_0 / k_m)$ = first order reaction rate constant.

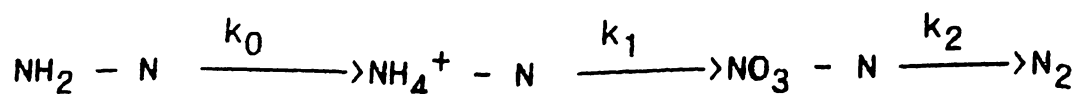
Eq (4) is identical to an enzyme catalysed reaction derived on the basis of first order kinetics.

Vinod Kumar and Wagnet (1984) studied the kinetics of urea transformation as a function of temperature in 2 soils, Panoche and Wellsville. They reported the values of first order rate constant (k) as 0.2518 h^{-1} and 0.0842 h^{-1}

at 10°C for Walsville and Panoche soils respectively. Similarly the k values at 20°C and 30°C was 0.4375 h^{-1} , 0.1194 h^{-1} , 0.5222 h^{-1} , 0.1919 h^{-1} for the 2 soils respectively.

Khanda (1985) reported the first order k values for urea hydrolysis for a medium land sandyloam soil to be 0.038 h^{-1} , 0.068 h^{-1} and 0.19 h^{-1} at 24°C , 29°C and 35°C respectively. He further reported that as the incubation period is increased above 18 h, the linearity of concentration vs time curve is affected. He also measured the activation energy for urea hydrolysis to be 21.7 kilocalorie per mole.

Jena et al. (1988) studied the fate of applied ^{15}N prilled urea applied to rice, pigeon pea and rice + pigeon pea system. They assumed the sequential transformation of applied fertilizer N in the soil to obey first order kinetics.



The mean rate coefficients of k_0 , k_1 and k_2 for urea

hydrolysis, oxidation of $\text{NH}_4^+ - \text{N}$ and reduction of $\text{NO}_3^- - \text{N}$ were estimated on the following equations:

$$\begin{aligned} C/C_0 &= e^{-k_u t} \\ C_1/C_0 &= (k_u / k_1 - k_u) (e^{-k_u t} - e^{-k_1 t}) \\ C_2/C_0 &= \frac{(k_u \cdot k_1)}{(k_1 - k_u)(k_2 - k_u)} e^{-k_u t} + \frac{(k_u \cdot k_1)}{(k_u - k_1)(k_2 - k_1)} e^{-k_1 t} \\ &+ \frac{(k_u \cdot k_1)}{(k_u - k_2)(k_1 - k_2)} e^{-k_2 t} \end{aligned}$$

Where, C_0 is the initial concentration of urea -N added, C, C_1, C_2 are concentration of urea -N, ammonium -N and nitrate -N respectively at any time t , following transformation reactions.

Using this relationship for the 60 days old crop, Jena et al. (1988) worked out the rate constants k_u, k_1 and k_2 to be 0.03, 0.05 and 0.02 per hour for rice; 0.035, 0.035 and 0.035 per hour for pigeon pea; 0.035, 0.027 and 0.034 per hour for rice +pigeon pea and 0.041, 0.038 and 0.027 per hour for the bare soil (ultisol) at Bhubaneswar respectively.

Khanda (1985) leached 15 ml of a solution pulse in 15 cm columns of sandyloam soil packed to B.D. of 1.65 gm/cc. He got a series of break through curves for leaching prilled urea solution (400ppm urea -N) prilled urea and neem cake extract (3kg neem cake per 10kg urea), prilled urea

solution (400ppm urea-N) in 2M KCl -5ppm PMA, prilled urea solution(400ppm urea-N)containing sucrose . He found that recovery fraction for urea, urea + sucrose, urea + neem cake extract , urea + KCl -PMA to be 0.42, 0.39, 0.39 and 0.79 respectively. Using the relation: $C/C_0 = e^{-kt}$, he computed the first order rate constants for these systems to be 0.079,0.086, 0.077 and 0.18 h^{-1} respectively.

2.1.3 Factors affecting hydrolysis of Urea.

Raynolds et al. (1985) reported that urea hydrolysis is positively correlated with total nitrogen and organic carbon of field soil collected in moist and dry condition.

Gill et al. (1991) from their incubation studies under aerobic and anaerobic conditions concluded that urea hydrolysis and FYM decomposition is five to six times more rapid under aerobic condition than under anaerobic condition.

Sharma and Chouhan (1994) reported that when urea is applied to salt affected soils, the rate of hydrolysis and nitrification are delayed where as accumulation and persistence of nitrite -N in toxic ammounts takes place (Nitant 1974). Soil water, clay organic matter in water and nature of urease enzyme are some of the important factors

governing urea hydrolysis in soil among which organic matter plays a very important role.

Increasing levels of prilled urea increase urea -N in salt affected soils by decreasing rate of hydrolysis. The slow rate of urea hydrolysis in salt affected soils have been reported by several workers (Nitant 1974; Frankenberger and Bingham 1982; Kumar et al. 1988).

The effect of sodicity is more prominent in the retardation of urea hydrolysis than that of salinity (Kumar et al. 1988). Further reduction of hydrolysis rate may be ascribed to the activation of urea molecules by sodium and hydroxyl ions, which are dominant in salt affected soils (Pal and Chhonkar, 1979, 1981).

Each successive addition of urea resulted significantly higher value of nitrite -N and nitrate -N over the lower doses. The excessive accumulation of nitrate-N in salt affected soils may be due to reduced activity of Nitrobacter (Buresh and Patrick 1978; Patra and Jain 1984).

Among sodium salts, carbonates and bicarbonates are more harmful than chlorides and sulfates which further suppress the activity of Nitrobacter in sodic soils resulting in to more accumulation of nitrite -N in these soils. Retardation of microbial activity in salt affected

soils may be held responsible for the slow rate of nitrification (Bondopadhyaya and Bondopadhyay 1983).

Sahrawat (1992) reported that hydrolysis of urea is completed in vertisol ($p^H = 8.3$) in one day; by two days in alfisol -1 ($p^H = 6.2$) but the hydrolysis is not completed by 10th day in alfisol -2 ($p^H = 4.5$). These results were agree with reports that the rates of urea hydrolysis are slow in soils with acidic p^H but high in soils with neutral or higher p^H (Bremner and Mulvaney 1978; Goswami and Saharawat 1982).

Sahrawat (1992) further reported that hydrolysis of urea to ammonia creates alkalinity and this could lead to the gaseous loss of ammonia. The volatile loss of ammonia was 14% in vertisol ($p^H = 8.35$), 6% in alfisol -1 ($p^H = 6.2$) and 2% in alfisol -2 ($p^H = 4.5$).

2.2 LOSSES OF N -FERTS FROM FLOODED SOILS

2.2.1 Leaching :

Nitrate formed from soil or fertilizer nitrogen can leach down in light textured soil because nitrate is not held with any kind of force in the soil. Similarly leaching of urea may also pose a problem if its application is followed by heavy irrigation or rainfall in coarse textured soils with low urease activity. Though

ammonium moves in reduced wetland soils its leaching is not a problem in soils with significantly higher exchange capacity. It has been recognised that the leaching loss of nitrogen occurs mainly as nitrate.

Suresh et al. (1994) reported that N-ferts applied to rice is highly susceptible to leaching and other types of losses. The forms of N in the leachate depend on source, type of soil and preferential absorption of N-forms by the crop. Modified N sources and improved application methods help to supply N to a crop more efficiently. They also reported that major portion of N in leachate were in form of ammonium -N followed by amide -N and least in nitrate -N form, in both kharif and rabi. Amide -N in the leachate was detected only up to a week from the day of fertilizer application. The lower concentration of ammonium -N and nitrate -N in leachate were observed incase of neem cake coated urea followed by urea zypsone, which is due to restricted nitrification.

Among the three N forms ammonium -N content in the leachate was proportionately higher than the other forms, because in the wet land rice soil, very little amount of ammonium -N is oxidized to nitrate -N due to reduce conditions and mineralization of N ferts proceeds up to the

formation of ammonium -N . The amide -N constituted the 2nd highest form of N in leachate. The nitrate -N content in the leachate was proportionately lower than other forms due to the reduce conditions.

They further reported that in kharif season, all the 3 forms of N in leachate were higher than in rabi, probably due to higher precipitation in kharif. Also the 3 forms of N in leachate were higher at transplanting followed by tillering and P.I. stage. This may be due to highest disintegration of aggregates , unclogged soilpores, limited utilization of applied N at transplanting but due to higher root activity and foraging at P.I. stage.

Santra et al. (1994) reported that leaching loss in form of ammonium -N accounts as high as 69% of total leaching loss from N ferts under submerged rice culture.

Singh and Singh (1988) reported leaching losses through ammonium -N was as high as 96% of total leaching loss under submerged rice culture. Sharma et al. (1989) observed that even for a percolation rate as low as 10 mm per day there was leaching loss of as high as 79 kg ammonium -N per hacter and such loss increased to as high as 175kg ammonium -N per hacter with the increase in percolation rate.

It was further reported by Santra,et al. (1994)

that green manure +P.U. treatment accounted highest perentge of total N loss through leaching followed by coated urea and urea split.

Sharma and Ghos (1976) reported that urea can be lost to the extent of 80% through leaching.

Sahrawat (1992) reported that leaching of urea could be a serious problem in the acidic sandy alfisol if heavy rainfall occurs soon after application of urea because of very slow rate of urea hydrolysis in these soils

Sharma (1990) reported that there is increase in leaching of N in relatively heavier soil by addition of FYM which may be due to increase in porosity. but no significant effect was observed when FYM was added to light textured soil. He reported that leaching loss of N (ammonium sulfate) increased from 14.2 to 30.9 % with decrease in clay content from 22.2 to 9.2 %. He also observed a highly significant correlation between rainfall ($r = 0.96^{**}$), clay content ($r = 0.82^{**}$), available and applied N ($r = 0.76^{**}$) and leaching of N.

2.2 Denitrification

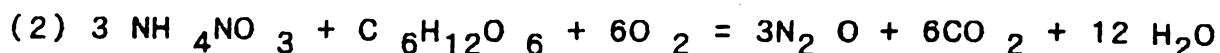
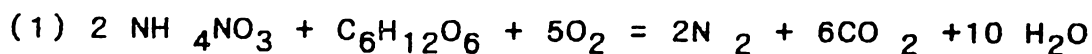
Denitrification is one of the most important pathways of nitrogen loss in wet land rice soils. Nitrate added to soil or formed from soil organic N pool is

microbially reduced to gaseous N_2 and N_2O and is lost from the system under anaerobic soil conditions. Denitrification is also supposed to be active in anaerobic sites in apparently aerobic soil systems. The bacteria use oxygen from nitrite or nitrate for respiration and this "nitrate respiration" result in loss of N in gaseous form mainly as N_2 and N_2O and in some cases NO.

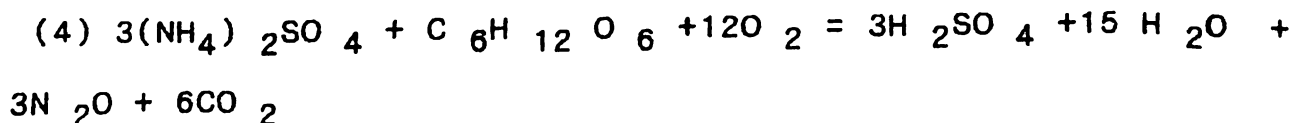
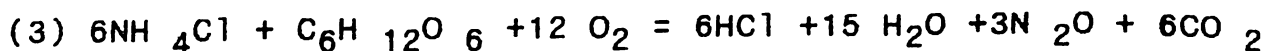
Denitrification in soil is affected by pH, moisture regime, oxygen concentration, temperature and organic matter content of the soil.

Mishra and Mishra (1988) conducted soil column study in field and laboratory condition and concluded that liming the soil led to higher rate of nitrification and lower amount of adsorption of added ammonium-N during leaching of ammonium-nitrate, thus detecting more amount of ammonium-N at lower profile depth than at surface. But in unlimed soil greater adsorption ammonium-N in surface layer is seen.

They also reported the rate of nitrification to be higher in case of ammonium nitrate than ammonium sulfate and ammonium chloride. This may be due to the fact that nitrification and denitrification are likely to proceed simultaneously according to any one of the following reaction steps:-



The dinitrification reaction taking place will tend to neutralize the resultant local acidity due to production of HNO_3 that would otherwise hindered the nitrification process. But such thing does not happen in case of ammonium chloride or ammonium sulfate. The oxidation reactions for these cases can be represented as :



The higher amount of transient local acidity created in the case of ammonium chloride or ammonium sulfate as compared with that in case of ammonium nitrate probably hinders or suppresses the nitrifying microbial activity.

Saharwat (1992) conducted an incubation study in laboratory condition and reported that nitrification of ammonium varies with pH. 78% of applied urea was nitrified in vertisol (pH =8.35), 64% in alfisol -1 (pH =6.2) and 1% in alfisol -2 (pH =4.5). He further reported that two acid sulfate soils (pH =3.4, 3.7) and an acid soil (pH = 4.4) did

not nitrify at all during four weeks. Mineral and organic soils having pH greater than 6.0 nitrified the soil ammonium at rapid rates. So nitrification takes place at lower rate in soil having pH less than 5.0 and that an acid soil is deterrent to nitrification.

He also stated that in vertisol (pH =8.35) rate of nitrification was 10.3mg nitrate -N per kg of soil per day was attained between 3rd and 7th day; while in alfisol -1 (pH =6.2) it was attained between 7th and 10th day with a value of 6.4 mg nitrate -N per kg of soil per day. The alfisol -2 (pH =4.5) had a very very slow rate of nitrification during 10 days incubation study.

Suresh et al. (1994) reported that in wetland rice soil very little amount of ammonium is oxidised to nitrate due to reduced conditions and mineralization of N ferts proceeds up to formation of ammonium -N. Thus nitrate -N constitute the least amount in the leachate than ammonium -N and amide -N when urea is applied to wet land rice.

Sims et al. (1967) suggested that the nitrogen mineralization under water logged conditions as an index of the N fert requirement of rice growing soils.

Senapati et al. (1992) reported that the transformation of nitrogen to a great extent is influenced by

water regimes. In urea treated soils, with increase in moisture content, the quantity of ammonium -N produced remained almost constant upto 90% of waterholding capacity. But with standing water, highest amount of ammonium -N was formed. With FYM, the added nitrogen after mineralization is transformed to nitrate -N quickly. The growth of microbes likes Basillus, Pseudomonas, Clostridium are not affected under water logged condition. Thus ammonia liberated is directly assimilated by the rice plant and a small part of it fixed by soil clay, but a bulk of it is converted to nitrite and nitrate. The quantity of nitrite produced in soil was low. The quantity of nitrite was slightly higher in presence of FYM and urea. The highest amount of nitrate -N was found at 40% saturation and least at water logging. And Simillar results were obtained by Alexander (1961).

2.2.3 Ammonia Volatilisation

Part of the applied ammonium or the ammonium hydrolysed from urea can be lost through ammonia volatilisation if the pH of the soil is high. Urea is hydrolysed by soil urease to ammonium carbonate which provide its own alkalinity for loss of ammonia through volatilisation.

The magnitude of ammonia volatilisation depends upon

pH, clay, CEC, temp., urease activity etc. (Terman 1979) and can be expected to be considerably high in calcareous, saline and sodic soils (Gandhi, Paliwal, 1976; Singh and Bajwa 1987). Significant ammonia loss from flooded sodic soils have been reported by Sahrawat (1980), Rao and Batra (1983).

Ammonia loss is also influenced by organic ammendments and biofertilizers particularly due to their effect on urease enzyme (Dalal 1975).

Higher loss of ammonia due to BGA might be due to algal growth on the surface of rice fields which accelerated period of volatilisation arising from removal of carbon dioxide from flood water and concomitant rise in pH (Mikkelsen and DeDatta 1979).

Singh and Prasad (1992) reported that after application of N ferts, in submerged rice soil cumulative loss of ammonia decrease with increase in floodwater height and increase with application of BGA and application of N at higher doses. The loss followed the order BGA > FYM > BGA + FYM.

They have also reported cumulative losses of ammonia at different period followed a pseudo first order reaction. They have recorded the peak cumulative ammonia loss at 12th day which declined to zero at 15th day.

The lower loss of volatilization from FYM and FYM + BGA may be due to exchange reactions and biological immobilization of ammonium (Singh and Singh 1987).

Sahrawat (1992) reported that the hydrolysis of urea to ammonia creates alkalinity and this could lead to the gaseous loss of ammonia. The volatile loss of ammonia was 14% of added N in vertisol (pH =8.35), 6% of added N in alfisol -1 (pH =6.2) and 2% of added N in alfisol -2 (pH =4.5).

Sankaracharya and Mehta (1969) reported the volatilization loss to be 58% at 15% WHC and 34% at 75% WHC in a loamy sand soil.

Higher loss values have been reported generally with urea than with ammonium sulfate and slow release N fertis. (Basudev and Gangwar 1976). Placement of fertilizer deep in soil has been reported to reduce such losses (Sarkar and Singh Verma 1973; Jena et al. 1993). Gupta (1955) reported that about 22% of 66kg N/ha applied as ammonium sulfate was lost as ammonia gas from a flooded soil of pH 8.4 .

Fenn and Kissel (1975) and Vlek and Stumpe (1978) reported significant loss of ammonia by volatilization resulting from liming the soil. The loss would be maximum if a

soil contains at least 6% calcium carbonate either as a soil component or as external dressing.

Martin and Chapman(1951) reported higher rate of ammonia loss in K and Na saturated soil than in Ca or Mg saturated soil, possibly because of higher pH in former than latter case.

The driving force for ammonia volatilization from a moist soil (or solution) is normally considered to be the difference between the partial pressure of ammonia in equilibrium with the liquid phase and that in the ambient atmosphere (Denmead et al. 1982). The equilibrium vapour pressure of ammonia is controlled by ammonia concentration in the adjacent solution which in absence of other ionic species is affected by ammonium ion concentration and pH.

It is reported that the higher is the pH, the loss through ammonia volatilization is more (Sahrawat 1980). Similarly a soil with lower CEC and high temp. favours increased loss of ammonia from N ferts (Singh Verma and Sarkar 1974, Daftardar and Shinde 1980).

Santra et al. (1988) reported that ammonia volatilization was in the order of urea basal > neem cake coated urea > lac coated urea > urea split > dhanicha + urea (1:1 N basis) in both kharif and rabi. They further reported

that in rabi volatilization loss of ammonia was higher than in the kharif which may be due to clear sunshine, clear flood water in rabi leading to increased photosynthetic activity of submerged biomass and thus increasing pH of flood water.

Mikkelson et al. (1978) observed nitrogen losses as ammonia gas to be 20% from fertilizer broadcasted into floodwater on a fertile neutral soil.

Singh and Bajwa (1978) reported as high as 43% volatilization loss of applied N (prilled urea) in sodic soil (Kotli -Amb. soil). He stated that such ammonia loss were controlled by pH of soil ($r = 0.947^{**}$); flood water pH ($r = 0.75^{**}$) and alkalinity ($r = 0.948^{**}$). They also stated that ammonia loss to be greater from light textured soil at similar pH values.

Sannigrahi and Mandal (1988) reported that from volatilization loss point of view crotonylidene diurea (CDU) is significantly superior to urea, lac coated urea, isobutylidene diurea and urea-form under submerged conditions. They recorded only 0.88% of added N volatilized in case of CDU. They further reported that urea form and IBDU has got some advantage over urea and LCU in initial period but on long run they are at par. The mineralization of CDU is

very slow even under alkaline condition.

Sharma et al. (1992) reported that volatilization loss from N fertis decreased from field capacity to flooding but increased with increase in ESP values at all moisture levels. They also reported addition of 1% organic matter to alkaline soil (pH =8.3) reduces ammonia volatilization as more NH_4^+ gets adsorbed to organic colloids. However Reddy and Chhonkar (1991) reported that addition of 5% organic matter to a nearly neutral soil (pH =7.6) increased urease activity, thus volatilization of ammonia.

Jena et al. (1994) reported that the volatilization loss is influenced by soil pH. They stated that during kharif the volatilization loss of ammonia goes on decreasing from transplanting to tillering to P.I. stage but reverse in rabi season rice. This may be due to the fact that the atmospheric temp. and thus flood water temp. goes on decreasing from transplanting to tillering to P.I. stage in kharif rice but in a reverse way increase of rabi rice.

They have also reported that when FYM was added with PU the ammonia volatilization gets increased due to increase in urease activity. They have also recorded lower ammonia volatilization (2.1 -3.3% of added N) increase of deep placed USG than surface applied PU (6.51 - 8.49% of added N).

2.3 EFFICIENCY OF N FERTS IN SUBMERGED RICE CULTURE.

The presence of oxidised and reduced soil layers makes a flooded soil a unique system in which both aerobic and anaerobic nitrogen transformations can occur in close proximity. In a flooded field nitrogen is markedly susceptible to losses resulting in poor utilization of fertilizer N by rice. Flooded rice generally recovers less than 40% of fertilizer N (De Datta et al. 1971; Craswell and Vlek 1979).

Dhyani and Mishra (1993) reported that N uptake was lower with basal application than with top dressing the same amount at the late tillering and P.I. stage. This may be due to higher N loss through ammonia volatilization and apparent denitrification from the basal application of urea than from the top dressing. Higher plant recoveries (36.3-39%) of nitrogen applied at later growth stages or in three splits than single dressing may be attributed to efficient absorption of applied N by the plants due to presence of excessive root system at later growth stages. Simillar result were reported by De Datta et al. (1968) and Khind and Datta (1975).

Dhyani and Mishra (1993) also reported that more amount of applied N remained in the soil and plant roots in treatments receiving fertilizer N at P.I. stage while it was

lowest with basal dressing.

Mishra et al. (1994) reported that basal application of prilled urea is significantly inferior to split application of prilled urea. They also reported that split application of prilled urea and deep placement of USG at 20 DAT produced similar effect on the recovery of N by rice in a sandy clay loam textured low land soil.

Nayak and Panda (1994) reported that in a rainfed intermediate low land rice single basal application of urea at the time of sowing, preferably as band placement of prilled urea in solid or solution form in seed furrows was significantly better than broadcasting of prilled urea at the rate of 60kg N per hacter at active tillering.

Racho and De Datta (1968) reported that apparent recoveries of fertilizer N in flooded soil ranged from 17-57% for dry season. Mandal and Dutta (1981) reported a total recovery by rice in flooded rice soil from 41 -47 % depending upon ammonium to nitrate ratio in the fertilizer.

Vlek and Byrnes (1986) reported that fertilizer N recovery by flooded rice is seldom more than 40% where as upland crops normally recover about 40- 60% . Jipelos (1989) observed that rice from flooded alluvial soil recovered as much as 22 -65% of applied 15N prilled urea.

Goswami et al. (1988) reported that due to incorporation of Sesbania aculeata, recovery of fertilizer N by rice was 60 -61% as compared to 35.4% from soil without green manuring. The labeled fertilizer was applied @ 120 kg N/ha.

Tyagi et al. (1992) reported that total N uptake (grain +straw) in rice was found higher due to urea than with Ankur (a liquid N fert with 32% N in amide , ammonium and nitrate form). When Ankur was applied with urea @ 60kg /ha , the total N uptake was found slight higher than Ankur alone. Grain yield was found to be correlated significantly with N content at P.I. stage, total N up take and total dry matter yield.

Ali and Singh (1994) reported highest grain yield with USG (deep placed) followed by USG broad casted and incorporated followed by urea adduct than by PU splits. This may be due to reduced ammonia volatilization and nitrification (Craswell and De Datta 1980).

Schiner et al. (1987) reported 61 -66% recovery of labeled fertilizer nitrogen by rice. Phongspan (1988) observed and average 29 -47% of fertilizer N recovery by grains and 12 -20 % by straw.

Mukherjee and Mandal (1994) observed from a green house experiment with rice (IR 36), the recovery of ^{15}N from

fertilizer urea by rainfed rice ranges from 16.2 to 38.0% . They also suggested that ^{15}N recovery from fertilizer was maximum under continuously submerged condition and being lower down with increased imposition of water stress. The recovery was in the order of continuous submergence > late stress > continuous drought > earlier stress.

Apparent recovery of applied N by rice happened to be 34.3% in the experiments under taken in IARI (Fertilizer News, Feb1982) and 39.56% in experiments conducted under the PL 480 project at O.U.A.T. Bhubaneswar. However the apparent N recovery through the application of USG point placement in the rootzone of rabi rice was recorded as 54% (Anonymous , 1989)

Meelu et al. (1990) reported the response of rice to urea, ammonium sulfate, ammonium chloride to be similar but better than nitrate N sources.

Misra and Pyare (1994) reported application of 45kg N /ha as combination of 2/3rd N basally through NCU followed by top dressing of 1/3rd N as PU at P. I . stage recorded the highest grain and straw yield which were comparable to those obtained with 3 splits of PU at 60kg N /ha. The NCU +PU combination had higher efficiency of N usage , number of panicles per square meter and filled

grains per panicles but lower spikelet sterility than 3 splits of PU at simillar doses of N.

Bandyopadhyay (1993) evaluated the efficiency of different urea based N fertis i.e USG, GCU, UNP (27 -9 -0) and UNP (19 -19 -0) in rabi rice. The grain yield N uptake ,agronomic efficiency and apparent N recovery percent due to USG application was found at par with 3 splits of PU at equal nitrogen level.

Sahu (1994) reported that the grain yield of rice due to USG application was significantly superior to PU,GCU, UNP (27 -9 -0),UNP (19 -19 -0),PU +ECC and gromer +PU treaments for equal doses of nitrogen.

Suresh et al. (1994) reported that higher doses of PU recorded highest straw yield and N uptake due to excessive vegetative growth,less productive tillers and poor partioning of N for grain development.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

MATERIALS

3.1 General physicochemical properties of experimental site

The field experiments were conducted in a medium land and low land site of Central Research Station, Orissa University of Agriculture & Technology, Bhubaneswar, Orissa. (20°5'N latitude, 85°50'E longitude at 100 m above mean sea level). The general physical and chemical properties of experimental site are listed in Table-1.

3.2 Field Experiments:

During Kharif 1994, two field experiments were conducted in the medium land and low land situation with rice as the test crop to evaluate the efficiency of prilled urea and urea super-grannule under different management practices.

The experiments were laid out in a randomised block design (RBD) with three replications.

The treatments allocated to medium land (Plot size = 4.5 x 4 m²) experiment were :-

T₁ : Control (No)

T₂ : 38 kg N/ha as PU (3 splits)

T₃ : 58 kg N/ha as PU (3 splits)

- T₄ : 76 kg N/ha as PU (3 splits)
T₅ : 38 kg N/ha as USG (7 DAT - 7 days after transplanting)
T₆ : 58 kg N/ha as USG (7 DAT)
T₇ : 76 kg N/ha as USG (7 DAT)

The treatments allocated to low land experiment were :-

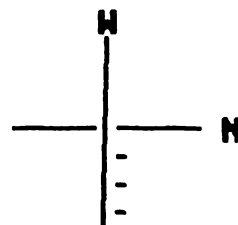
- T₁ : Control (No)
T₂ : 58 kg N/ha (2/3rd N as USG at 7 DAT+
1/3rd N as PU at P .I.)
T₃ : 76 kg N/ha (2/3rd N as USG at 7 DAT+
1/3rd N as PU at P.I.)
T₄ : 95 kg N/ha (2/3rd N as USG at 7 DAT+
1/3rd N as PU at P.I.)
T₅ : 58 kg N/ha as USG (7 DAT)
T₆ : 76 Kg N/ha as USG (7 DAT)
T₇ : 95 kg N/ha as USG (7 DAT)

The detailed lay out plan of both experiments are presented in Fig 1 (a) and Fig 1 (b).

25 days old rice seedlings (cultivar lalat) were transplanted at 20 x 15 cm spacing in PU treatments. Modified spacing of 20 x 15 cm according to IFDC design (Anonymous, 1990) was followed for USG placement. Fig 2 (a,b,c,d).

LAYOUT PLAN OF MEDIUM LAND KHARIF RICE EXPT.

FIG:1(a)



T1	T3	T6	T2	T5	T4	T7
T2	T5	T1	T4	T7	T3	T6
T3	T6	T2	T5	T4	T7	T1

TREATMENTS:-

- T1:CONTROL (NO NITROGEN)-
- T2:38Kg N/ha AS PU (3 SPLITS)
- T3:58Kg N/ha AS PU (3 SPLITS)
- T4:76Kg N/ha AS PU (3 SPLITS)
- T5:38Kg N/ha AS USG(7 DAT)
- T6:58Kg N/ha AS USG(7 DAT)
- T7:76Kg N/ha AS USG(7 DAT)

LAYOUT PLAN OF LOW LAND KHARIF RICE EXPT.

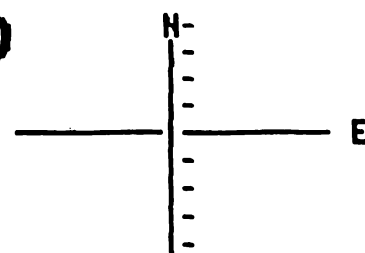


FIG:1(b)

T6	T4	T5	T3	T7	T2	T1
T1	T7	T6	T5	T2	T4	T3
T2	T4	T6	T3	T5	T7	T1

TREATMENTS:-

T1: CONTROL (NO N)

T2: 58Kg N/ha (2/3rd N AS USG AT 7DAT + 1/3rd N AS PU AT P.I.)-

T3: 76Kg N/ha (2/3rd N AS USG AT 7DAT + 1/3rd N AS PU AT P.I.)-

T4: 95Kg N/ha (2/3rd N AS USG AT 7DAT + 1/3rd N AS PU AT P.I.)-

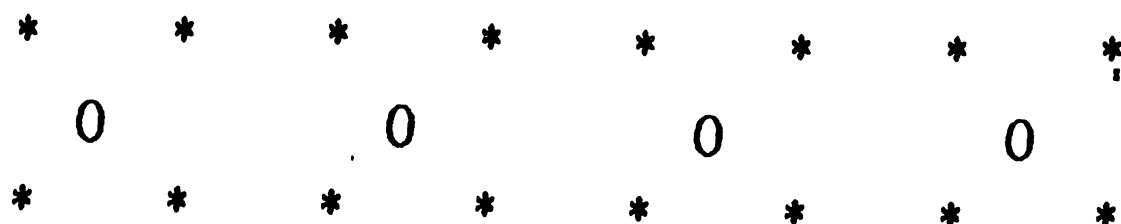
T5: 58Kg N/ha AS USG (7DAT)§

T6: 76Kg N/ha AS USG (7DAT)§

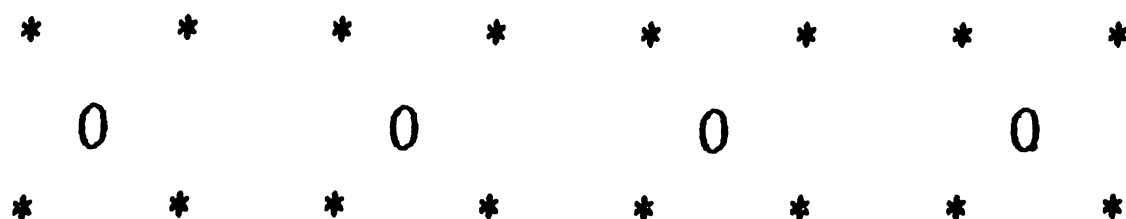
T7: 95Kg N/ha AS USG (7DAT)§

PLACEMENT PATTERN OF USG

N DOSE : 38 Kg N/ha



TRAFIC LINE



Legend: *=Rice hill, 0=USG 1gm grannule

Fig. 2(a) Placement pattern of USG applied at the rate of 38 kg N/ha.

PLACEMENT PATTERN OF USG.

N DOSE : 58 Kg N/ha

*	*	*	*	*	*	*	*
00		0		00		0	
*	*	*	*	*	*	*	*

TRAFIC LINE

*	*	*	*	*	*	*	*
00		0		00		0	
*	*	*	*	*	*	*	*

Legend: *=Rice hill, 0=USG 1gm grannule

Fig. 2(h) Placement pattern of USG applied at the rate of 58 kg N/ha

PLACEMENT PATTERN OF USG

N DOSE : 76 Kg N/ha

*	*	*	*	*	*	*	*
00		00		00		00	
*	*	*	*	*	*	*	*

TRAFFIC LINE

*	*	*	*	*	*	*	*
00		00		00		00	
*	*	*	*	*	*	*	*

Legend: *=Rice hill, 0=USG 1gm grannule

Fig. 2(c) Placement pattern of USG applied at the rate of 76 kg N/ha

PLACEMENT PATTERN OF USG

N DOSE : 95 Kg N/ha

*	*	*	*	*	*	*	*
000		00		000		00	
*	*	*	*	*	*	*	*

TRAFFIC LINE

*	*	*	*	*	*	*	*
000		00		000		00	
*	*	*	*	*	*	*	*

Legend: *=Rice hill, 0=USG 1gm grannule

Fig. 2(d) Placement pattern of USG applied at the rate of 95 kg N/ha

Muriate of Potash @ 50 kg K_2O /ha and single super phosphate @ 50 kg P_2O_5 /ha were applied at the time of transplanting.

USG was point placed at 5 cm soil depth (approx.) after 7 days of transplanting. Prilled urea was surface broadcasted at transplanting, tillering & P.I. stages @ 1:2:1 proportion.

3.2.1. : Soil solution sampler :

Soil solution samplers of hard p.v.c. pipes (I.D. = 4 cm) glued to a porous ceramic cup at lower end and fitted with a rubber stopper at upper end were installed at a depth of 10 cm soil in between 2 rows of rice plant in T_1 , T_4 , T_7 treatments (replication-2) of medium land experiment in order to monitor the changes in concentration of amide-N, ammonium-N in the rootzone of rice.

3.2.2. Collection of flood water and soil solution samples:

Flood water samples were collected at a depth of 1.5 cm from water surface at four randomly selected spots in T_1 , T_4 , T_7 (rep.-2) treatments of medium land experiment at 0h (before N-application), 3h, 6h, 9h, 12h, 15h, 18h, 21h, 24h, 48h, 72h, 96h, 120h, 144h, 168h, 192h after fertilizer-N application with the help of a 20 ml pipette. Soil solution samples were collected simultaneously at 10 cm soil depth



Photoplate No. 1. Collection of flood water and soil solution samples from experimental plot.

from soil solution samplers. 1-2 drops of 50 ppm phenyl mercuric acetate (PMA) solution was added to each sample to inhibit microbial growth. These samples were kept in the refrigerator and were analysed for $\text{NH}_2\text{-N}$, $\text{NH}_4\text{-N}$ & $\text{NO}_3\text{-N}$.

3.2.(c) Collection of plant and soil samples :

Over ground plant samples at 21 DAT, 31 DAT and panicle initiation (P.I.) stage as well as flag leaf and grain and straw at harvest were collected from each treatments. These samples were oven dried at 60°C , ground by willey mill through 30 mesh seive and analysed for total-N.

After harvesting(at 5 DAH,12DAH and 17DAH) soil samples from 0-15 cm (surface layer) and 15-30cm (sub surface layer) were collected from the medium land by an augur from 5 spots randomly from T4 and T7 treatments(Rep-2) and are subjected to incubation study to know the inorganic N status.

3.2.(d) Biometric observations :

Biometric observations such as plant height, effective tiller number/hill and panicle length were recorded for ten plants in each treatment. The per cent sterility was also calculated for each treatment.



Photoplate No. 2. Taking biometric observation
after harvesting kharif rice.

3.3 Laboratory experiments:

3.3.1. Incubation study :

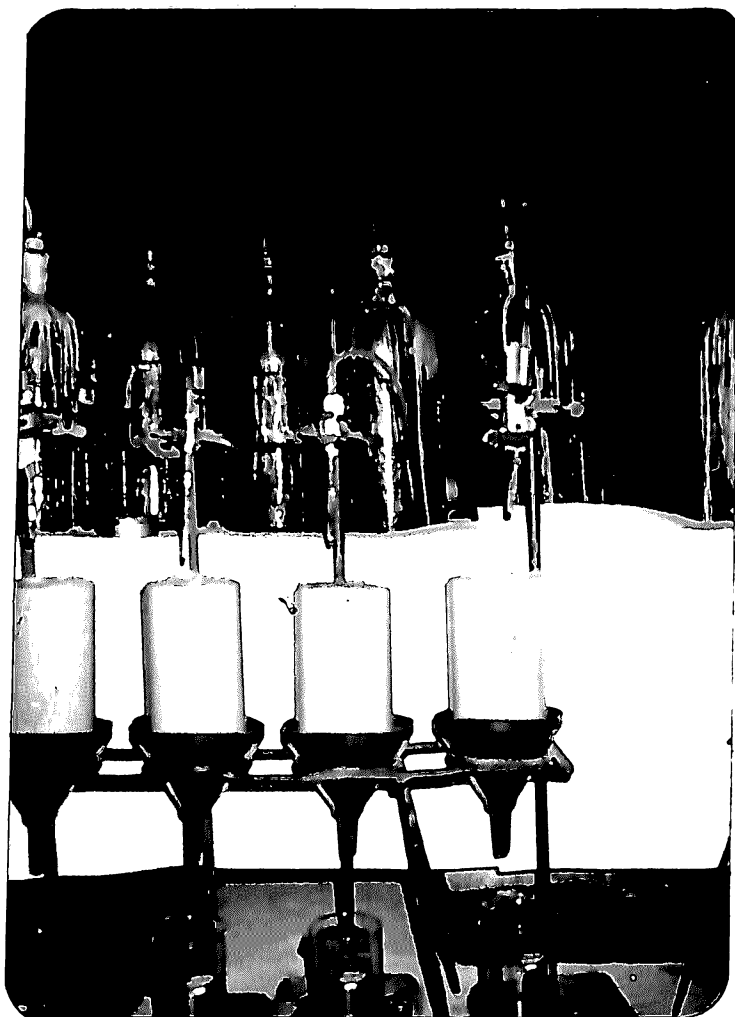
A laboratory incubation study was undertaken in order to know the N-status of soil in T_4 and T_7 treatments following harvest of medium land kharif rice. Soils from T_4 and T_7 treatments (Rep-2) were sampled at 0-15 cm and 15-30 cm depth and incubated at 30°C with P_2O_5 K_2O @ 50 kg/ha under saturated conditions for 72 hours. Then the soil is extracted with 200 cc 2 M KCl.PMA. The extracts were stored at 5°C aseptically and subsequently analysed for NH_4^+-N and NO_3^-N .

This study was continued for 3 weeks at one week intervals.

3.3.2. Leaching Study

Setting up of columns

Three No. of p.v.c. columns (I.D = 9 cm, 15 cm high) were taken and glued to Watman No.42 filter paper at their lower ends. Soils (finely ground, 200 mesh sieved) of RSS, Bhubaneswar(Alfisol), Chiplima(Entisol) and Ranital(Inceptisol) were packed in these columns, 1 cm layer by layer up to 14 cm at their natural B.D. values.



Photoplate No. 3. Laboratory set up of Leaching Experiment.

Preparation of Leaching solution :

25 litres of 0.01N CaSO_4 solution was prepared in a carboy by magnetic stirring.

Soaking of soil column:

In a china clay basin, 0.01N CaSO_4 solution (around 5 litre) was taken and the soil columns were kept in it in order to allow soaking from bottom upwards, so as to drive out the pore air as completely as possible. It was continued for 10-12 hr. when upper surface of soil column was observed to be wet, the process was terminated. A thin layer of glass wool was spread over the surface of each soil column. Soil column were then kept in buchner funnels over tripoid stands under the capillary tubes of Marriott device.

Marriott device and Leaching of soil columns :

Winchester bottles of 2.5 litre capacity filled with 0.01N CaSO_4 solution (which served as the leaching solution) were employed to leach soil columns. The Winchester bottles were made perfectly air tight by rubber corks fitted to the mouths of the bottles and sealed with paraffin wax. Two long glass tubes of uniform diameter were inserted into each bottle through the rubber cork such that they almost reached the bottom. One of them acted as solution delivery tube and the other served as the air inlet. A capillary tube

was fitted to the outlet by a rubber tubing.

The velocity of solution flow was maintained by adjusting the hydraulic head difference between inlet and outlet of the device, as per Poiseuille's equation.

$$Q = \frac{-\pi R^4 \int g}{8\eta} \left(\frac{h + L}{L} \right)$$

where Q = amount of discharge (cc/sec)

L = length (cm) of capillary tube.

R = radius (cm) of capillary tube

$\int$ = density (gm/cc) of solution

g = acceleration due to gravity (cm/sec²)

h = pressure head (cm)

η = coefficient of viscosity (gm/cm.sec)

Periodically the solution flow rates were checked and were maintained by varying the difference in the pressure head, if necessary.

0.01N CaSO₄ solution from the Mariott bottle was allowed to drip continuously on the soil columns (surface of which kept covered with a layer of glass wool). After 2-3 days of leaching, the soil columns were assumed to be Ca⁺² saturated. By this time, the influent and effluent velocities also became equal. The columns were then ready for leaching with N-pulses.

Application of Pulse :

Immediately before application, solution containing 400 PPMN of ^{15}N PU, was prepared. These solutions were filled in 3 separate burettes. Individual soil column got the pulse (15 c.c.) at the rate of outflow velocity of leaching solution for one hour.

Then the leaching of soil columns with 0.01N CaSO_4 solution from Marriott device continued for 24 hrs.

Collection of Leachates :

Leachates were collected hourly up to 24 hr in collection tubes. 1-2 drops of 50 ppm PMA solution was added. Each tube was closed with sterilised cotton and stored in refrigerator at 5°C . They were subsequently analysed for NH_4^+-N , NO_3-N and NH_2-N .

KCl-PMA extraction of soil columns :

After collection of leachates up to 24 hr, the soil columns were removed and sectioned into 4 equal slices. Approximately 30 gm from each soil slice was extracted with 200 c.c of 2 M KCl-5 PPM PMA solution and kept in refrigerator at 5°C for subsequent determination of NH_2-N , NH_4-N and NO_3-N . A separate sample was kept for each slice for moisture determination.

3.4 EXPERIMENTAL METHODS (PHYSICAL) :

3.4.1 Bulk Density (BD)

Bulk density of the experimental soil was determined by core method (Black, 1965).

3.4.2 Particle size analysis:

Particle size analysis was done by hydrometer method (Piper, 1950).

3.5 EXPERIMENTAL METHODS (CHEMICAL) :

3.5.1 Soil pH:

The pH of the soil (1:2 ratio) was determined by means of glass electrode with the help of an Elico make digital pH meter.

3.5.2 Electrical Conductivity (EC):

The electrical conductivity of soil water suspension (1:2 ratio) was determined by means of an Elico make conducting bridge.

3.5.3 Cation Exchange Capacity (CEC):

Cation exchange capacity of the soil was determined by the method described in 'Soil Chemical Analysis' (Black, 1965).

3.5.4 Organic carbon :

Organic carbon content of the soil was determined by Walkley and Black's rapid titration method following Jackson (1973).

3.5.5 Available phosphorous :

The available P content of the soil was determined following Olsen's method employing NaHCO_3 extraction buffered at pH 8.2 (Jackson, 1973).

3.5.6 Available N of Soil :

Available N content of soil was determined by alkaline KMnO_4 method (Subia and Asija,).

3.5.7 Total N Content in Plant Sample

Total N content of plant sample was determined following the method outlines in AOAC (1970). The results were expressed on dry weight basis (60°C).

3.5.8 Estimation of $\text{NH}_2\text{-N}$, $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ content of soil/flood water/Soil solution :

Immediately after collection, the soil samples weighing 20 gm were taken in 250 ml Conical flasks containing 200 ml of 2M KCl -5ppm PMA solution. Then the flasks were shaken by a mechanical shaker (International make) for one hr. The suspensions were then filtered through Watman No.1 filter paper and the filtrate was collected in

another flask with proper label. These filtrate samples were kept in refrigerator at 5°C and subsequently analysed for $\text{NH}_2\text{-N}$, $\text{NH}_4^+\text{-N}$ and $\text{NO}_3\text{-N}$.

3.5.8.1. Estimation of $\text{NH}_2\text{-N}$:

The $\text{NH}_2\text{-N}$ content of soil-extract , flood water and soil solution was determined colorimetrically following modified diacetyl-monoxime method (Mulvaney and Bremner, 1979).

3.5.8.2. Estimation of $\text{NO}_3\text{-N}$ in flood water and soil solution :

The estimation of NO_3 in flood water and soil solution was determined colorimetrically by 2,4 phenol disulfonic acid method (Jackson, 1973).

3.5.8.3. Estimation of $\text{NH}_4\text{-N}$ and $\text{NO}_3^-\text{-N}$ in KCl-PMA extract:

The estimation of $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ was carried out in the KCl-PMA extract following the methods described by Black (1965).

3.5.8.4. Estimation of $\text{NH}_4^+\text{-N}$ in flood water, soil solution and KCl-PMA extract :

The estimation of $\text{NH}_4\text{-N}$ in flood water, soil solution and KCl-PMA extract (leaching study) was made colorimetrically by Indophenol blue method (Dorich, Nelson, 1983).

3.5.9 Nitrogen Use Efficiency Parameters :

Three Nitrogen use efficiency parameters were used in this study.

(A) Agronomic efficiency (AE):

$$A.E. = \frac{Y_T - Y_O}{N_F}$$

where Y_T = Yield in treatment (kg/ha)
 Y_O = Yield in control (kg/ha)
 N_F = N supplied by fertiliser (kg/ha)

(B) Relative efficiency (RE):

$$R.E. (\%) = \frac{Y_T - Y_O}{Y_S - Y_O} \times 100$$

where Y_S = Yield of standard source.

(C) Apparent N recovery (ANR)

$$ANR (\%) = \frac{U_T - U_O}{N^F} \times 100$$

where U^T = N uptake in treatment (kg/ha)
 U^O = N uptake in control (kg/ha)
 N^F = N supplied by fertilizer (kg/ha).

CHAPTER IV

RESULTS AND DISCUSSION

RESULT AND DISCUSSION

Field experiments were conducted in medium and low land site of the Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar, Orissa during kharif season 1994 in order to compare the efficiency of PU/USG under different management practices. Attempts were also made to compare the transformation pattern of urea based nitrogen fertilizers in the field and laboratory condition.

4.1. PHYSICAL AND CHEMICAL PROPERTIES OF THE EXPERIMENTAL SOIL

The physical and chemical properties of the soil collected from experimental sites (Medium land /low land) are presented in table-1. As it is observed from the table the texture of the surface soil (0-15cm) of the experimental site are observed to be silt loam.

The steady state infiltration rate of the experimental soil measured by other workers was observed to be 0.67 cm/h for low land (Sahu 1994; Bandyopadhyay, 1993).. The pH_w of the medium land and lowland was 6.8 and 6.4 respectively being close to neutrality. which resembles a typical medium land submerged rice soil around Bhubaneswar.

The electrical conductivity value of the surface

Table 1. PHYSICAL AND CHEMICAL PROPERTIES OF THE SURFACE SOIL(0-15cm) BEFORE START OF THE EXPERIMENT.

	Physical and chemical Properties	
	Medium Land	Low Land
Sand	73.8	71.76
Silt(%)	14.0	26.00
Clay	12.2	2.24
Texture	Siltyloam*	Silty loam**
B.D.(g/cm ³)	1.69	1.71
pH _w (1:2)	6.8	6.4
EC(dsm ⁻¹)	0.12	0.45
CECCmol(p ⁺)/kg	5.0	6.0
Org C(%)	0.45	0.99
Total N(kg/ha)	855	1250
Available-N-(kg/ha)	298	310
Exch.NH ₄ - N(kg/ha)	72.34	76.22
Available P ₂ O ₅ (kg/ha)	29.5	33.45
Available K ₂ O (Kg/ha)	214	242

* Bandhyopadhyay (1993)

* Sahu (1994)

soil of both sites (0.12 and 0.45 ds m^{-1}) indicates its non saline nature. The organic carbon, total nitrogen, available nitrogen and $\text{exch. NH}_4\text{-N}$ content of surface soil of medium land is 0.45% , 855 kg/ha , 298 kg/ha and 72.34 kg/ha respectively as compared to 0.99% , 1250 kg/ha , 310 kg/ha and 310 kg/ha for low land.

Olsen's available P_2O_5 and IN ammonium-acetate extractable K_2O of the surface soil for both sites are observed to be medium to high.

Based on these soil characteristics and other morphological feature of the profile, the medium/low land site of the central Research station has been classified to be a member of fine loamy mixed hyperthermic family of haplaquept.

4.2. RICE GRAIN AND STRAW YIELD IN MEDIUM LAND:

Table 2 and 3 list the grain and straw yield data of medium land kharif rice with ANOVA. Fig 3 gives the graphical representation of different doses of N with grain yield, straw yield, total grain and straw yield for the same situation.

The mean grain yield data due to application of 58 kg N/ha as USG in T_6 and PU is T_3 is observed to be 43.38 and 39.31 q/ha (Table 2) respectively. The computed

Table 2. GRAIN YIELD OF MEDIUM LAND KHARIF RICE

TREATMENT	GRAIN YIELD (q/ha)				
	R1	R2	R3	Mean	
T1.Control(No)	34.27	31.00	36.66	33.98	
T2.38kg N/ha as PU (3splits)	36.57	32.03	35.26	34.62	
T3.58kgN/ha as PU (3splits)	42.30	37.93	37.71	39.31	
T4.76kgN/ha as PU (3splits)	35.59	38.76	34.37	36.24	
T5.38KgN/ha as USG (7DAT)	36.60	36.56	35.39	36.18	
T6.58kgN/ha as USG (7DAT)	43.46	47.77	38.62	43.28	
T7.76KgN/ha as USG (7DAT)	38.80	43.49	35.34	39.21	
ANOVA					
Source	Degree of freedom	Sum of Square	Mean Sum of Square	Calculated F value	Table Fvalue at 5% error
Treatment	6	191.02	31.84	3.54	3.00
Replication	2	19.25	9.62	1.07	3.88
Error	12	107.81	8.98		
CD (5%) = 5.32					
CV (%) = 7.98					

Table 3. STRAW YIELD OF MEDIUM LAND KHARIF RICE

TREATMENT	GRAIN YIELD (q/ha)				
	R1	R2	R3	Mean	
T1.Control(No)	37.60	34.75	31.47	34.61	
T2.38kg N/ha as PU (3splits)	40.49	33.68	37.63	37.27	
T3.58kgN/ha as PU (3splits)	48.50	45.14	44.92	46.19	
T4.76kgN/ha as PU (3splits)	39.03	45.56	40.04	41.54	
T5.38KgN/ha as USG (7DAT)	41.47	35.50	42.72	39.90	
T6.58kgN/ha as USG (7DAT)	46.70	47.24	42.76	45.57	
T7.76KgN/ha as USG (7DAT)	44.44	44.97	48.83	46.08	
ANOVA					
Source	Degree of freedom	Sum of Square	Mean Sum of Square	Calculated F value	Table Fvalue at 5% error
Treatment	6	382.29	63.72	6.52	3.00
Replication	2	10.92	5.46	0.56	3.88
Error	12	117.27	9.77		
CD (5%) = 5.56					
CV (%) = 7.51					

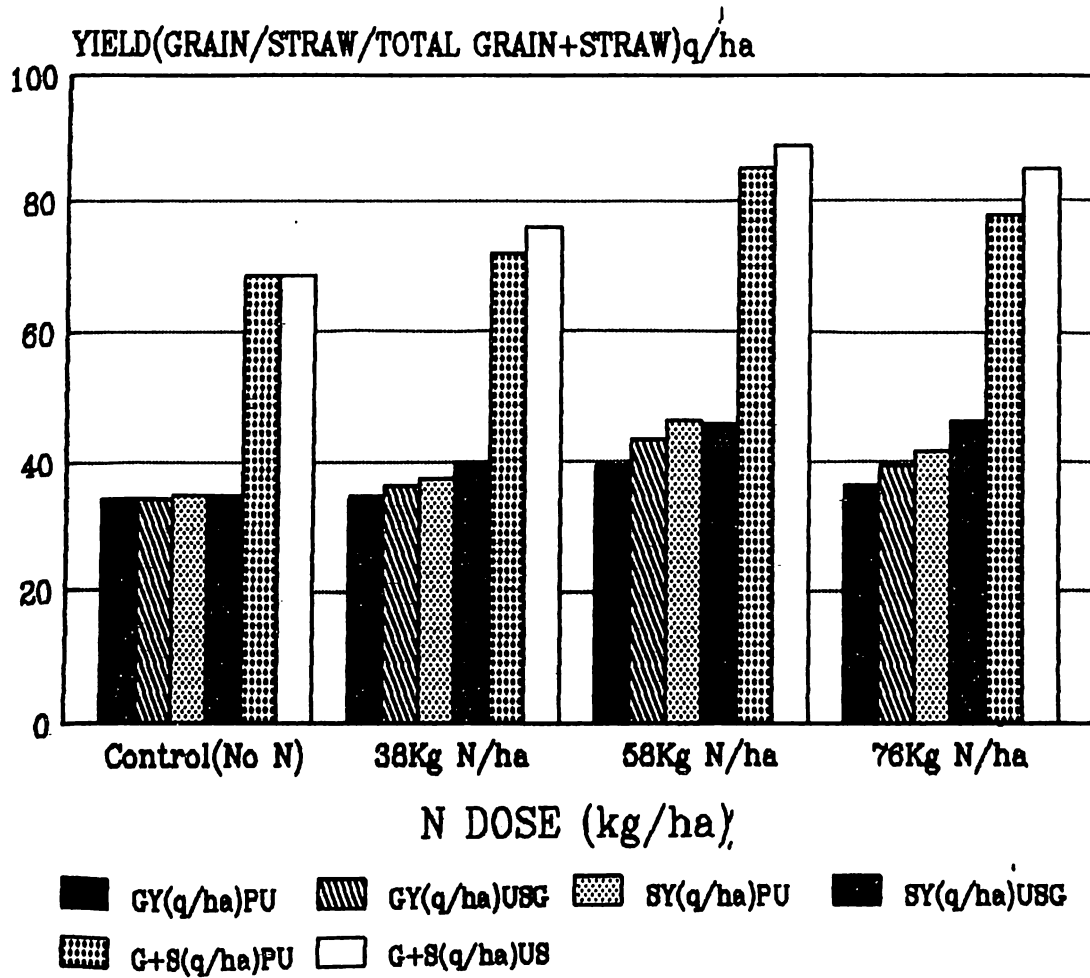


fig. 3. Response of medium land rice to different doses of PU and USG.

C.D. value of 5.32 q/ha at 5% level of probability rendered the mean grain yield data stemming from T_6 and T_3 to be significantly superior to T_1 , T_2 , T_4 , T_5 and T_7 treatments. However application of N as USG (point placed 7 days after transplanting) is better than PU (split application) at equal N dose.

Also neither the standard three split application of P.U. (@ 76kg N/ha) nor USG (@76 kg N/ha) proved significantly superior to the no nitrogen control treatment although it is at par with T_2 and T_5 treatments owing possibly due to excess rainfall received during crop growth period (Fig 44 a,b). The results stemming from field experiments conducted under PL 480 project during 1986 dry season in this research station established the significant superiority of USG over three standard split prilled urea application at equivalent N dose (Jena and Mishra, 1987).

The results of experiments conducted by IFFCO agronomist on farmer's field during kharif 1981 in 9 states of the country showed the superiority of USG point placement recording 17.9% higher yield over split application of prilled urea at 60kg N/ha (Kumar and Mishra, 1988).

A series of field experiments were conducted during 1991-93 with USG in three different major agroclimatic zones of the state (RRS, Bhubaneswar, RRS Ranital, RRS

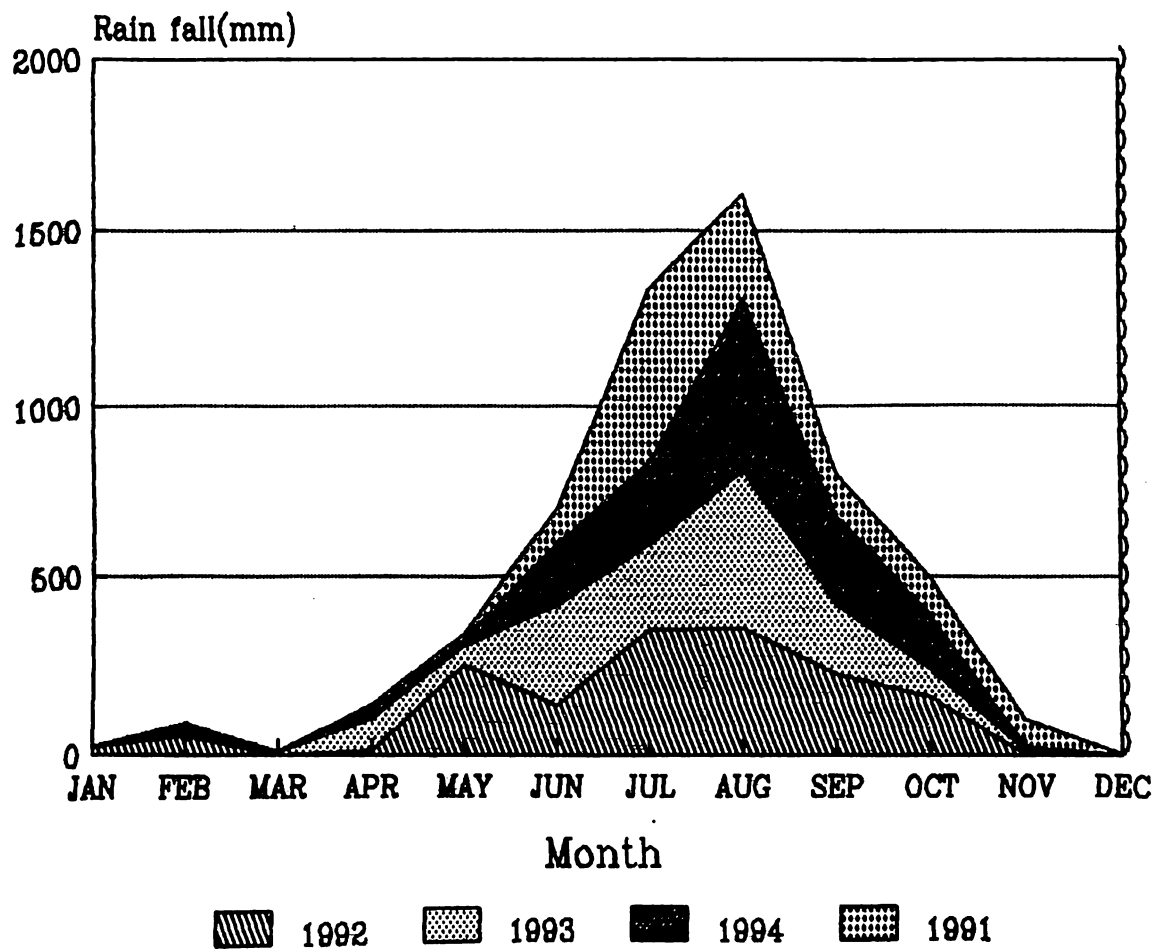


Fig. 4(a) Rain fall distribution during 1991-1994.

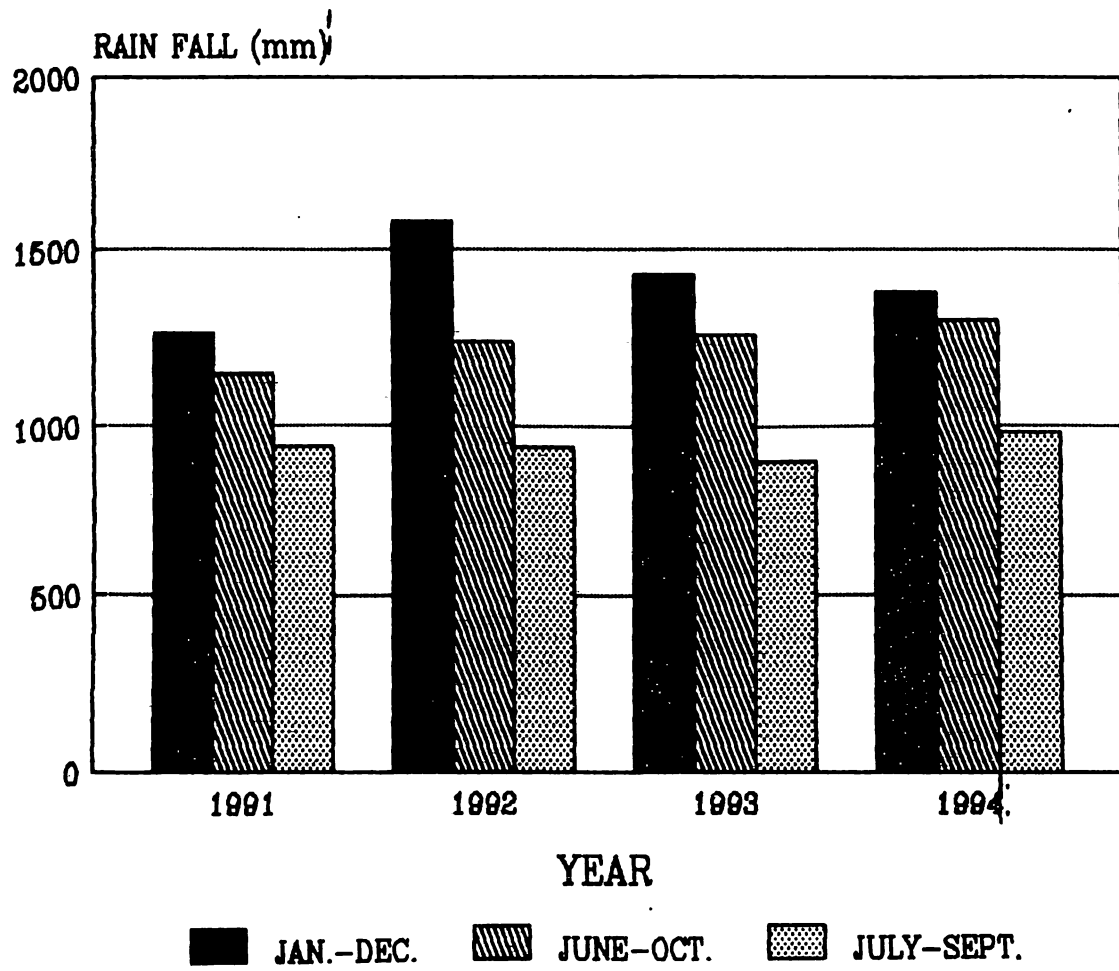


Fig. 4(b) Rain fall distribution pattern from 1991 to 1994.

Chiplima) covering different agroecological situations. Better performance of USG over split applied PU has been established in all the experiments conducted during 1991 to 1993 (Anonymous, 1993). However the yield of rice during present investigation is depressed as compared to the yield obtained during kharif season of 1991, 1992 and 1993, which may be due to excess rainfall received during the month of Aug. and sept. which is the most critical period for kharif rice grown under medium/low land situation.

It is observed from the figure 4(a,b) that highest rain fall of 1297.2 mm was received during kharif (June-october) 1994 followed by 1257.50 mm, 1238.3 mm and 1146.4 mm during 1993, 1992 and 1991 respectively. Although the kharif season starts from the month of June, the intensity of rainfall received during August and September influence the yield of transplanted kharif rice, since it covers the tillering to flowering stages of rice crop. Excess rainfall received during these two months retards the rice grain yield significantly and reduces the efficiency of nitrogen fertilizers.

It is observed from the rain fall data presented in figure 4(b) and Appendix 3 that about 57% of rainfall of kharif season was received during tillering to panicle

initiation stage. (August and september) of rice crop during 1994. The values for 1993, 1992 and 1991 were 51.8, 47 and 37.8% respectively. This clearly shows that, not the total rainfall received during kharif season, but the amount of rainfall received during month of August and September influences rice grain yield.

The mean straw yield listed in table 3 presents a comparable picture with that observed in the grain yield data. The mean straw yield data in T₃, T₄, T₆ and T₇ treatments are observed to be significantly superior to T₁, T₂ and T₅ treatments. This shows that the application of higher dose of N (58 and 76 kg N/ha) either as PU or USG under high rainfall situation produced higher straw yield as compared to rice grain yield.

4.3. RICE GRAIN AND STRAW YIELD IN LOW LAND:

From the data listed in table 4, it is observed that the grain yield level in USG treatments were depressed in general as compared to medium land rice yield data which may be due to heavy down pours and water logging before and following fertilizer application as well as mealy bug attack in later stages of crop growth. But the yield obtained in no nitrogen control remains same as in case of medium land.

Table 4. GRAIN YIELD OF LOW LAND KHARIF RICE

TREATMENT	GRAIN YIELD (q/ha)			
	R1	R2	R3	Mean
T1.Control(No)	36.54	34.40	31.36	34.10
T2.58kg N/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	41.35	36.61	37.65	38.54
T3.76kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	37.80	38.86	39.96	38.83
T4.95kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	35.57	38.84	40.16	38.19
T5.58KgN/ha as USG (7DAT)	37.87	33.19	38.33	36.46
T6.76kgN/ha as USG (7DAT)	34.48	34.35	39.93	36.25
T7.95KgN/ha as USG (7DAT)	46.66	38.80	35.33	40.30

ANOVA

Source	Degree of freedom	Sum of Square	Mean Sum of Square	Calculated F value	Table Fvalue at 5% error
Treatment	6	75.771	12.629	1.195	3.00
Replication	2	16.547	8.273	0.783	3.88
Error	12	126.778	10.565		

CD = N.S.

CV (%) = 8.66

The yield obtained in T₅ (58 kg N/ha as USG) and T₆ (76 kg q/ha as USG) was 19 and 8% lower than the medium land rice yield. This could have been due to higher initial fertility status of the soil (Table- 1) coupled with fertilization due to seepage from the upper reaches reduces the efficiency of added N fertilizer and increases the rice yield in no nitrogen control treatment. Under similar situation Sahu (1994) reported that the rice yield obtained in no nitrogen control was apprecably higher than nitrogen treated plots due to seepage of fertilizer from the upper reaches. Low steady state infiltration rate (Table 1) and lack of suitable drainage systems keeps the land under submergence for longer period.

The mean grain yield due to USG application in T₇ (@95 kg/ha) is observed to be highest among all the treatments tested. The grain yield of rice in T₂, T₃ and T₄ treatments seems to be stable as compared to T₅, T₆ and T₇ treatments. Two third nitrogen applied USG at 7 days after transplanting with one third N as PU at PI stage registers better response than USG alone. However the technology should be tested further before its recommendation for field application.

Sahu (1994) studied the relative efficiency of some urea based fertilizer applied to kharif rice under

Table 5. STRAW YIELD OF LOW LAND KHARIF RICE

TREATMENT	STRAW YIELD (q/ha)			
	R1	R2	R3	Mean
T1.Control(No)	37.13	35.48	27.44	33.35
T2.58kg N/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	44.74	42.36	41.04	42.72
T3.76kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	46.90	44.55	49.11	46.85
T4.95kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	42.39	47.35	47.60	45.78
T5.58KgN/ha as USG (7DAT)	40.77	42.31	46.81	43.29
T6.76kgN/ha as USG (7DAT)	40.71	42.95	43.46	42.38
T7.95KgN/ha as USG (7DAT)	47.88	45.61	50.09	47.86

ANOVA

Source	Degree of freedom	Sum of Square	Mean Sum of Square	Calculated F value	Table Fvalue at 5% error
Treatment	6	419.398	69.0	6.986	3.00
Replication	2	2.379	1.189	0.119	3.88
Error	12	120.076	10.006		

CD(0.05) = 5.63

CV (%) = 7.32

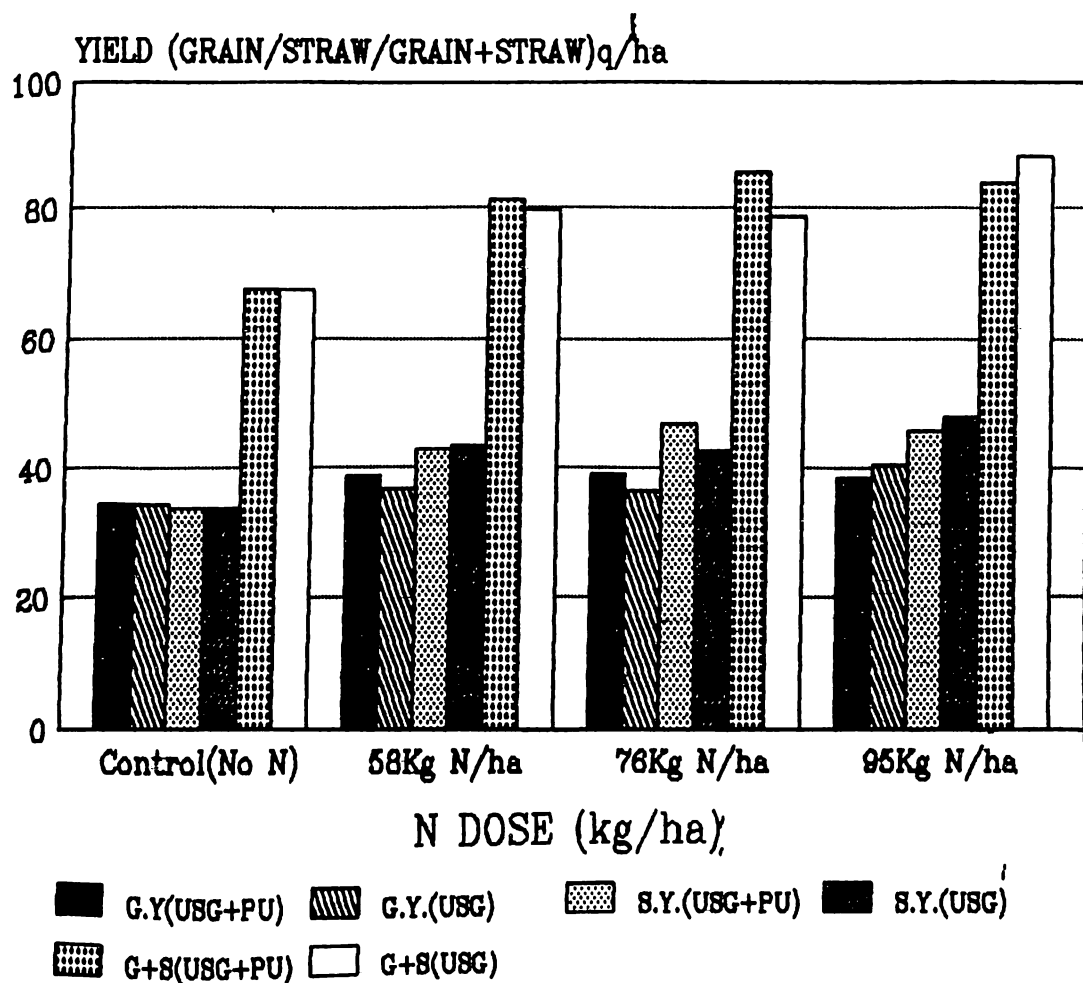


Fig. 5. Response of low land rice to different doses of USG + PU and USG.

simillar situations. He reported the standard three split application of PU @ 76kg /ha did not respond significantly superior to the control treatment owing possibly due to excess rainfall received during the experimental season.

The mean straw yield data listed in table 5 present almost a comparable picture with that observed in grain yield data in table 4. The graphical representetion of effect of different doses of N on grain yield, straw yield, total grain and straw yield for lowland situation is cited in fig 5.

4.4. STRAW / GRAIN RATIO

Table 6(a,b) lists the straw / grain ratio for medium land and low land kharif rice. It is observed from the table that the straw/grain ratio of medium land kharif rice in control plot was 1.02. The value for low land was 0.98. The ratio ranged between 1.05 and 1.18 for medium land and 1.11 to 1.21 for lowland. This shows that the fertilizer treatments lead to higher amount of straw production compared to grain yield under no nitrogen treatment. Such a trend indicates that inorganic fertilizer treatments lead relatively to higher straw production as compared to no nitrogen treatment. The straw to grain ratio reported by Sahu (1994) for kharif rice (cv lalat) under simillar situation was 0.73

Table 6(a). RICE STRAW GRAIN RATIO (MEDIUM LAND)

TREATMENT	Straw to grain ratio
T1.Control(No)	1.02
T2.58kg N/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	1.08
T3.76kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	1.18
T4.95kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	1.15
T5.58KgN/ha as USG (7DAT)	1.10
T6.76kgN/ha as USG (7DAT)	1.05
T7.95KgN/ha as USG (7DAT)	1.18

TABLE 6(b) RICE STRAW / GRAIN RATIO (LOW LAND)

TREATMENT	STRAW TO GRAIN RATIO
T1.Control (No)	0.98
T2.58kg N/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	1.11
T3.76kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	1.21
T4.95kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	1.20
T5.58KgN/ha as USG (7DAT)	1.19
T6.76kgN/ha as USG (7DAT)	1.07
T7.95KgN/ha as USG (7DAT)	1.19

for no nitrogen treatment and the ratio ranged between 0.75 and 0.86 which is appreciably lower than the present investigation. The quantity of rainfall received from tillering to P.I stage (July to September) during present investigation was 979 mm as compared to 893-4 mm during 1993 during the same period..

4.5: NITROGEN CONCENTRATION IN THE RICE PLANT AT DIFFERENT STAGES OF ITS GROWTH AND PLANT N UPTAKE (MEDIUM LAND AND LOW LAND).

Table 7 and 8 list the nitrogen concentration (%) of plant at initial tillering (21 DAT), peak tillering (31DAT), P.I. stage flagleaf and at harvest stage of rice grown in medium and lowland situation under the present investigation. It is observed from the table that irrespective of stage and age of the crop, the concentration (%) of N in plant parts in no nitrogen treatment is appreciably lower than nitrogen treated treatments. The nitrogen concentration (%) in rice plant on USG treatments is appreciably higher than PU treatments in all stages of crop growth except at harvest under both situations. However it may be observed from these data that the concentration of N (%) in plant parts decreases with increasing age of the crop, which might be due to increase in dry matter production.

**Table 7. N CONCENTRATION(%) IN DIFFERENT PLANT PARTS AT
DIFFERENT GROWTH STAGES OF MEDIUM LAND KHARIF RICE**

TREATMENT	N CONCENTRATION (%)					
	shoot at initial tillering (21 DAT)	shoot at peak tillering (31DAT)	shoot at P.I. stage	flag leaf	straw at harvest	grain at harvest
T1.Control(No)	1.97	2.00	1.07	1.79	0.68	1.07
T2.38kg N/ha as PU(3splits)	2.94	1.79	1.19	2.25	0.74	1.09
T3.58kgN/ha as PU(3splits)	2.88	2.23	1.08	2.25	0.74	1.10
T4.76kgN/ha as PU(3splits)	2.60	2.04	1.26	2.17	0.91	1.05
T5.38KgN/ha as USG(7DAT)	2.73	2.24	1.15	2.13	0.77	1.03
T6.58kgN/ha as USG(7DAT)	2.72	2.44	1.27	2.21	0.84	1.12
T7.76KgN/ha as USG(7DAT)	3.12	2.82	1.09	2.32	0.83	1.10

**Table 8. N CONCENTRATION(%) IN DIFFERENT PLANT PARTS AT
DIFFERENT GROWTH STAGES OF LOW LAND KHARIF RICE**

TREATMENT	N CONCENTRATION (%)					
	shoot at initial tillering (21 DAT)	shoot at peak tillering (31DAT)	shoot at P.I. stage	flag leaf	straw at harvest	grain at harvest
T1.Control(No)	2.18	2.18	1.01	1.96	0.65	0.81
T2.58kg N/ha (2/3rdN as USG at 7 DAT+1/3rd as PU at P.I.)	3.09	2.67	1.12	1.97	0.78	1.09
T3.76kgN/ha (2/3rdN as USG at 7 DAT+1/3rd as PU at P.I.)	3.05	3.00	1.45	1.95	0.90	1.26
T4.95kgN/ha (2/3rdN as USG at 7 DAT+1/3rd as PU at P.I.)	2.63	3.04	1.40	2.25	0.77	1.31
T5.58KgN/ha as USG(7DAT)	3.07	2.55	1.19	2.10	0.70	1.09
T6.76kgN/ha as USG(7DAT)	3.18	2.52	1.36	2.17	0.70	1.14
T7.95KgN/ha as USG(7DAT)	3.28	2.87	1.48	2.28	0.77	1.37

However, no consistent conclusion can be drawn from these data.

N uptake data of rice plant, calculated, based on the nitrogen concentration (%) and yield (grain + straw) obtained from both land situations are presented in table 9, 10 and fig 6 and 7. The values of N uptake by both grain and straw range between 53.94 to 87.22 kg/ha for medium land as against from 49.4 to 91.15 kg/ha for low land.

Fig 6 describes the effect of different doses of N (PU/USG) on N uptake by grain, straw and grain + straw of medium land rice. It is observed from the figure that irrespective of dose, USG treatment registers higher N-uptake value by grain, straw and by grain + straw as compared to PU treatments.

Irrespective of the type of N-fertilizer added (PU/USG), the N uptake value by grain and grain + straw increases with increasing dose up to 58 kg N/ha and then declines whereas, the value for rice straw increases with increasing dose of fertilizer even beyond 58 kg N/ha which may be due to the fact that higher straw production is associated with higher dose of N fertilizer application.

Fig 7 depicts the effect of different doses of USG or its combination of PU on N uptake by low land rice. It is

Table 9. N UPTAKE BY MEDIUM LAND KHARIF RICE

TREATMENT	N UPTAKE				
	N UPTAKE BY STRAW (kg/ha)	N UPTAKE BY GRAIN (kg/ha)	TOTAL N UPTAKE (kg/ha)	kgN UPTAKE OF GRAIN	<u>N UPTAKE BY G</u> <u>N UPTAKE BY S</u> (Ratio)
T1.Control(No)	23.62	30.31	53.94	1.59	1.28
T2.38kg N/ha as PU(3splits)	27.61	37.56	65.17	1.88	1.36
T3.58kgN/ha as PU(3splits)	34.11	43.24	77.35	1.97	1.27
T4.76kgN/ha as PU(3splits)	37.81	38.05	75.86	2.09	1.01
T5.38KgN/ha as USG(7DAT)	30.75	37.36	68.11	1.88	1.21
T6.58kgN/ha as USG(7DAT)	38.28	49.24	87.52	2.02	1.29
T7.76KgN/ha as USG(7DAT)	38.44	43.23	81.67	2.08	1.12

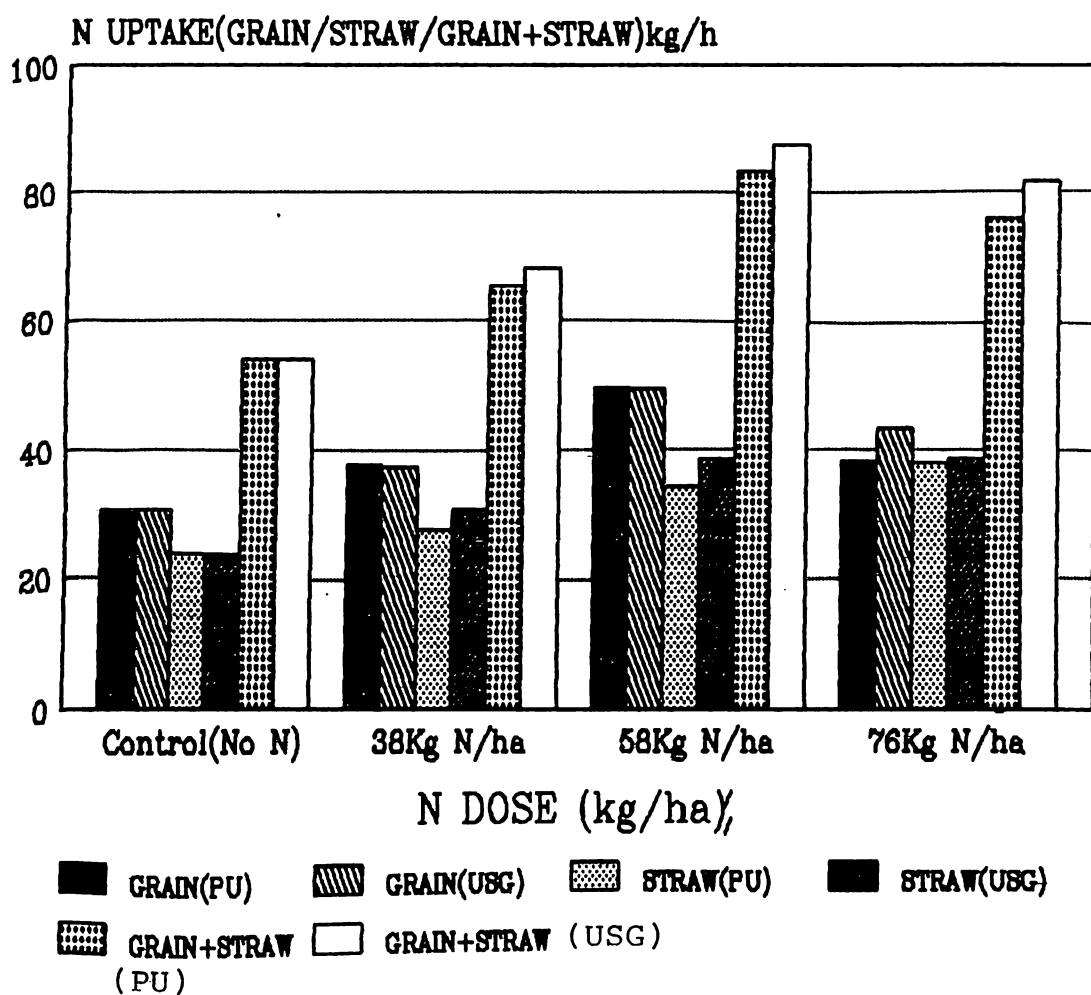


Fig. 6. Effect of different doses of N(PU/USG) on N uptake by medium land kharif rice.

Table 10. N UPTAKE BY LOW LAND KHARIF RICE

TREATMENT	N UPTAKE (kg/ha) BY			kg N UPTAKE q of grain	N UPTAKE BY G N UPTAKE BY S
	STRAW	GRAIN	TOTAL		
T1. Control (No)	21.78	27.62	49.40	1.45	1.27
T2. 58kg N/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	33.32	42.00	75.32	1.95	1.26
T3. 76kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	42.17	48.98	91.15	2.34	1.16
T4. 95kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	35.25	50.11	85.36	2.24	1.42
T5. 58KgN/ha AS USG(7DAT)	30.31	39.57	69.88	1.92	1.31
T6. 76kgN/ha at USG(7DAT)	29.66	41.18	70.84	1.95	1.41
T7. 95KgN/ha asUSG(DAT)	33.98	55.44	89.42	2.22	1.63

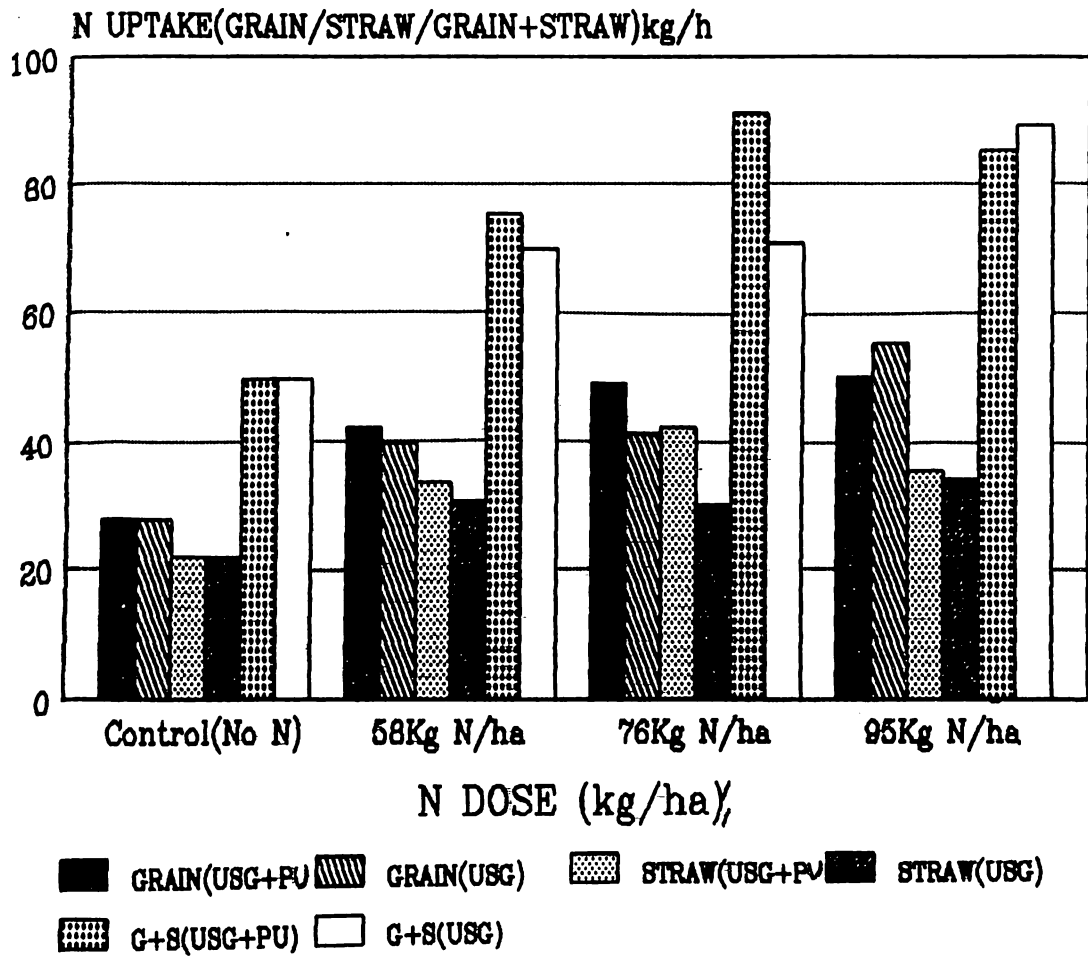


Fig. 7. Effect of different doses of N (USG/USG + PU) on N uptake by low land kharif rice.

observed from the fig that 2/3rd N applied through USG at 7DAT with 1/3rd N as PU at P.I. stage registers higher N uptake by rice grain, straw and grain+straw as compared to USG alone up to a dose of 76kg N/ha. But at higher dose (95 kg N /ha) the trend is reverse.

The value for kg N uptake /q of grain yield ranges between 1.59 and 2.08 and 1.45 and 2.34 for medium land and low land situations respectively. It is also observed from table 9 that the value for kg N up take /q of grain increased with increasing dose of fertilizer. Highest value of 2.08 was observed in PU/USG treatment at 76kg N/ha dose. Sahu (1994) reported the highest value of 1.85 kg N up take / q of grain for kharif rice as against 1.74 reported by Bandyopadhyay (1993) for rabi rice.

The value for N up take by grain to N uptake by straw ratio range between 1.01 to 1.36 and 1.16 to 1.63 for medium and low land situation respectively. However no consistent conclusion can be drawn from these data.

4.6. EFFICIENCY OF FERTILIZER N

Table 11 lists the nitrogen use efficiency parameters viz agronomic efficeency, relative efficiency, apparent N recovery perent in respect of PU and USG for medium land. The apparent recovery of fertilizer N for different treatments ranged between 29 -51% (table 11).

Table 11. EFFICIENCY OF UREA IN MEDIUM LAND KHARIF RICE

TREATMENT	GRAIN q/ha	TOTAL N UPTAKE (kg/ha)	RELATIVE EFFICIENCY (%)	AGRONOMIC EFFICIENCY (%)	APPARENT N RECOVERY (%)
T1.Control	33.98	53.94	-	-	-
T2.38kg N/ha as PU(3splits)	34.62	65.17	28	2	30
T3.58kgN/ha as PU(3splits)	39.31	83.46	235	9	51
T4.76kgN/ha as PU(3splits)	36.24	75.86	100	3	29
T5.38KgN/ha as USG(7DAT)	36.18	68.11	97.35	6	37
T6.58kgN/ha as USG(7DAT)	43.28	87.51	412	16	58
T7.76KgN/ha as USG(7DAT)	39.21	81.67	231	7	36

The highest value of apparent N recovery (58%) was obtained with USG when applied @ 58 kg N/ha as against 51% for PU at equal N level. The value for standard recommended dose of PU (@76 kg N/ha) was 29% as against 36% for USG (@76 kg N/ha). In addition, the agronomic efficiency and relative efficiency of N was higher in USG (58kg N/ha followed by PU (58kg N/ha Table 12 describes the agronomic efficiency and apparent N recovery % for different doses of USG and USG + PU applied to lowland kharif rice. The value for apparent N recovery % and agronomic efficiency for different treatments ranges from 28 to 55% and 3 to 8 respectively. It may be referred from the table that two third N as USG (7DAT) with one third N as PU (at P.I.) was found to be superior to USG alone at same level of nitrogen.

Bandyopadhyay (1993) reported the highest apparent nitrogen recovery value of 57% for USG followed by 54% for PU for equivalent N dose. Sahu (1994) reported the values for agronomic efficiency relative efficiency and apparent N recovery (%) parameters in USG treatments were higher than the recommended dose of PU (@76kg N/ha) applied in standard 3 splits. Mishra et al. (1994) reported the highest value of apparent N recovery (73.8%), agronomic and physiological efficiency of N in NCU + PU treatments as compared to

Table 12. EFFICIENCY OF UREA IN LOW LAND KHARIF RICE

TREATMENT	GRAIN YIELD (q/ha)	TOTAL N-UPTAKE (kg/ha)	AGRONOMIC EFFICIENCY	APPARENT EFFICIENCY (%)
T1.Control	34.1	49.4	-	-
T2.58kg N/ha (2/3rd N as USG at 7DAT + 1/3rd N asPU at P.I.)	38.54	75.32	8	45
T3.76kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N asPU at P.I.)	38.83	91.15	6	55
T4.76kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N asPU at P.I.)	38.19	85.36	4	38
T5.58KgN/ha as USG (7DAT)	36.46	69.88	4	35
T6.76kgN/ha as USG (7DAT)	36.25	78.84	3	28
T7.97KgN/ha as USG (7DAT)	40.30	89.42	7	42

standard three split application of PU. However, the present study indicates that medium dose of N (58kg/ha) applied @2/3rd N as USG at 7DAT and 1/3rd N as PU at P.I. was found superior to other treatment combinations. In an equivalent study by Jena and Mishra (1987), the USG has been rated as the most efficient source with an apparent N recovery percentage of 54.2 as compared to 44.7 due to split applied urea. The superiority of USG over PU has been reported by many workers for Bhubaneswar situation (Panda and Pattanaik, 1989 and Mishra et al. 1989) and especially in the case of soils with heavier texture and lower infiltration rate. (Mohanty, 1991)

Savant et al. (1990) summarised the results of several hundred trials conducted in south and south east Asia and found that the agronomic efficiency of deep placed USG was found to be superior to that of split application of urea in 40-50 % of national or international trials. In nearly 50% of the network trials, the performance of split applied PU was statistically at par with deep placed USG.

Fig 8 to 11 depict the effect of different doses of N (PU/USG) on agronomic efficiency and apparent nitrogen recovery percentage. It is observed from Fig. 8 and 9 that the values for agronomic efficiency and apparent nitrogen recovery percentage of USG is higher than PU for equivalent

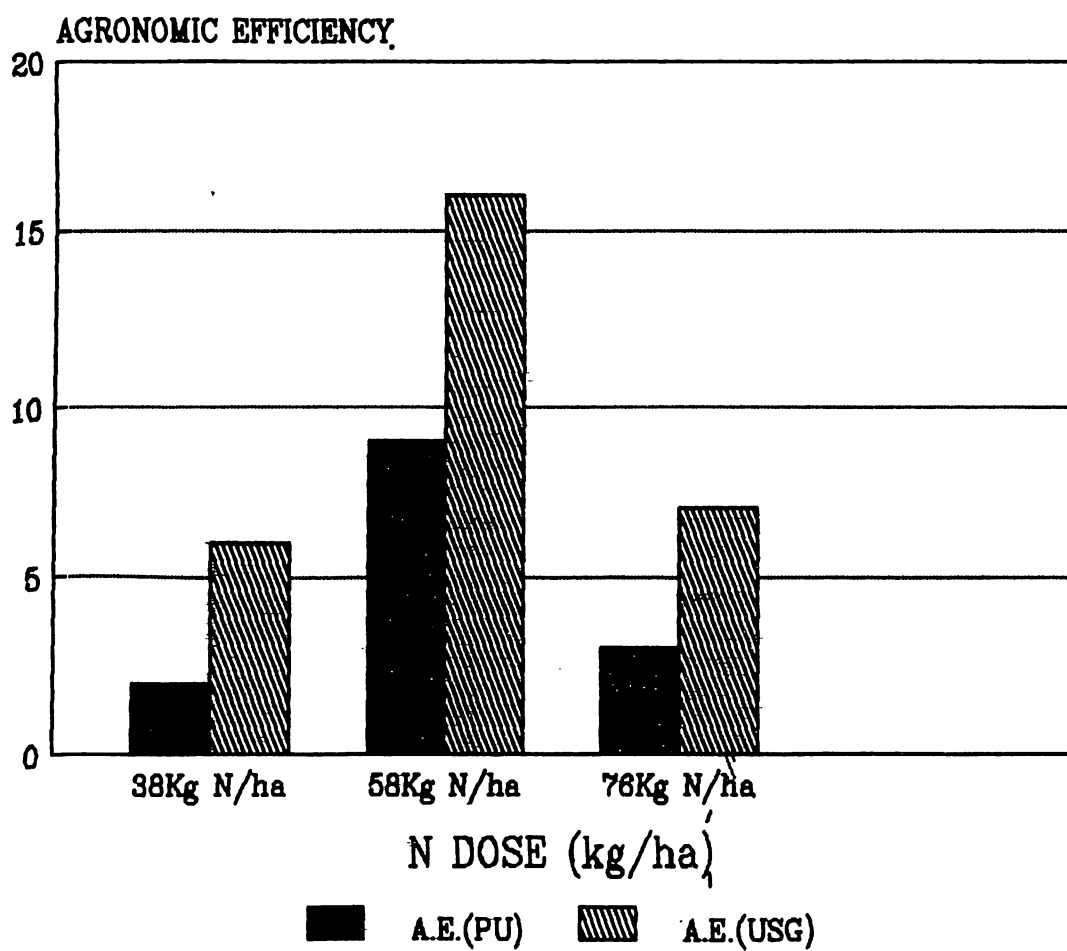


Fig. 8. Effect of different doses of N(PU/USG) on agronomic efficiency of medium land kharif rice.

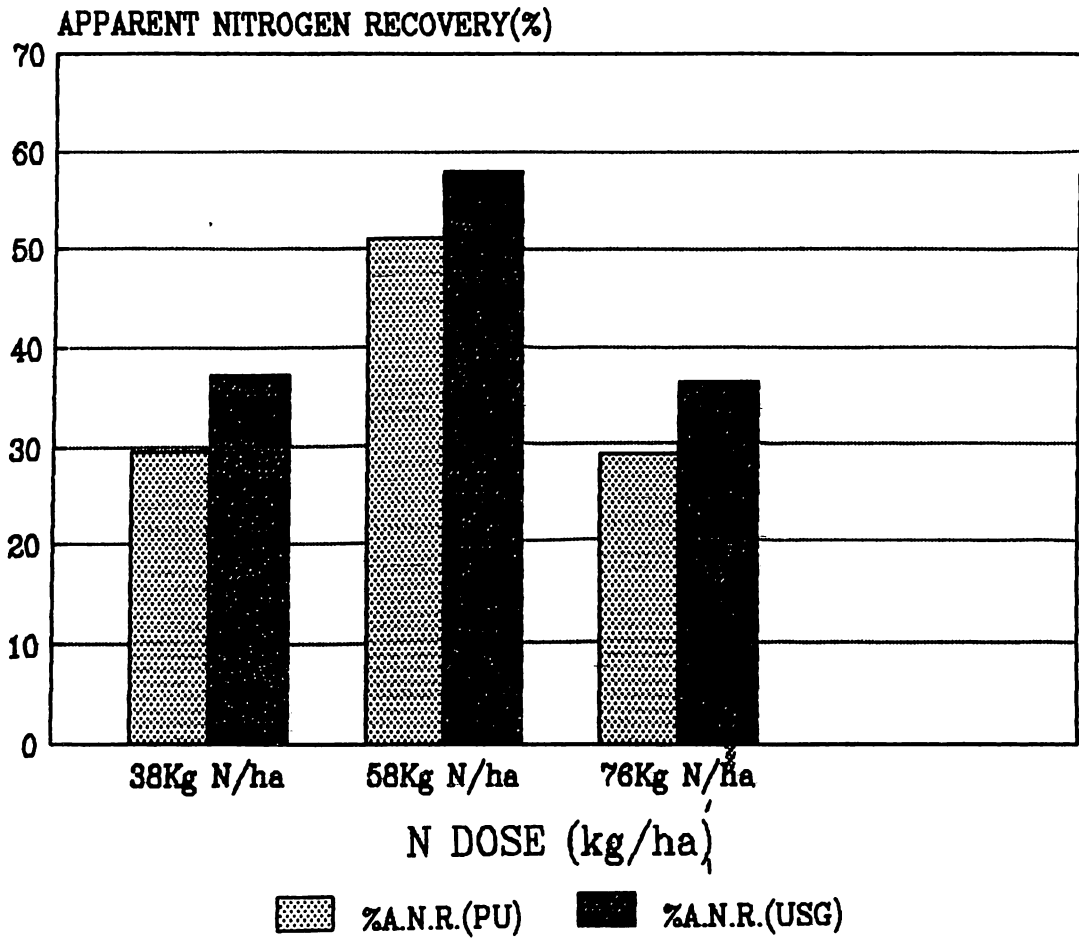


Fig. 9. Effect of different doses of N (PU/USG) on apparent nitrogen recovery (%) of medium land kharif rice.

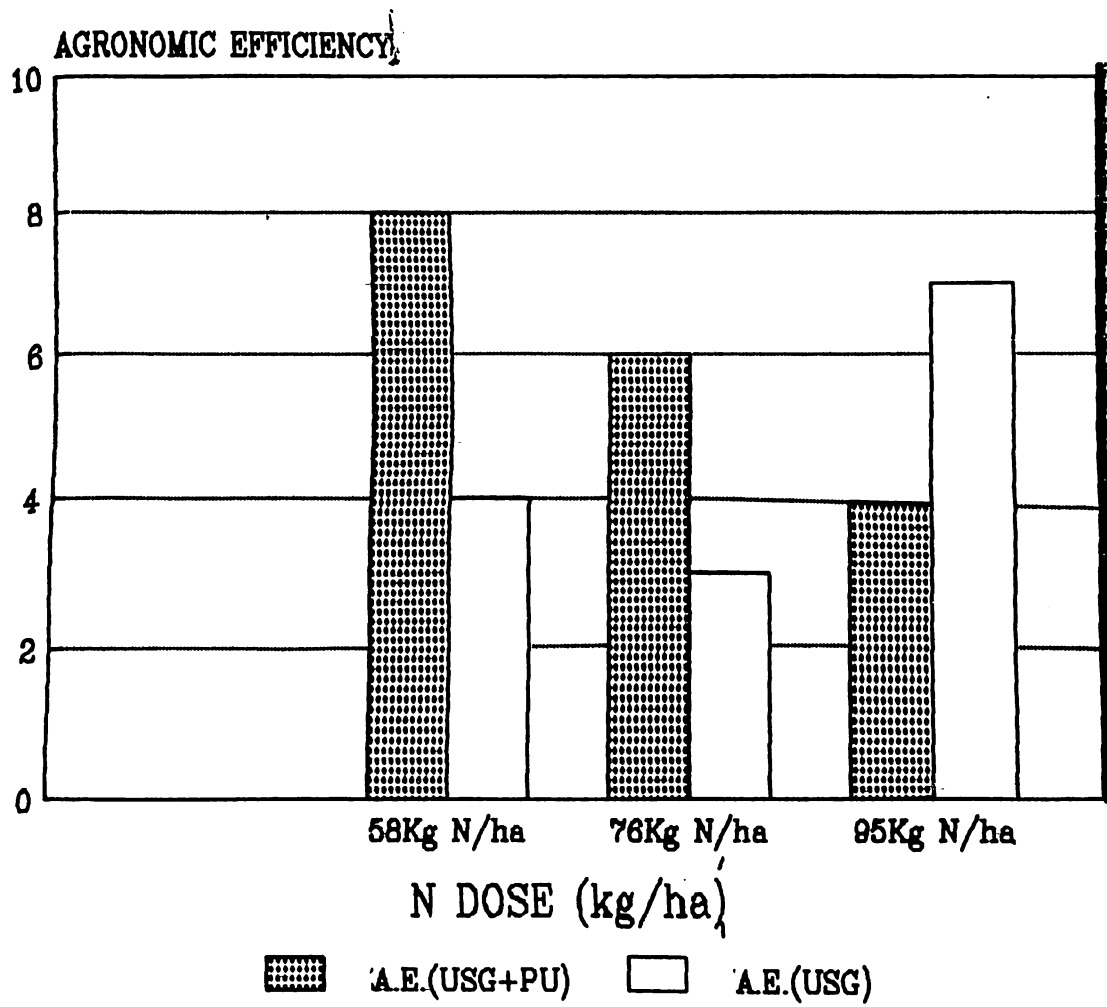


Fig. 10. Effect of different doses of N (USG + PU/USG) on agronomic efficiency of low land kharif rice.

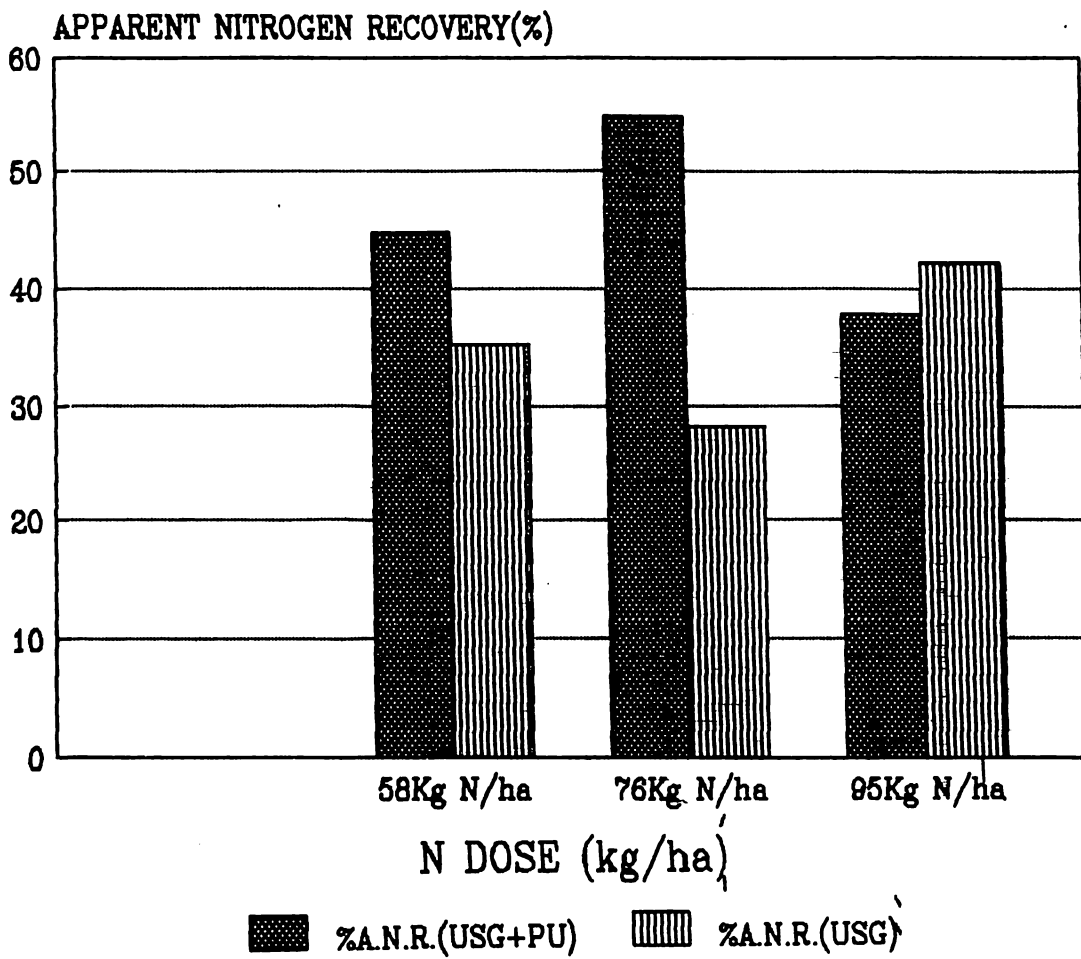


Fig. 11. Effect of different doses of N(USG + PU/USG) on apparent nitrogen recovery (%) of low land kharif rice.

dose. Irrespective of the type of nitrogen fertiliser (PU/USG), the agronomic efficiency and apparent nitrogen recovery percentage increased up to the dose of 58 kgN/ha and then declines. Similar trend is observed for agronomic efficiency and apparent nitrogen recovery of USG + PU treatment in lowland situation. (Fig 10,11)

4.7 YIELD CONTRIBUTING CHARACTERS

Table 13, 14, and fig 12, 13 present mean plant height, number of effective tiller per hill, panicle length and percentage sterility for kharif rice grown in medium and lowland situations. The mean plant height ranges between 91.45 to 99.48cm for medium land rice and 91.27 to 102.93cm for lowland. The values for mean number of effective tiller/hill and mean panicle length range between 8 to 11 and 23.52cm to 24.63cm for medium land rice as compared to 9 to 11 and 23.31cm to 24.67cm for lowland rice.

The sterility percentage was observed to be 17.1 to 20.74% for no-nitrogen control for both situations. The values increase with increasing dose of fertiliser. Highest value of 31.79% was observed in higher dose of USG (76kgN/ha) treatment as compared to PU for equal dose.

Table 3 BIOMETRIC OBSERVATIONS IN MEDIUM LAND KHARIF RICE

TREATMENT	PLANT CHARACTER*			
	Mean Plant height(cm)	Mean no. of effective tiller/hill	Mean panicle length(cm)	% sterility
T1.Control	89.28	8	23.68	20.74
T2.38kg N/ha as PU (3splits)	91.45	9	23.52	22.22
T3.58kgN/ha as PU (3splits)	99.48	11	24.63	22.28
T4.76kgN/ha as PU (3splits)	94.48	10	24.43	24.25
T5.38KgN/ha as USG (7DAT)	91.53	8	23.65	21.10
T6.58kgN/ha as USG (7DAT)	96.43	11	24.27	18.78
T7.76KgN/ha as USG (7DAT)	95.67	8	24.17	31.79
CD (0.05)	3.47	1.01	N.S	N.S
CV (%)	2.07	8.99	2.62	17.61

* = Mean of 10 no. of observations

Table 14. BIOMETRIC OBSERVATIONS IN LOW LAND KHARIF RICE

TREATMENT	PLANT CHARACTER			
	Mean Plant height (cm)	Mean panicle length (cm)	Mean No. of effective tiller/hill	% sterility
T1. Control (No)	91.27	23.31	8	17.1
T2. 58kg N/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	100.17	24.17	9	18.01
T3. 76kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	102.68	24.67	9	27.24
T4. 76kgN/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at P.I.)	102.93	24.43	11	24.60
T5. 58KgN/ha as USG (7DAT)	99.53	24.08	10	24.43
T6. 76kgN/ha as USG (7DAT)	100.17	24.28	10	25.34
T7. 97KgN/ha as USG (7DAT)	99.38	24.43	9	31.71
CD(0.05)	N.S.	N.S.	1.23	6.03
CV (%)	4.27	2.52	7.35	14.08

* Mean of 10 numbers of observations.

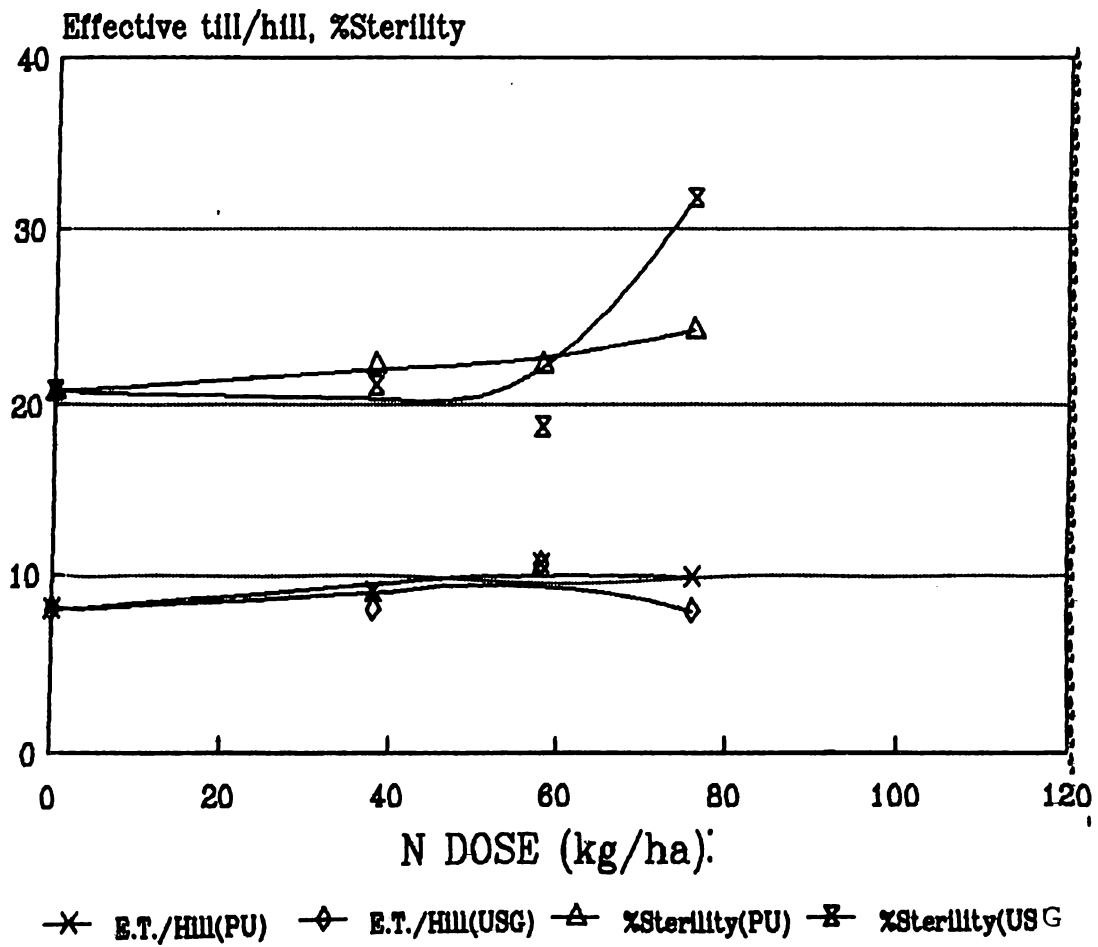


Fig. 12. Effect of different doses of N on no. of effective tillers/hill and % sterility of medium land kharif rice.

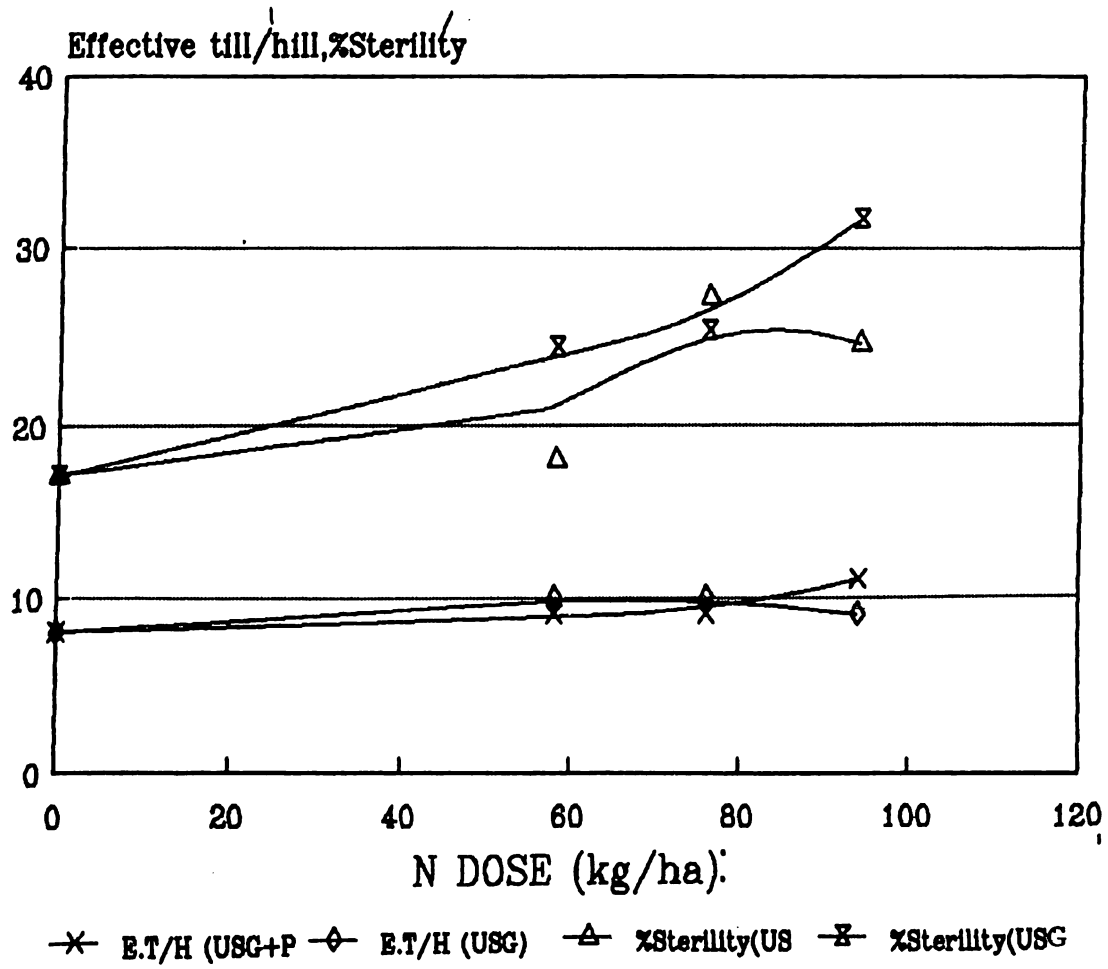


Fig . 13. Effect of different doses of N on no. of effective tillers/hill and % sterility of low land kharif rice.

4.8 RELATIONSHIP BETWEEN YIELD AND VARIOUS PLANT PARAMETERS

Table 15 presents the coefficient of regression among the different doses of nitrogen Vs. various plant parameters along with the corresponding regression equations. The co-efficient of co-relation between dose and % N at tillering, % N at PI, % N in flag leaf, % N in grain, straw yield, plant height, panicle length, % sterility, N uptake by grain + straw, and total biomass product were found significant.

Table 16 presents the coefficient of regression among the yield and various plant parameters. The coefficient of correlation which are found to be significant with grain yield are % N at tillering, % N at PI, % N in grain of and straw, N uptake by grain + straw, plant height, panicle length and total biomass production. Similar observation were reported by Sahu (1994) for kharif rice.

4.9 TEMPORAL VARIATION OF AMIDE N CONCENTRATION IN FLOOD WATER AND SOIL SOLUTION IN MEDIUM LAND RICE EXPERIMENT.

Fig 14 -17 depict the changes in amide N concentration in the flood water and soil solution (10cm soil depth) with time following application of PU at transplanting and tillering as well as placement of USG after 7days after transplanting at a depth of 5cm. Point placement of USG and

Table 15 . COEFFICIENT OF REGRESSION AND CORRELATION AMONG DOSE AND VARIOUS PLANT PARAMETRES IN LOW LAND EXPERIMENT.

Predictor variable : Dose (x) kg/ha		
Dependant variable(Y)	Regression equation	'r' value
%N at tillering	$y = 8.12 \times 10^{-3}x + 2.158$	0.866**
%N at PI	$y = 4.89 \times 10^{-3}x + 0.96$	0.92**
%N in flaf leaf	$y = 2.99 \times 10^{-3}x + 1.901$	0.693*
%N in Straw	$y = 1.40 \times 10^{-3}x + 0.66$	0.57*
%N in grain	$y = 5.98 \times 10^{-3}x + 0.795$	0.947**
Grain Yield (q/ha)	$y = 0.051 x + 34.167$	0.813**
Plant height (cm)	$y = 0.06 x + 92.539$	0.885**
Panicle length (cm)	$y = 238 \times 10^{-2}x + 23.39$	0.92**
% Sterility	$y = 0.12 x + 15.97$	0.79**
N Uptake (kg/ha) by grain	$y = 0.26 x + 26.48$	0.94**
N Uptake(kg/ha) by straw	$y = 0.143 x + 23.008$	0.794*
N Uptake(kg/ha) by grain + staw	$y = 0.404 x + 49.487$	0.904**
Total biomass product (q/ha)	$y = 0.19 x + 68.18$	0.93**

Table 16. COEFFICIENT OF REGRESSION AND CORRELATION AMONG YIELD AND VARIOUS PLANT PARAMETRES IN LOW LAND EXPERIMENT.

Dependant variable : Grain yield (y)		
Predictor variable(x)	Regression equation	'r' value
%N at tillering	$y = 5.766 x + 22.013$	0.857*
%N at P9	$y = 8.516 x + 26.66$	0.719*
%N in grain	$y = 6.87 x + 29.38$	0.69*
%N in Straw	$y = 19.276 x + 23.012$	0.757*
N Uptake by grain(kg/ha)	$y = 0.213 x + 28.24$	0.938**
N Uptake by straw(kg/ha)	$y = 0.27 x + 28.55$	0.8**
N Uptake by grain+straw	$y = 0.13 x + 27.55$	0.93**
Plant height	$y = 0.38 x + 8.7 \times 10^{-2}$	0.71*
Panicle lenght	$y = 3.901 x - 56.853$	0.827**
Total biomass product (q/ha)	$y = 0.29 x + 14.11$	0.95*

top dressing of PU was done at 5 ± 0.5 cm of standing water.

After the end of every 24 h. of fertiliser application, part of the infiltrated water was replenished with irrigation water for facilitating sample collection. The flood water sample was collected 1.5 cm below the water surface using a pipette. The soil solution sample at a depth of 10 cm soil depth was done with the help of a solution sampler.

In fig 14 -17 the observed amide N concentration appear as points which have been connected by means of Havards Graphics software to form smooth graphs. The features of these graphs appear to be in general similar in that the amide nitrogen concentration in flood water increased from near zero level, attains a peak and then decreases.

Fig 14 illustrates the amide N concentration in flood water and soil solution following application of 19 kg N/ha as PU broadcasted at transplanting. The peak value of 18.5 ppm of amide N in flood water is observed to have been attained in around 7 h and the concentration drop to zero near 50 h. However in the case of soil solution the peak is not clearly defined and the soil solution concentration drop from 2 ppm to zero within 50 -70 h attening the maximum value around 8 h.

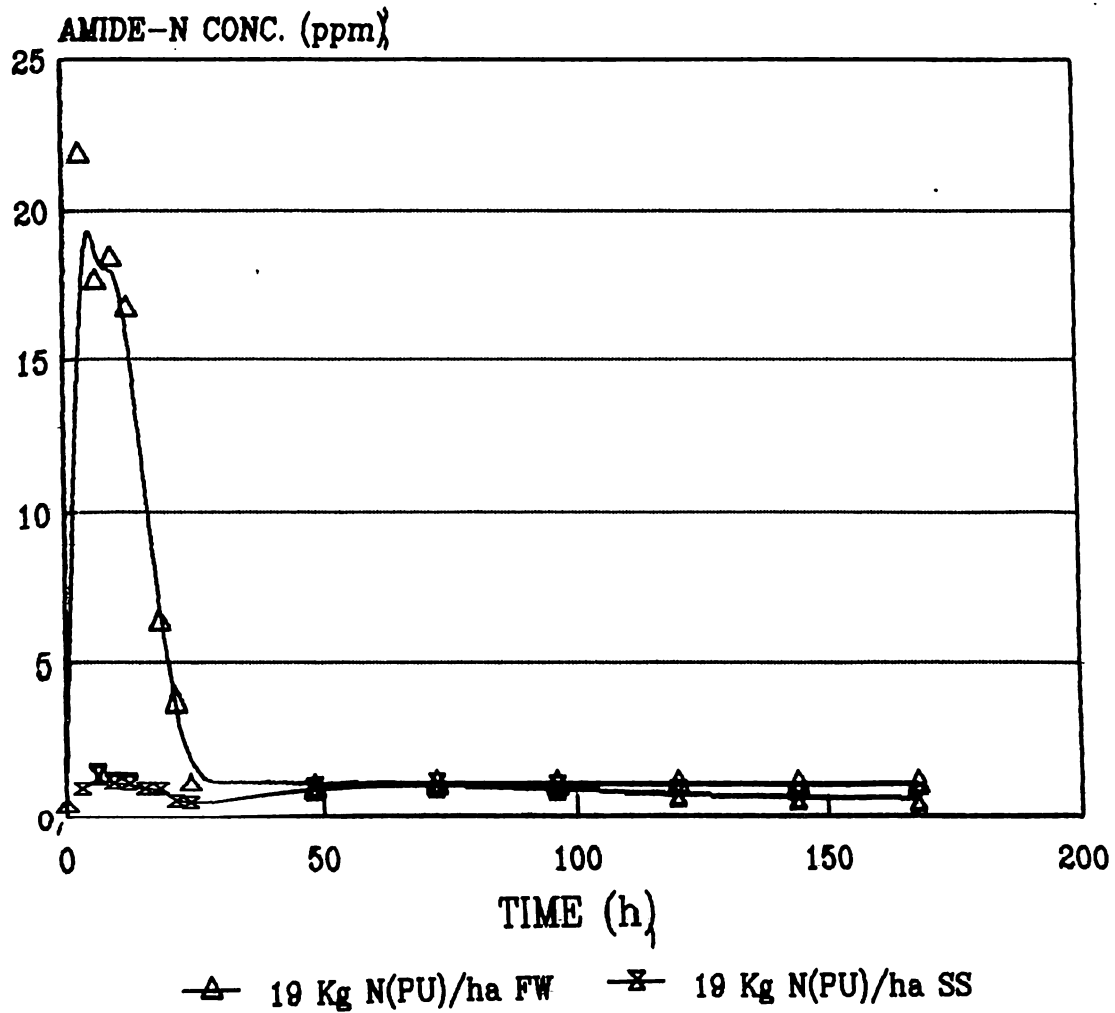


Fig. 14. Concentration of amide-N (ppm) in flood water and soil solution (10 cm depth) after application of 19 kg N(PU)/ha to medium land kharif rice at transplanting.

Fig 15 depicts the amide N concentration in flood water and soil solution following application of 38kg N per/ha as PU at tillering stage of the crop. The peak value of 52ppm of amide N in flood water is observed to have been attained in around 8h and the concentration drop to zero near 75h. But in case of soil solution the concentration of amide N seems to be negligible. The results depicted in fig 14 suggested the urea hydrolysis process was continued at least for 50 hours in the flood water following basal application of PU where as this process took only 75 hours following top dressing presumably due to increased biological activity and higher flood water temperature ($28.52 - 40.5^{\circ} \text{C}$) at transplanting as compared to tillering ($27 - 33^{\circ} \text{C}$) (Appendix 6-8).

Sahu (1994) reported that the hydrolysis of urea was faster in soil suspension than in sterilised water, distilled water and flood water owing possibly to higher urease activity.

It should be noted that decreased in amide N concentration after 24hours in flood water is both due to hydrolysis and dilution caused by partial replenishment of water that infiltrated /evaporated that may have been the possible cause, why they had observed a long tail.

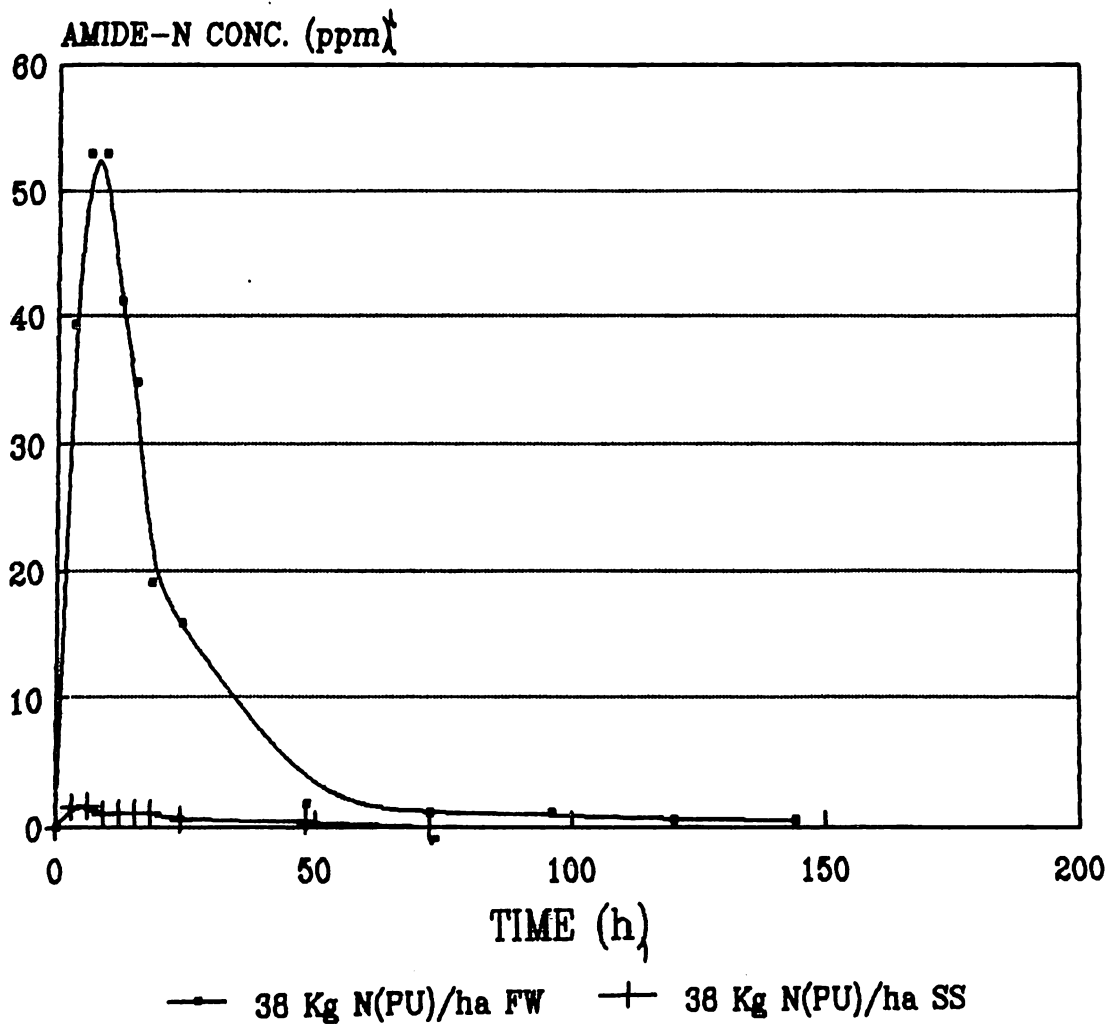


Fig. 15. Concentration of amide-N (ppm) in flood water and soil solution (10 cm depth) after application of 38 kg N(PU)/ha to medium land kharif rice at tillering.

The results of temporal variation of amide N in flood water and soil solution were analysed by Mishra et al.(1991) and based on the solution of a convective diffusion model subject to Dirac Delta function boundary condition and reported 0.015/h, 0.05/h and 0.09/h as the values for the urea hydrolysis rate constants for flood water, reduced zone and oxidised zone of the soils respectively.

Fig 16 describes the concentration of amide N in flood water and soil solution following point placement of USG (@ 76kg N /ha) at 7DAT. The flood water amide N concentration peak value of 3.5 ppm is attained at 12.5 hours and drop to zero near 175 hours. The concentration for soil solution increased from 1 ppm to 7ppm at 12.5 hours and drops to zero near 148 hours. The lower peak concentration in flood water in USG treatment as compare to PU treatments is suggestive of the slower rate of migration of amide N upwards into flood water from 5cm soil layer. On the other hand, the amide N distribution pattern in soil solution appears to be quite distinct as compare to PU treatment.

The result depicted in fig 16 suggest that urea hydrolysis process for USG(@76 kg N/ha) was continued in flood water at least for 175 hours as compare to 50 and 70 hours for PU at transplanting and PI stage. On the other

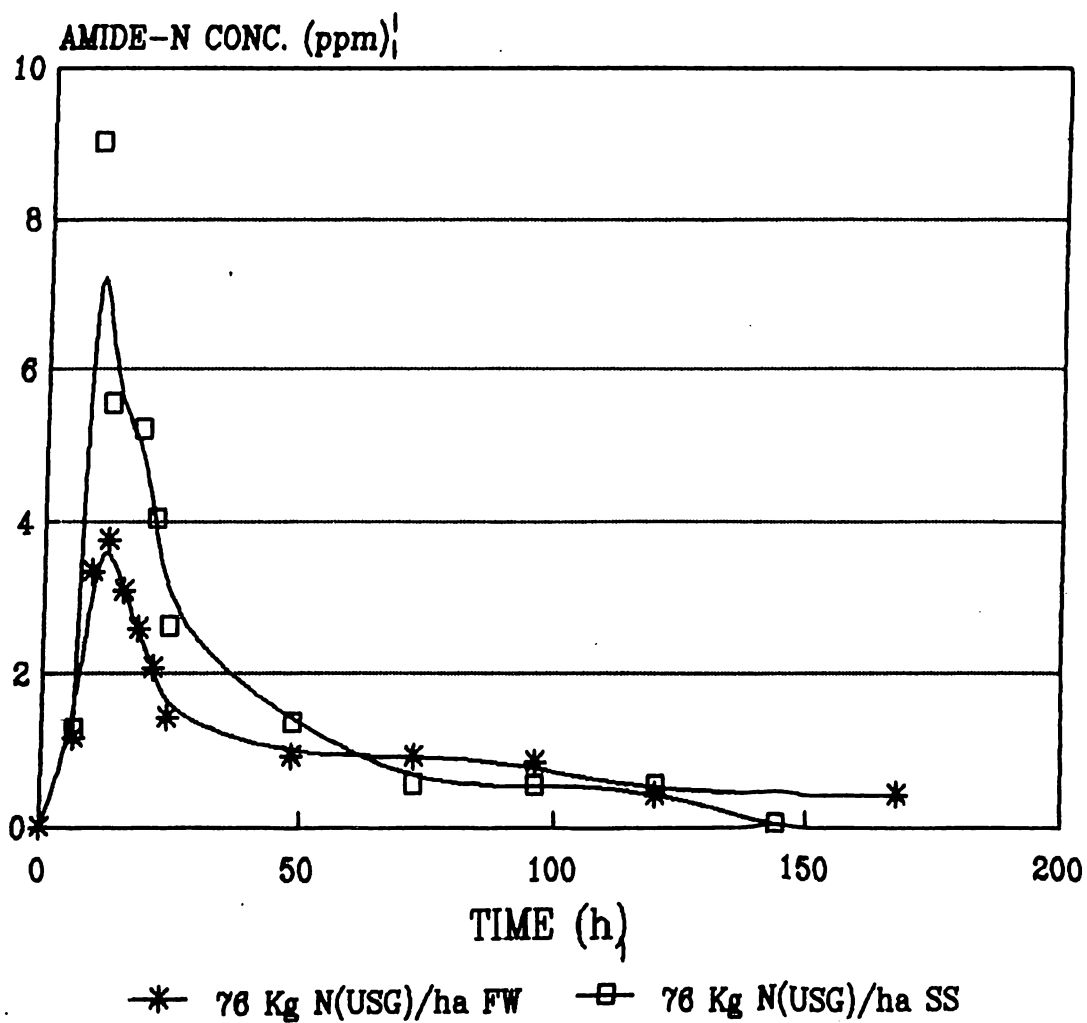


Fig. 16. Concentration of amide-N (ppm) in flood water and soil solution (10 cm depth) after application of 76 kg N(USG)/ha to medium land kharif rice at 7 DAT.

hand, the amide N distribution in soil solution appears to quite distinct as compared to PU treatments.

The soil solution amide N concentration peak value of 7 ppm reaches around 12.5 hours and drops to zero within 148 hours. Higher concentration of amide N in soil solution as compared to flood water in USG treatment, is suggestive of the faster rate of migration of amide N downwards from the placement site as compared to upward migration.

The result of the present study agrees to its findings reported by Bandyopadhyay (1993). He found that most of the amide N remains in soil solution at 7.5cm depth and traceable until 150 hours following application of 76kg N/ha USG in winter rice. He observed the amide N peak value of 6ppm for flood water reaches around 12 hours as compared to the peak value of 25 ppm for soil solution. He observed higher peak values as compared to this present investigation might be due to difference in rain fall and temperature. The present experiment received 979 mm of rain fall during transplanting to PI stage where as the experiment conducted by Bandyopadhaya (1993) during winter 1992-93 received only 100.3mm rainfall from January to Aprill during the growth period.

Fig 17 depicts the amide N concentration in flood water and soil solution in no nitrogen control treatment .

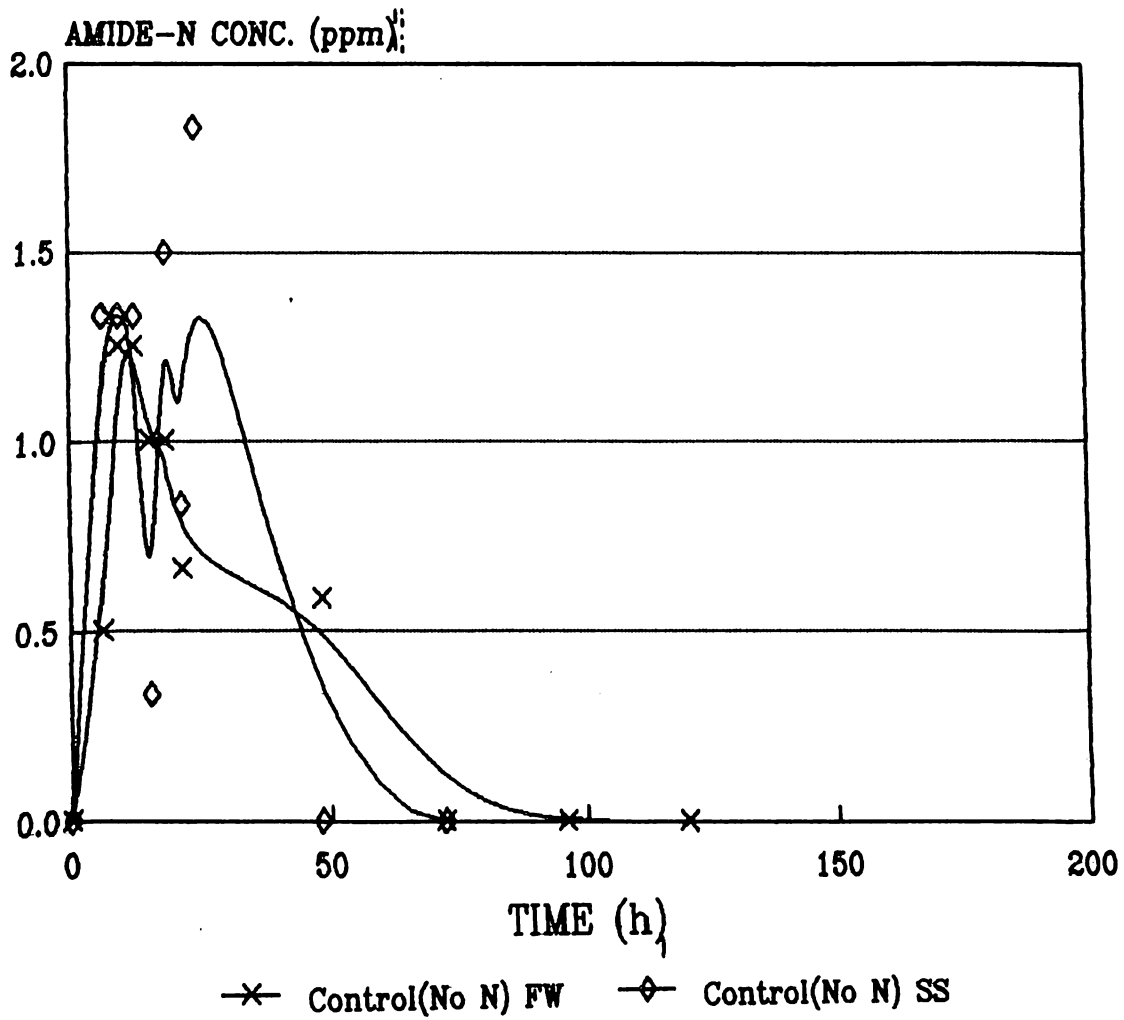


Fig. 17. Concentration of amide-N (ppm) in flood water and soil solution (10 cm depth) in control plot at transplanting.

The amide N concentration in flood water and soil solution reaches the maximum value of 1.3ppm around 10- 24 hours and drops to zero near 75 to 100 hours. This clearly shows the lateral movement of amide N from treated plots / upper reaches to the control plot due to seepage of flood water.

Panda et al (1988 a,b) carried out a series of investigations in order to measure nitrogen distribution in flooded rice soil following application of PU and USG. These authors observed that surface broad cast nitrogen in the form of PU was found mostly in the top 0.5 cm layer and there was only small vertical movement of applied nitrogen to 5 -10 cm depth, under the soil conditions (CRRRI,Cuttack) in which these authors worked the leaching loss in the form of ammonium N and nitrate N was only 0.2 to 0.4% of nitrogen applied.

Hydrolysis of urea in the soil develops alkalinity and soil pH increases at placement site. Flood water pH under present investigation attained its peak within 35-50 hours of PU /USG application and then declines (Fig 18). This may be due to formation of ammonium bicarbononate from urea hydrolysis. These results confirm the observation of Fillery et all(1986) and Chauhan and Mishra(1989a).

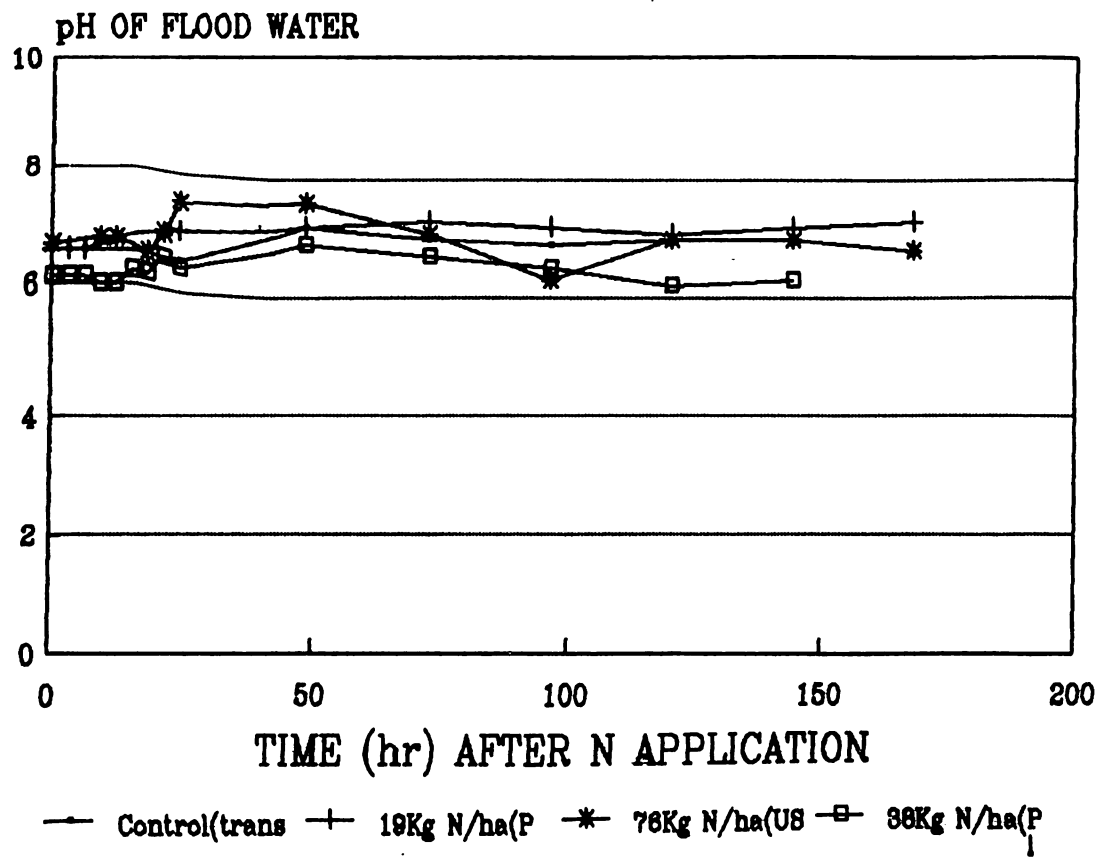


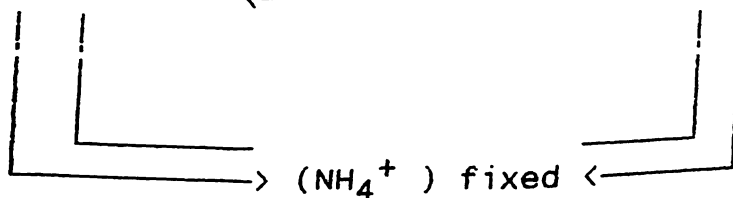
FIG:18: pH OF FLOOD WATER

Fig. 18. pH of flood water.

4.10 TEMPORAL VARIATION OF AMMONIUM-N CONCENTRATION IN FLOOD WATER AND SOIL SOLUTION (MEDIUM LAND RICE).

The ammonium formed as a product of urea hydrolysis in a reduced soil environment tends to accumulate at the placement sites in three main forms.

(NH_4^+) solution $\xrightarrow{\quad}$ (NH_4^+) exchangeable
 $\xleftarrow{\quad}$



The relative proportion of these forms varies and mainly depends on the nature and amount of soil colloids. For a typical rice soil, the order of their amounts may be written as :

(NH_4^+) exchangeable $>$ (NH_4^+) solution $>$ (NH_4^+) fixed.

Fig 19 to 22 depict ammonium -N concentration of flood water and soil solution at 10cm depth following application of PU at transplanting and tillering as well as USG at 7 DAT. The shape of ammonium N concentration for flood water (PU) and soil solution (USG) bears bell shaped curve as observed in flood water amide N concentration, attaining a peak and then decreasing.

Fig 19 describes the flood water ammonium N concentration following application of 19kg of N as PU at

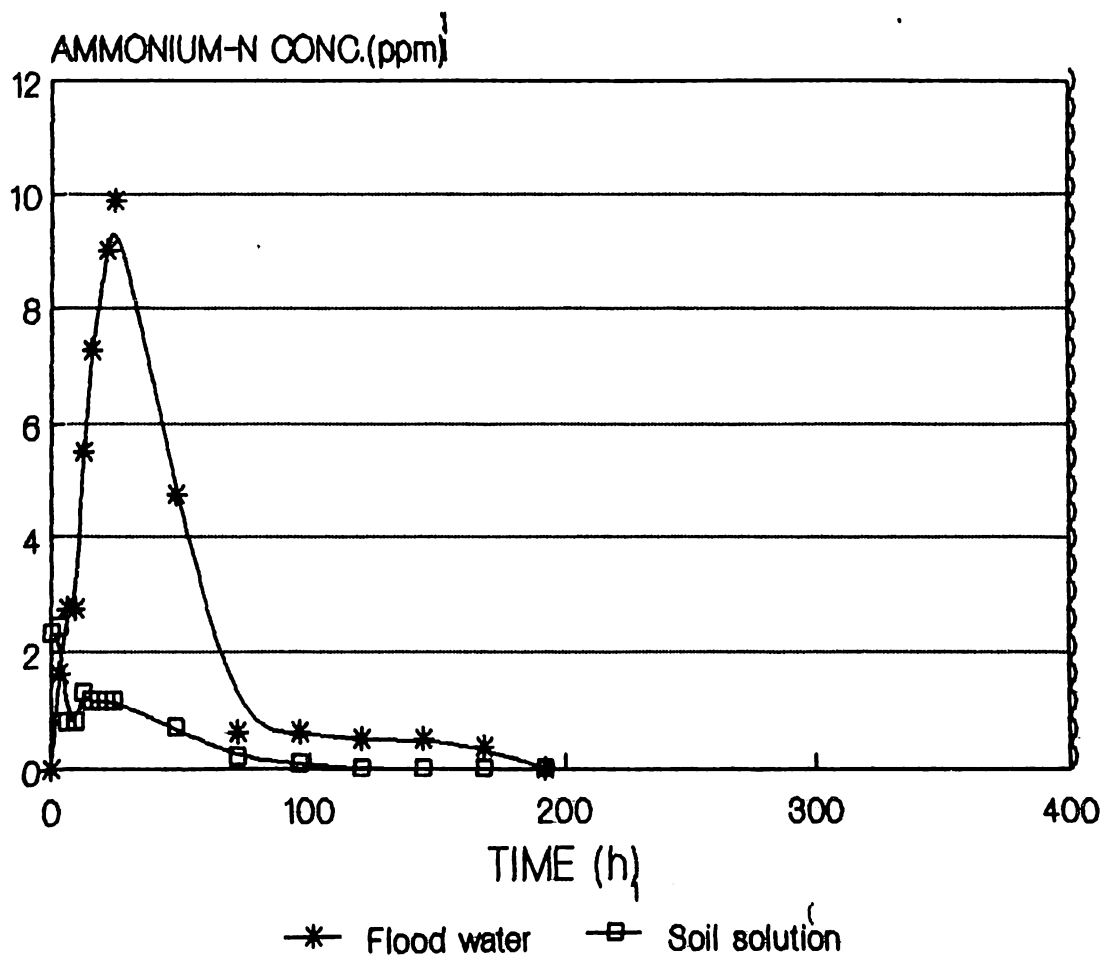


Fig. 19. Concentration of ammonium N (ppm) in flood water and soil solution (10 cm depth) after application of 19 kg N(PU)/ha to medium land kharif rice at transplanting.

transplanting. The flood water ammonium N concentration increased from zero to a peak value of 9ppm (at 25h) and then decreases to near zero beyond 150h. The soil solution ammonium N concentration value decreases from 2 ppm to zero within 100 hours. Flood water and soil solution ammonium N concentration following application of 38kg N/ha as PU at tillering is presented in Fig 20. The value of 16 ppm was attained in flood water around 20h and the zero concentration is reached beyond 150 h. The ammonium N concentration of soil solution decreased from 5ppm to zero within 100h.

The flood water ammonium N concentration in USG treatment was found negligible. However, the peak value of ammonium N in soil solution was observed to be 63ppm (170h) and decreased to 25ppm around 350h without attaining zero (Fig 21). Sevant and De Datta (1980) reported the overall movement of ammonium after deep placement of USG in a typical puddled submerged rice soil is down ward > lateral > upward. Under the present investigation, the ammonium N concentration in soil solution observed to decrease from a peak concentration of 63ppm to 25ppm within 350h. of USG application.

Fig 22 depicts the ammonium N concentration of flood water and soil solution in no nitrogen control plot.

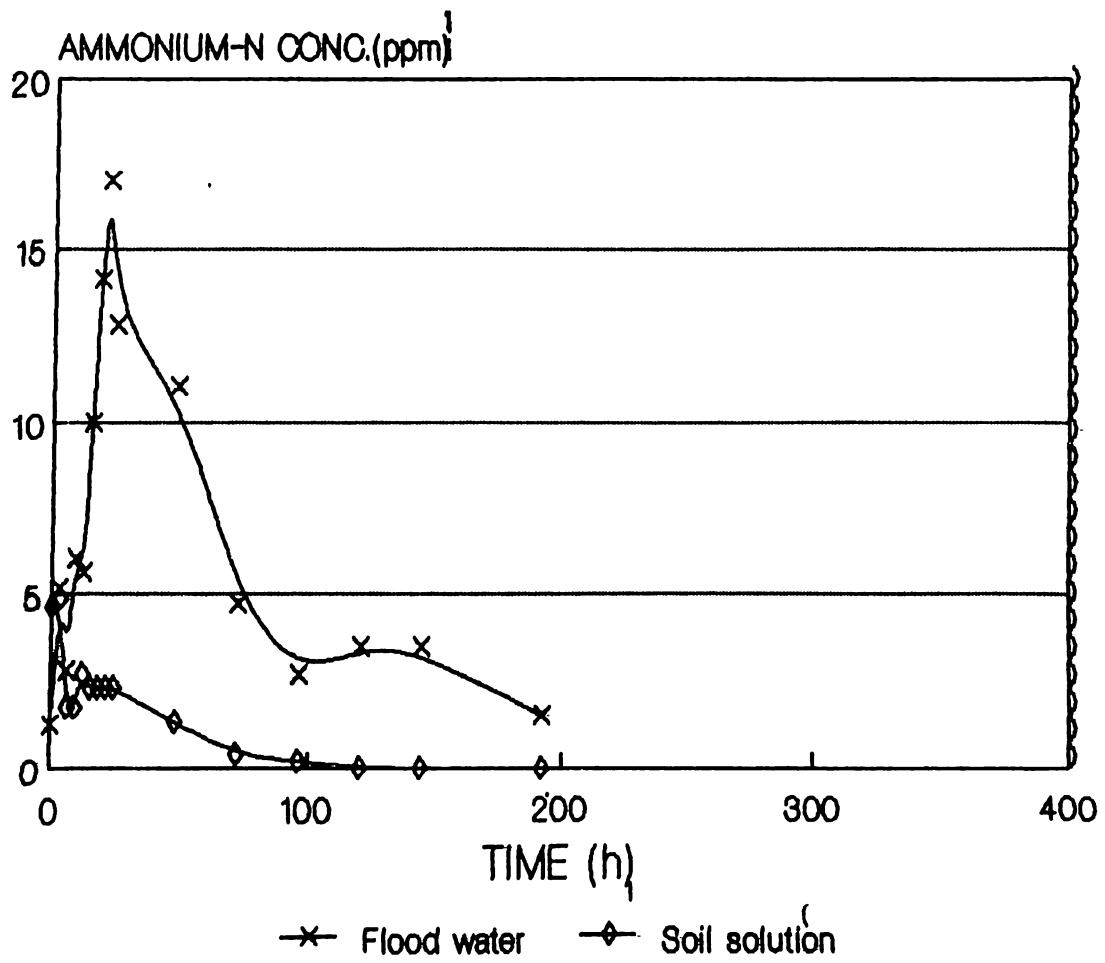


Fig. 20. Concentration of ammonium N (ppm) in flood water and soil solution (10 cm depth) after application of 38 kg N(PU)/ha to medium land kharif rice.

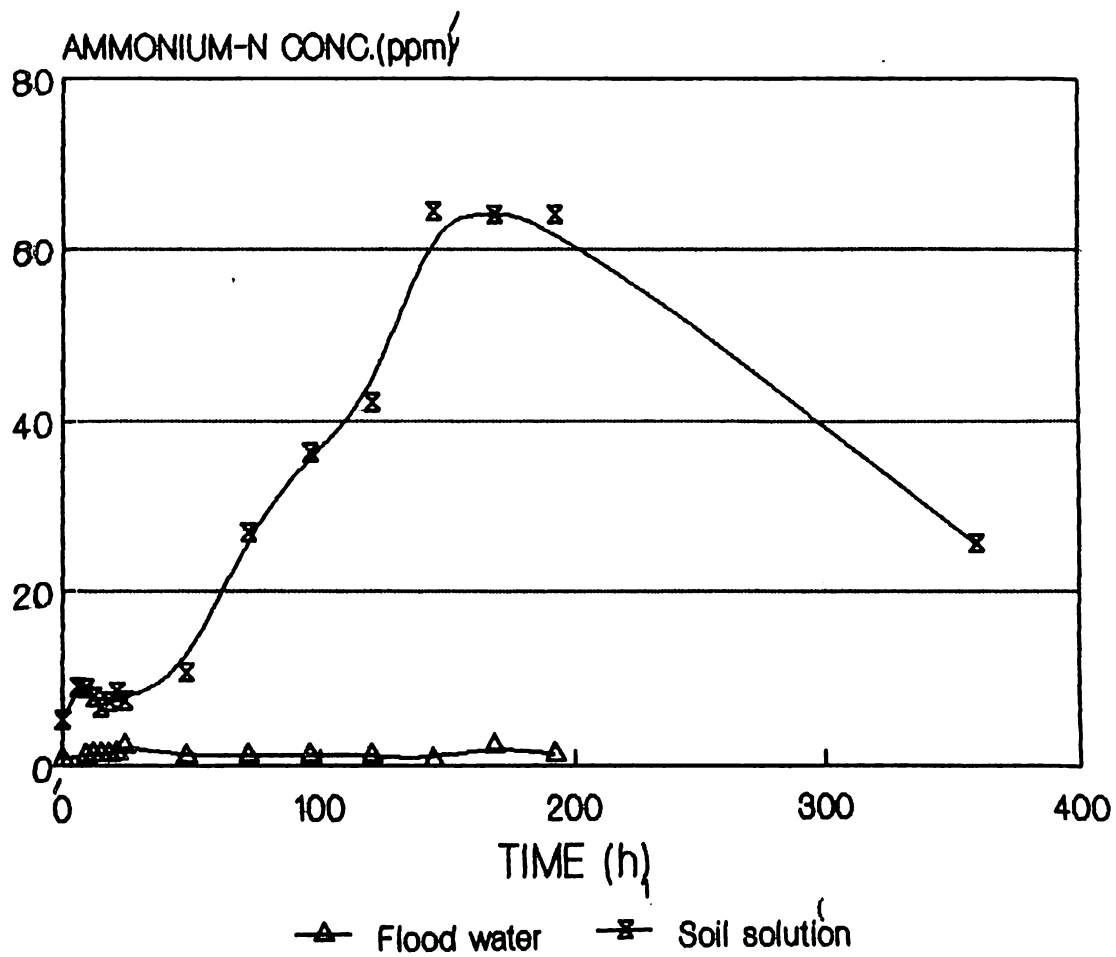


Fig. 21. Concentration of ammonium N (ppm) in flood water and soil solution (10 cm depth) after application of 76 kg N(USG)/ha to medium land kharif rice at 7 DAT.

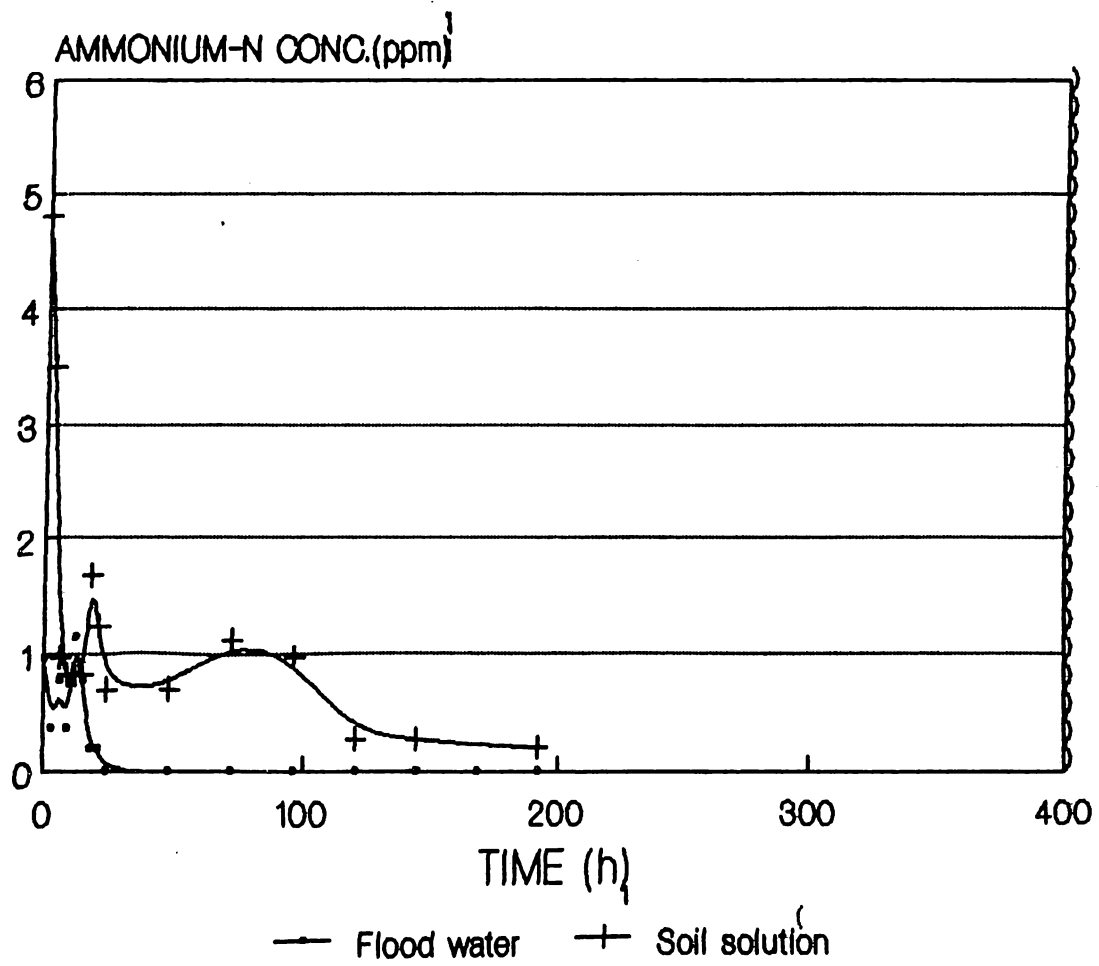


Fig. 22. Concentration of ammonium N (ppm) in flood water and soil solution (10 cm depth) in control plot at transplanting.

It is observed from the figure that the ammonium N concentration in flood water decreased from 1ppm to zero within 50 h. However, the soil solution ammonium N concentration decreased from an initial value of 5ppm to 0.5ppm within 150 h. The higher concentration of ammonium N at 10cm depth might be due to lateral movement of soil water from fertilized field due to seepage.

4.11 INORGANIC NITROGEN CONTENT OF SOIL AFTER HARVEST.

Inorganic nitrogen contents of the surface (0-15cm) and subsurface soils (15 -30 cm) from PU (@76kg N /ha) and USG (@76kg N/ha) treatment at 5th, 12th and 19th days after harvest of medium land rice are listed in table- 17 and 18.

The interesting features of this data happen to be very high ammonium N and nitrate N contents in PU treatment (@ 76 kg N/ha) at 5th day after harvest. The rootzone in USG treatment (76kg N/ha at 7 DAT) has resulted in relatively poor nitrogen content. This may be due to higher nitrogen uptake by grain and straw in USG treatment as compared to split application of PU.

The mineralization cycle in the soil may result in variable amounts of ammonium and nitrate at a given time under different situation. The ammonium N content of the

**Table 17 . . . NH_4^+ - N STATUS OF MEDIUM LAND
AFTER HARVEST OF KHARIF RICE.**

TREATMENT	SAMPLING DEPTH (cm)	NH_4^+ - N (kg/h)		
		5 DAH	12 DAH	19 DAH
T ₅ 76kg N/ha as PU(3 splits)	0 - 15	103.25	34.12	62.14
	15 - 30	44.55	56.22	47.17
T ₇ 76kg N/ha as USG(7 DAT)	0 - 15	54.7	47.92	35.45
	15 - 30	54.6	53.47	26.19

**Table 18 . . . NO_3 - N (kg/ha) STATUS OF MEDIUM LAND
AFTER HARVEST OF KHARIF RICE.**

TREATMENT	SAMPLING DEPTH (cm)	NO_3 - N (kg/h)		
		5 DAH	12 DAH	19 DAH
T ₅ 76kg N/ha as PU(3 splits)	0 - 15	55.07	27.30	0
	15 - 30	59.04	133.53	0
T ₇ 76kg N/ha as USG(7 DAT)	0 - 15	0	0	0
	15 - 30	40.95	26.73	0

DAH = Days after harvest of rice.

surface soil in PU treatment decreased from 103 to 62 kg/ha at 19th day after harvest of kharif rice as compared to 54 to 35kg /ha in USG treatment at equivalent dose.

The nitrate N content of the surface soil in PU treatment decreased from 55kg /ha to zero within 19 days after harvest, whereas in USG treatment it is observed zero. The nitrate N content of subsurface(15-30cm) soil in PU treatment increased from 59 to 133 kg /ha within 12 days and then becomes zero. But in case of USG treatment the nitrate N content decreased from 41 to 26kg and then becomes zero during same period. The reason for rich inorganic nitrogen content of soil in PU treatment might be due to lower recovery of applied nitrogen by rice crop in PU treatment than USG treatment. The other reason might be full dose of nitrogen in USG treatment is point placed at 5cm soil depth 7DAT, which is effectively utilised by rice crop. On the other hand PU is applied in three splits - at transplanting, tillering and PI stage, nitrogen applied at PI stage may not be fully utilised by this crop which leads to higher residual effect.

However, the causes as to why the PU treatment should have led to such a nitrogen -rich rhizosphere at the harvest of the rice crop should be investigated further.

4.12. LEACHING STUDY IN SOIL COLUMNS

The relevant data pertaining to the different soil columns used for the leaching experiment are presented in table-19. Three different soils collected from RRS Ranital (inceptisol), RRS Chiplima (Entisol) and RRS Bhubaneswar (Alfisol) were used for the expt. The soil of RRS Bhubaneswar and RRS Ranital were collected just before start of the expt., where as the soil of RRS chiplima was collected three months before the start of the expt.

Tagged prilledurea (^{15}N PU) pulse of 400ppm N was applied in soil columns as pulse in order to understand the transformation pattern of ^{15}N PU following reaching with 0.01N CaSO_4 solution for 24hr.

4.12.1 Water content distribution in the soil columns.

The volumetric water content distribution in different layers of soil columns are presented in table 20. These data are derived by sectioning the soil column in each treatment. The data show that the volumetric water content values range between 32.56 and 35.59, 30.98 and 36.30 and 34.67 and 36.74 (cc/cc) for RRS Ranital soil, RRS Bhubaneswar soil and RRS Chiplima soil respectively. The mean volumetric water content valumn for RRS Ranital, RRS Bhubaneswar and RRS

TABLE -19 SOIL COLUMNS DATA

	RRS RANITAL SOIL	RRS BBSR SOIL	RRS CHIPLIMA SOIL
1. Gross length(cm)	15.0	15.0	15.0
2. Length of the prepared soil columns (cm)	14.0	14.0	14.0
3 length measured after leaching experiment.	14.0	14.0	14.0
4. Internal diameter of the pipes. (cm)	8.5	8.5	8.5
5 Volume of soil packed (cc)	794.75	794.75	794.75
6 Mass of soil packed (gm)	1311.34	1351.08	1311.34
7. B.D. maintained at packing.(gm/cc)	1.65	1.70	1.65
8. Duration of the application of solution pulse.(h)	1.0	1.0	1.0

* Solution pulse : 15_N PU(400ppm N) = 6mg.

Chiplima soil were observed to be 33.77, 32.90 and 35.59 (cc/cc) respectively. The values volumetric water content distribution in RRS Chiplima soil were observed to increase from top to bottom where as a reverse trend was obtained in case RRS Ranital soil . The higher water content value compared with the mean, may have resulted from swelling -a phenomenon also observed by Patnaik (1982)and Khanda (1985).

4.12.2 Retention of $\text{NH}_4^- \text{N}$ in soil column following leaching of ^{15}N PU

Following application of ^{15}N PU pluse in all soil columns, leachate samples were collected for 15 minutes at one hour interval. After 24 hr of leaching , the soil sections of 3.5cm thickness were taken and extracted with KCl-PMA solution. The aliquot of the extract as well as the leachate samples were used for determination of $\text{NH}_4^+ \text{-N}$ colorimetrically.

The mean solution flow velocity v was calculated according to the relationship.

$$v = \frac{V}{AtQ}$$

where $\frac{V}{t}$ = solution flowrate (ml/h)

A = cross sectional area of soil columns (cm^2)

$\bar{Q}$ = mean volumetric water content.

The data presented in Table 20 show that, this mean solution flow velocity for RRS Ranital, RRS Bhubaneswar and RRS Chiplima soil were observed to be 0.417, 0.321 and 0.401 cm/h respectively. This shows that the solution flow rate and mean solution flow velocity was observed to be same for RRS Ranital and RRS Chiplima soil whereas it was lower in case of RRS Bhubaneswar soil. From the mean solution flow velocity presented in Table 20, it can be calculated that the peak value for $\text{NH}_2\text{-N}$ concentration in the leachate might be attained after 33.5h, 43.6h and 34.9h of leaching for RRS Ranital, RRS Bhubaneswar and RRS Chiplima soil respectively. Since this leaching experiment was continued only for 24 hours, it was not possible to get $\text{NH}_2\text{-N}$ and $\text{NH}_4\text{-N}$ in leachate solutions - collected at every one hour interval following application of ^{15}N PU pulse. However, 24 hours after urea application no urea was detected in the soil at any depth, indicating complete hydrolysis of urea applied.

Fig 23. (Table 21) depicts the amount of $\text{NH}_4\text{-N}$ retained in different soil layers following 24 hours leaching of ^{15}N PU. It is observed from the figure that the peak concentration of $\text{NH}_4\text{-N}$ was observed in 0-3.5 cm layer of

TABLE 2D FORMATION OF AMMONIUM N IN DIFFERENT SOIL COLUMNS
FOLLOWING 24 HOURS LEACHING OF ^{15}N PU

SOIL TYPE	CONC. OF SOLUTION PULSE (ppm)	SOLUTION FLOW RATE (ml/h)	MEAN SOLUTION FLOW VELO- CITY(ml/h)	AMIDE N ADDED TO COLUMN(mg)	AMMONIUM-N FORMED AFTER 24HOUR(mg)
RRS Ranital (Incepti sol)	400	8	0.417	6	31.09
RRS Bhubane- swar (Alfisol)	400	6	0.321	6	24.65
RRS Chiplima (Entisol)	400	8.1	0.401	6	20.40

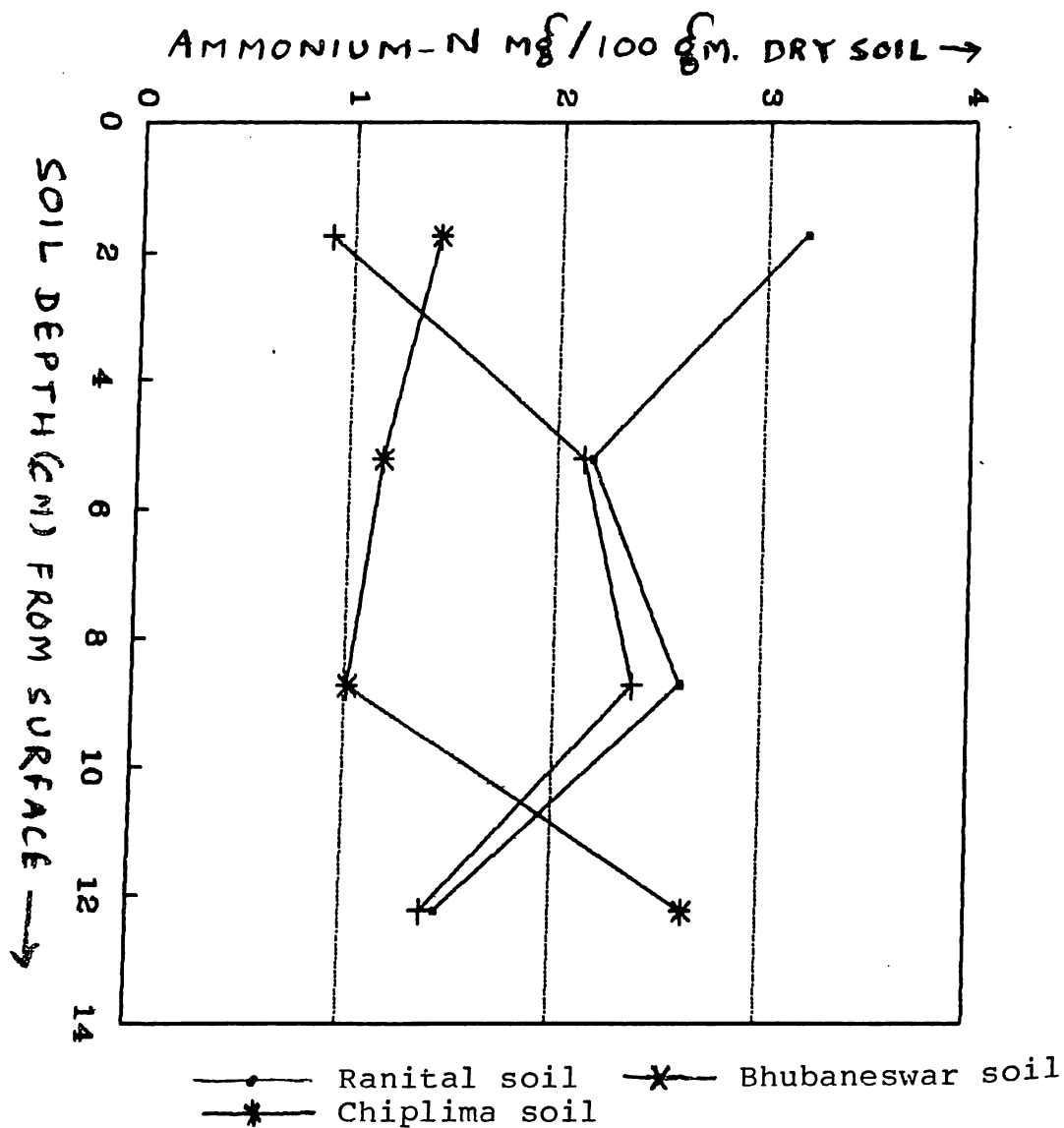


Fig. 23. Retention of ammonium N in different soil layers after completion of 24 hour leaching with ^{15}N PU(400 ppm N) through 14 cm soil columns.

Table 21

VOLIMETRIC WATER CONTENT DISTRIBUTION AND AMMONIUM N RETAINED IN DIFFERENT SOIL LAYERS AFTER COMPLITION OF 24 HOUR LEACHING

SOIL COLUMN LAYER(cm)	VOLUMETRIC WATER CONTENT cc/cc	MEAN VOLUMETRIC WATER CONTENT cc/cc	B.D. BY PACKING	NH ₄ -N RETAINED (mg/100g)SOIL
RRS RANITAL SOIL				
0-3.5	35.59			3.19
3.5-7.0	33.28	33.77	1.65	2.17
7-10.5	32.56			2.61
10.5-14	33.65			1.51
RRS B.B.S.R SOIL				
0.3.5	31.09			0.853
3.5-7.0	30.98			2.13
7.0-10.5	33.23	32.90	1.70	2.93
10.5-14.0	36.30			1.38
RRS CHIPLIMA SOIL				
0-3.5	34.67			1.41
3.5-7.0	35.17			1.16
7.0-10.5	35.78	35.59	1.65	1.01
10.5-14.0	36.74			2.64

RRS Ranital soil and concentration value decreases with increasing depth. The peak value for $\text{NH}_4\text{-N}$ concentration in case of RRS Bhubaneswar and RRS Chiplima soil was observed to be at 7.0-10.5 and 10.5-14 cm soil depth respectively. This resembles with the mean solution flow velocity being 0.321 cm/h, 0.401 cm/h for RRS Bhubaneswar and RRS Chiplima soil respectively. But why the peak concentration in case of RRS Ranital soil remained in topmost layer (0-3.5cm) having higher mean solution flow velocity (0-417 cm/h) is not understood.

The $\text{NH}_2\text{-N}$ added in different treatments in the form of solution pulse was 6mg in each case. This calculates to be nearly 12Kg/ha on area basis and 17kg/ha on soil wt. basis. This was intended to simulate the behaviour during leaching of a dose of $\text{NH}_2\text{-N}$ which is added at one instalment to a normal field crop.

The $\text{NH}_4\text{-N}$ retained as calculated by integrating this area under each curve are observed to be 31.09, 24.65 and 20.40 kg for RRS Ranital, RRS Bhubaneswar and RRS Chiplima soils respectively.

These values were obtained by neglecting the amount of exchangeable $\text{NH}_4\text{-N}$ present in initial soil sample before leaching. However, these values might be changed if

one soil column without ^{15}N PU could have been leached with 0.01N CaSO_4 solution under similar condition.

The data in Table 20 show that the soil columns enriched with 400 ppm of ^{15}N PU (6 mg N) are observed to have 3-5 folds as much $\text{NH}_4\text{-N}$ as compared to the amount of $\text{NH}_2\text{-N}$ added might be due to priming effect. The highest magnitude was observed to be in RRS Ranital soil followed by RRS Bhubaneswar and RRS Chiplima. This shows that the rate of mineralisation due to microbial activity from native organic source was highest in RRS Ranital soil followed by RRS Bhubaneswar soil. It was sluggish in RRS Chiplima soil. The soil from RRS Chiplima was collected three months before the start of the experiment and preserved in the laboratory. This might be one of the reason for slow mineralisation rate due to low bacterial population. However the bacterial population could not be taken up for the present experiment.

From an incubation study Khanda (1985) reported that the formation of $\text{NH}_4\text{-N}$ in a $\text{NH}_2\text{-N}$ treated soil was 2-3 times higher than an untreated soil, especially when incubated at 35°C . This could have resulted from priming effect due to ammonification of soil organic matter.

The results of present investigation agrees with the findings reported by Khanda (1985).

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

1. SUMMARY

Field experiment were laid out during 1994 kharif season with rice (cv Lalata) as test crop in order to study the efficiency and transformation process of PU and USG in the crop root zone. The site of the experiment was medium land and low land in the Regional Research Station in Orissa University of Agriculture and Technology, Bhubaneswar.

The experimental design for medium and low land experiment were RBD with 3 replication, as detailed below:

MEDIUM LAND EXPERIMENT

T ₁ .	Control	(no nitrogen)
T ₂ .	38kg N/ha	as PU (3spilts)
T ₃ .	58kg N/ha	as PU (3spilts)
T ₄ .	76kg N/ha	as PU (3spilts)
T ₅ .	38kg N/ha	as USG (7 DAT)
T ₆ .	58kg N/ha	as USG (7 DAT)
T ₇ .	76kg N/ha	as USG (7 DAT)

LOW LAND EXPERIMENT

T ₁ .	Control	(no nitrogen)
T ₂ .	58kg N/ha	(2/3rd N as USG at 7DAT +1/3rd N as PU at PI)

- T₃. 76kg N/ha (2/3rd N as USG at 7DAT + 1/3rd N as PU at PI)
T₄. 95kg N/ha (2/3rd N as USG at 7DAT + 1rd n as PU at PI)
T₅. 58kg N/ha as USG (7 DAT)
T₆. 76kg N/ha as USG (7 DAT)
T₇. 95kg N/ha as USG (7 DAT).

Twenty one days old rice seedlings were transplanted in medium land experiment and 22 days old seedling in low land experiment with 50kg P_2O_5 /ha and 50Kg K_2O /ha in form of single super phoshate and muriate of patash respectively, applied as basal dose. Just before transplanting 25% of PU in PU treatments were incorporated in surface soil and remaining 50% and 25% were applied at tillering and primordia initiation stage respectively in medium land experiment. Full dose of USG was point placed ^{at} a depth of 5cm between alternate four hills 7 days after transplantation (7DAT) in both experiments where as in low land experiment the second type of tretment consists of 2/3rd of N as USG point placed at 7DAT and remaining 1/3rd of N as PU was top dressed at primordia initiation stage. Soil solution samplers were set up in some selected treatments in mediumland experiment in order to measure NH_2^-N concentration distribution in the soi solution at 10cm depth over 7-8days following fertilizer application. Hand in hand flood water samplers were collected and employed for the determination of NH_2^-N

concentration. Cultural practices including irrigation and plant protection measures were adopted time to time depending on need. The depth of water level in each treatment was measured from time to time following fertilizer application. Samples of surface soil were collected from both sites before the start of the experiments for the determination of physical and chemical properties. Plant samples at tillering, panicle initiation as well as grain and straw at harvest with yield parameters were collected/recorded. All physical and chemical determinations for soil, flood water, soil solution, grain, straw and plant parts were carried out following standard procedures.

The Texture of the surface soil in both site was observed to be silt loam with B.D. values of 1.69 to 1.71 g cm^{-3} . The soils are slightly acidic in nature, non-saline; The C.E.C. values varies between 5.0 to 6.0 $\text{cmol(p}^+\text{) kg}^{-1}$. The medium land site is low with O.C (%), medium in available nitrogen and potassium but rich in phosphorous. However, the low land site is high in O.C (%), available N & Phosphorus but medium in potassium.

The grain yield and straw yield data stemming from low land and medium land experiments were subjected to statistical analysis. It was observed in medium land

experiment that the treatment effects in T_3 (58kg N/ha as PU) and T_5 (58kg N/ha as USG) were statistically significant from other treatments although the highest yield was recorded under T_5 treatment followed by that under T_3 . The effect of fertiliser on straw yield was almost identical to that observed for the grain yield data.

It is observed from the low land grain yield data that the yield level in USG treatments were depressed in general as compared to medium land yield data might be due to heavy drowpours and water logging before and following fertiliser application. However the treatment received 58kg N/ha through 2/3rd N as USG at 7DAT plus 1/3rd N as PU at primordia intitation was found to be superior to the USG treatment for equal dose.

The highest nitrogen uptake as well as nitrogen content (%) at tillering, panicle initiation were recorded for the USG treatment in both situations. The values for agronomic efficiency, relative efficiency and apparent N recorvery (%) parameters in the USG treatment (@ 58kg N/ha) were found to be higher than those for the recommended dose of N (@76kg N/ha) applied in 3 standard splits in medium land experiment. However the values for agronomic efficiency and apparent N recovey (%) obtained due to USG + PU

treatments in lowland experiment were found to be superior to the equal dose of USG treatment.

The coefficient of correlation between rice grain yield and N uptake by grain and straw at harvest was found to be highly significant. The other significant correlation coefficients were observed to be yield Vs N concentration (%) at tillering, panicle initiation, total N uptake by grain and straw, plant height and panicle length. Similarly the correlation coefficient between dose vs % N at tillering, % N at P.I., % sterility, N uptake by grain + straw, total biomass production were found to be highly significant.

The NH_2 -N concentration distribution in the flood water as well as in soil solution following fertiliser application was observed to describe bell shaped curves in PU (19 and 38 kg N/ha) and USG treatments, the peak values in these curves mostly attaining around 7-8 hours for PU and 12.5 hours for USG treatment. The zero concentration in flood water was attained around 50-75 hours in PU treatments as compared to 175 hours in USG treatment possibly indicating slower hydrolysis rate of USG might be due to higher concentration.

The magnitude of NH_2 -N concentration in flood water following application of PU was influenced by the dose

of N applied . The peak value of 52 ppm was observed in tillering stage (38kg N /ha as PU) as compared to 18.5 ppm at transplanting (19kg N/ha as PU). The lower peak concentration in USG treatment as compared to that of PU, is suggestive of the slower rate of migration of NH_2 -N upwards into the flood water from 5cm soil depth. Based on these observed distribution curves, it was inferred that hydrolysis of urea was slower in USG treatment as compared to PU treatment.

The peak value for NH_2 -N concentration in soil solution of USG treatment was found higher (7ppm) as compared to flood water NH_2 -N concentration (3-5 ppm) is suggestive of this faster rate of migration of NH_2 -N down wards from the placement site as compared to upward migration.

The lateral movement of NH_2 -N from the treated plots/ upper reaches to the no nitrogen control plot due to seepage of flood water was suspected based on the NH_2 -N concentration of soil solution at 10cm soil depth as well as the yield data in control plot.

The magnitude of flood water NH_4 -N concentration in PU was found to be higher as compared to that in USG treatment. The flood water peak concentration of NH_4 -N was attained around 20-25 hours following PU

application. The zero concentration of $\text{NH}_4\text{-N}$ was attained beyond 150 hours. However, the peak concentration of $\text{NH}_4\text{-N}$ in soil solution following deep placement of USG was found to be 63 ppm (at 170 hours) and then decreased to about 25 ppm after 350 hours. Based on these observed data, it was inferred that the rate of ammonification is faster in PU treatment whereas the process was slower in USG treatment.

Inorganic nitrogen content of surface (0-15cm) and sub surface soil (15-30cm) was determined at 5th, 12th and 19th day following harvest of medium land kharif rice. It was observed that irrespective of this treatment, the $\text{NH}_4^+ \text{-N}$ and $\text{NO}_3^- \text{-N}$ content in USG treatment (@76kg N/ha) was lower than PU treatment for same dose. This suggests that fertiliser nitrogen is effectively utilised by rice in USG treatment as compared to PU treatment. This finding also confirmed with the nitrogen uptake, agronomic efficiency and apparent nitrogen recovery (%) data of USG treatment as compared to PU treatment.

Loose soil collected from three different Regional Research Stations of the state (RRS Ranital, RRS Bhubaneswar and RRS Chiplima.) were packed in PVC cylinders and used for leaching experiment. Tagged prilled urea (400ppm) was applied as pulse (@15ml/hr) for one hour and leaching with 0.01 N CaSO_4 continued for 24 hours. Leachate

samples were collected for 15 minutes at one hour intervals and was analysed for NH_2 -N and NH_4 -N. At the end of the experiment the soil columns were sectioned into 4 layers (3.5cm thickness) and extracted with 2M KCl-PMA solution. These extracts were analysed for NH_2 -N and NH_4 -N.

It is observed from this result that the mean volumetric water content values for RRS Ranital, Bhubaneswar and Chiplima soils were 33.77, 32.90 and 35.59 (cc/cc) respectively.

The mean solution flow velocity for RRS Ranital, Bhubaneswar and Chiplima soil were observed to be 0.417, 0.321 and 0.401 cm/h respectively. Twenty four hour after urea application, no urea was detected in the soil at any depth, indicating complete hydrolysis of urea applied.

The NH_2 -N added in different treatments in the form of solution pulse was 6mg. This calculated to be nearly 12kg /ha on area basis and 17kg /ha on soil basis. The NH_4 -N content in each soil column after completion of this leaching expt. observed to be 31.09, 24.65 and 20.40 mg for RRS Ranital, Bhubaneswar, Chiplima soils respectively could result due to priming effect. This shows that the rate of mineralisation from native organic source was highest in RRS Ranital followed by Bhubaneswar soil. However it was sluggish in Chiplima soil.

2. CONCLUSION

- * The grain yield of rice due to application of 58kg N/ha as USG/PU is significantly higher than that from 76kg N/ha applied through USG/PU. The observed non-significant difference between PU and USG during the present investigation (1994 kharif) may have been due to high intensity of rain fall received during transplanting to panicle initiation stage.
- * The efficiency of nitrogen to kharif rice can be increased when 2/3rd of N is applied ^{as USG} at 7DAT and 1/3rd of N as PU at panicle initiation stage.
- * The values for agronomic efficiency, relative efficiency and apparent N recovery (%) parameters in USG treatment are appreciably higher than that for equivalent dose of PU (58kg N/ha) applied in standard 3 splits.
- * The relationship between dose of N applied / grain yield vs nitrogen concentration at tillering, panicle initiation, N uptake by grain and straw, plant height, panicle length are found to be highly significant.
- * The rate of urea hydrolysis can be higher under PU treatment than that under USG treatment as inferred from the amide N distribution data in the flood water and soil solution.

- * Lateral seepage of amide N in flood water from upper reaches /treated plots does occur in flooded rice fields during kharif season.
- * From the values of amide N/ammonium N concentration in flood water/in soil solution in USG treatment, it can be concluded that downward movement of amide N/ammonium N is higher than upward movement.
- * The mean solution flow velocity in packed soil columns was observed to be 0.417, 0.321 and 0.401 cm/h for RRS Ranital, Bhubaneswar and Chiplima soils respectively.
- * Recovery percent of applied nitrogen in soil column was found to be higher than the applied amount might be due to priming effect resulting from ammonification from organic source.

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APPENDICES

APPENDIX I. DETAILS OF CROP CALENDER OF THE FIELD EXPERIMENTS.

Particulars	Medium Land	Low Land
Design	RBD	RBD
No. of treatments	7	7
No. of replication	3	3
Plot size	4.5 x 4 m ²	6 x 3 m ²
Crop	Rice	Rice
Variety	lalat	lalat
Spacing	15 x20 cm(PU) Modified spacing (USG)	15 x20cm(PU) Modified spacing (USG)
Dose of N(kg/ha)	As per treatment	As per treatment.
Dose of P ₂ O ₅ (kg/ha) as SSP	50	50
Dose of K ₂ O (kg/ha) as MOP.	50	50
Date of sowing in nursery.	7.7.94	7.7.94
Date of transplanting.	3.7.94	1/8/94
Date of USG application	6.8.94	6.8.94
Date of 1st top dressing (PU)	21.8.94	21.8.94
Date of 2nd top dressing (P.U.)	20.9.94	20.9.94
Pesticide spray /pest attack	31.8.94 Ekkalux Ekkalux	31.8.94
	13.9.94Demecron Demecron	13.9.94
	28.9.94 Demecron Stemborer & Mealy bug	Stemborer & Mealy bug
No of a irrigation applied.	Rainfed	rainfed
Date of harvesting .	30.10.94	29.10.94

APPENDIX II. RAINFALL RECEIVED DURING CROP GROWTH PERIOD

Date	Rainfall(mm) 1994		
	August	September	October
1	12.8	3.0	-
2	-	2.5	-
3	7.9	17.8	15.7
4	-	35.3	-
5	7.9	7.9	31.2
6	2.5	-	63.3
7	78.0	-	12.9
8	-	-	8.4
9	5.8	-	-
10	10.9	-	9.4
11	14.2	7.6	-
12	-	0.3	-
13	-	2.5	-
14	-	1.8	-
15	-	18.3	-
16	39.9	31.0	-
17	20.3	81.8	-
18	124.7	14.7	-
19	3.1	2.8	-
20	-	-	1.8
21	-	-	-
22	41.9	-	-
23	-	5.6	-
24	2.5	-	2.0
25	22.8	-	-
26	8.6	-	3.1
27	14.2	18.8	-
28	19.3	-	1.8
29	47.7	-	-
30	4.3	-	-
31	-	-	-
Total	489.3	251.7	149.3

APPENDIX III. RAINFALL DATA FROM 1991 TO 1994

Month	Rainfall (mm)			
	1991	1992	1993	1994
January	-	20.5	Nil	Nil
February	-	54.9	Nil	33.6
March	-	Nil	9.7	0.8
April	16.5	11.0	90.6	21.9
May	13.6	251.4	55.7	17.9
June	106.9	138.2	284.8	168.9
July	500.6	354.0	241.4	238.0
August	307.2	356.3	456.7	489.3
September	127.0	225.9	195.3	251.7
October	104.7	163.9	79.3	149.3
November	79.9	1.3	14.2	5.6
December	3.0	Nil	Nil	Nil
Total	1259.4	1577.4	1427.7	1377

APPENDIX IV. TEMP. AND pH OF FLOODWATER OF CONTROL PLOT AT THE TIME OF TRANSPLANTING, 7DAT AND 1st TOP DRESSING OF MEDIUM LAND KHARIF RICE .

HOURS AFTER IN TREATED PLOTS	TRANSPLANTING		7DAT		1ST TOP DRESS	
	TEMP ($^{\circ}$ C)	pH	TEMP ($^{\circ}$ C)	pH	TEMP ($^{\circ}$ C)	pH
0 h(12 noon)	-	6.5	35.5	6.7	33	6.2
3 h(3 PM)	34	6.5	-	-	30	6.1
6 h(6 PM)	31.5	6.5	29.5	-	28.5	6.1
9 h(9 PM)	30	-	27	6.6	27.5	6
12 h(Mid night)	30	-	27	6.7	27	5.8
15 h(3 AM)	29	-	27	-	27	5.9
18 h(6 AM)	28.5	-	27.5	6.4	29	5.9
21 h(9 AM)	31	-	31	6.7	33	6.1
24 h(12 NOON)	36	6.5	37	7.1	32.5	7.0
48 h(12 NOON)	36	7.2	34	6.4	34	6.2
72 h(12 NOON)	31	7.0	33	6.3	33	6.3
96 h(12 NOON)	39	6.9	29	6.2	31	6.3
120 h(12 NOON)	40.5	7.0	34	6.8	30	6.3
144 h(12 NOON)	35.5	7.0	36	6.4	29	6.0
168 h(12 NOON)	37	8.1	35	6.2	-	-
192 h(12 NOON)	34	6.9	37	6.5	32	6.0

APPENDIX - V. CONC. OF UREA N AND AMMONIUM N IN FLOOD WATER
AND SOIL SOLUTION(10cm DEPTH) CONTROL PLOT
AT TRANSPLANTING OF MEDIUM LAND KHARIF RICE.

HOURS AFTER PU APPLICATION	FLOODWATER		CONC. OF UREA N(ppm)		CONC.OF AMMONIUM N(ppm)	
	TEMP(⁰ C)	pH	F.W.*	S.S.**	F.W.*	S.S.**
0 h(12 noon)	-	6.5	0	0.	0.7	4.8
3 h(3 PM)	34	6.5	-	-	-	3.5
6 h(6 PM)	31.5	6.5	0.5	1.33	0.7	0.975
9 h(9 PM)	30	-	1.25	-	1.65	0.825
12 h(Mid night)	30	-	1.25	-	0.475	0.825
15 h(3 AM)	29	-	1	-	0.475	0.825
18 h(6 AM)	28.5	-	1	1.5	0.825	1.675
21 h(9 AM)	31	6.5	0.66	0.833	0.825	1.125
24 h(12 NOON)	36	7.2	-	0.833	0.237	0.7
48 h(12 NOON)	36	7.0	0.583	0	0.475	0.7
72 h(12 NOON)	31	6.9	0	0	0.475	1.124
96 h(12 NOON)	39	7.0	0	0	0.575	0.975
120 h(12 NOON)	40.5	7.0	0	0	0.75	0.275
144 h(12 NOON)	35.5	7.0	0	0	0.575	0.275
168 h(12 NOON)	37	7.0	0	0	0.575	-
192 h(12 NOON)	34	6.9	0	0	0	0

APPENDIX VI FLOOD WATER TEMP., pH, CONC. OF UREA N AND AMMONIUM N IN FLOOD WATER AND SOIL SOLUTION (10cm DEPTH) AFTER APPLICATION OF PU 19 Kg N/ha AT THE TIME OF TRANSPLANTING IN MEDIUM LAND KHARIF RICE.

HOURS AFTER PU APPLICATION	FLOODWATER		CONC. OF UREA N(ppm)		CONC. OF AMMONIUM N(ppm)	
	TEMP(⁰ C)	pH	F.W.*	S.S.**	F.W.*	S.S.**
0 h(12noon)	-	6.5	-	-	-	0.33
3 h(3 PM)	34	6.5	21.835	1.5	1.625	2.43
6 h(6 PM)	31.5	6.5	17.563	2.00	2.75	0.8
9 h(9 PM)	30	-	18.354	1.583	2.75	0.8
12h(12Midnight)	30	-	16.653	1.75	5.5	1.3
15 h(3 AM)	29	-	-	1.5	7.25	1.15
18 h(6 AM)	28.5	-	6.329	1.5	-	1.15
21 h(9AM)	31	7.0	3.955	0.833	9	1.15
24 h(12noon)	36	7.0	1.661	0.75	9.875	1.15
48 h(12noon)	36	7.2	0.791	0.75	4.75	0.7
72 h(12noon)	31	7.3	0.791	0.75	0.625	0.19
96 h(12noon)	39	7.2	0.791	0.666	0.625	0.08
120 h(12noon)	40.5	7.1	0.791	0.5	0.5	0.0
144 h(12noon)	35.5	7.2	0.791	-	0.5	0
168 h(12noon)	37	7.3	0.791	0.583	0.375	0
192 h(12noon)	34	7.1	0.791	0.25	0	0

*F.W = Floodwater

**S.S. =Soil solution at 10cm depth.

APPENDIX -VII FLOOD WATER TEMP.,pH, CONC. OF UREA N AND AMMONIUM N IN FLOOD WATER AND SOIL SOLUTION(10cm DEPTH) AFTER APPLICATION OF USG @ 76Kg N/ha AT 7DAT TO MEDIUM LAND KHARIF RICE.

HOURS AFTER PU APPLICATION	FLOODWATER		CONC. OF UREA N(ppm)		CONC.OF AMMONIUM N(ppm)	
	TEMP(⁰ C)	pH	F.W.*	S.S.**	F.W.*	S.S.**
0 h(12 noon)	-	6.5	-	-	0	2.33
3 h(3 PM)	34	6.5	21.835	1.5	1.625	2.43
6 h(6 PM)	31.5	6.5	17.563	2	2.75	0.8
9 h(9 PM)	30	-	18.354	1.583	2.75	0.8
12 h(Mid night)	30	-	16.658	1.75	5.5	1.3
15 h(3 AM)	29	-	-	1.5	7.25	1.15
18 h(6 AM)	28.5	-	6.329	1.5	-	1.15
21 h(9 AM)	31	7.0	3.955	0.833	9.0	1.15
24 h(12 NOON)	36	7.0	1.661	0.75	9.875	1.15
48 h(12 NOON)	36	7.2	0.791	0.75	4.75	0.7
72 h(12 NOON)	31	7.3	0.791	0.75	0.625	0.19
96 h(12 NOON)	39	7.2	0.791	0.666	0.625	0.08
120 h(12 NOON)	40.5	7.1	0.791	0.5	0.5	0
144 h(12 NOON)	35.5	7.2	0.791	-	0.5	0
168 h(12 NOON)	37	7.3	0.791	0.583	0.375	0
192 h(12 NOON)	34	7.1	0.791	0.25	0	0

APPENDIX -VIII FLOOD WATER TEMP.,pH, CONC. OF UREA N AND AMMONIUM N IN FLOOD WATER AND SOIL SOLUTION (10cm DEPTH) AFTER APPLICATION OF PU 38 Kg N/ha AT THE TIME OF 1ST TOPDRESS IN MEDIUM LAND KHARIF RICE.

HOURS AFTER PU APPLICATION	FLOODWATER		CONC. OF UREA N(ppm)		CONC.OF AMMONIUM N(ppm)	
	TEMP(⁰ C)	pH	F.W.*	S.S.**	F.W.*	S.S.**
0 h(3PM)	33	6.1	2.768	0	1.275	4.675
3 h(6 PM)	30	6.1	39.24	1.5	5.175	4.875
6 h(9 PM)	28.5	6.1	53.006	1.58	2.8	1.75
9 h(12Midnight)	27.5	6	53.006	1	6.028	1.75
12 h(3AM)	27	6	41.139	1.08	5.628	2.752
15 h(6 AM)	27	6.2	34.81	1.08	10	2.325
18 h(9 AM)	29	6.2	18.987	1.08	14.1	2.325
21 h(12noon)	33	6.5	13.844	1.06	17.05	2.325
24 h(3PM)	32.5	6.4	15.82	0.5	12.8	2.325
48 h(3PM)	34	6.9	1.819	0.416	11.025	1.35
72 h(3PM)	33	6.7	1.028	0	4.725	0.375
96 h(3PM)	31	6.5	1.028	0	2.675	0.198
120 h(3PM)	30	6.2	0.553	0	3.45	0
144 h(3PM)	29	6.3	0.553	0	3.45	0
192 h(3PM)	32.0	6.1	0.553	0	1.555	0

*F.W = Floodwater

**S.S. =Soil solution at 10cm depth.