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ALL-INDIA COORDINATED RICE IMPROVEMENT PROJECT
(AICRIP)

Grams : RICE
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Rajendranagar
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A. P., (India)

Registered - Post

Dr. J.E. Shinde
Senior Soil Scientist

No. D.O. SS/5200/77-78 21st February 1978.

Dear Dr. Murthy:

With reference to your D.O. No. NRL/635/7 dated 14-2-78 in connection with the review of projects financed by IAEA, I am enclosing two progress reports and other relevant information. After your review, kindly return the progress reports [and other papers marked to be returned] since I do not have any extra copies of the same.

With best regards,

Yours sincerely,

JShinde

(J.E. Shinde)

Enclosure: As above.

Dr. B.R. Murthy
Project Director
Nuclear Research Laboratory
Indian Agricultural Research Institute
NEW DELHI 110 012.

Title: The fate of applied organic and inorganic N in flooded rice soil in relation to nitrate pollution under tropical conditions (Part of a co-ordinated programme on agricultural N residues with particular reference to their conservation as fertilizers and behaviour as potential pollutants)

Research contract No:- 1438/R3/GS

Location:- All-India Coordinated Rice Improvement Project, Hyderabad.

Principal Investigator:- Dr. J.E. Shinde, Senior Soil Scientist

Background:- The Project was awarded in October 1973 and located at Central Rice Research Institute. Although the project envisaged studies on the loss of fertilizer N through leaching and consequent nitrate pollution, it was recognized by IAEA that the developing countries would be mainly interested in most efficient utilization and conservation of fertilizer N (working paper No.5, Ist FAO/IAEA/GSF research coordination meeting, Vienna, March 1975).

In 1975, the above project became a part of an enlarged and long-ranged programme on N residues which would continue upto 1980 (vide Annex-II, status of programme as at 1-3-1975, working paper No.5, Ist FAO/IAEA/GSF research coordination meeting, Vienna, March 1975).

The project was transferred to All-India Coordinated Rice Improvement Project, Hyderabad in December 1975.

Work done: In accordance with the aim of the project and the above background the following projects were accomplished:

1. Development and testing of techniques for assessment of leaching and volatilization losses of fertilizer N under field conditions (A paper on this aspect was presented at the International Symposium on Nuclear techniques held at Nuclear Research Laboratories, New Delhi in February'77).
2. Use of non-edible oil cakes and their extracts for efficient use of fertilizer N by flooded rice crop.
3. Development of indigenous slow-release N sources for flooded rice from agricultural wastes and their evaluation under field conditions (A paper on this aspect is enclosed).
4. The transformation and turnover of N^{15}- labelled rice straw and farm yard manure under field conditions of flooded rice culture (details enclosed in the form of a Ph.D. synopsis of Mr. A.M. Krishnappa).
5. The transformation of an initial N^{15}- pulse added with and without neem cake, over three crop seasons and two inter-crop wet or dry fallows. The losses of fertilizer N through leaching, Clay-fixation, irreversible immobilization and volatilization were continuously monitored. (details enclosed in the form of Ph.D. synopsis of Mr. A.M. Krishnappa).

Work in progress: A long-term field experiment, extending upto 1980, on "The transformation of N^{15}- urea in rice-wheat cropping system with reference to N balance" is at present continuing.

Additional information: The data obtained under the IAEA project had been compiled into two Ph.D. theses and submitted to the Orissa University of Agriculture and Technology, Bhubaneswar, Orissa. One more Ph.D. thesis is under preparation.

J Shinde
21-2-78

(J. E. Shinde)
Principal Investigator.

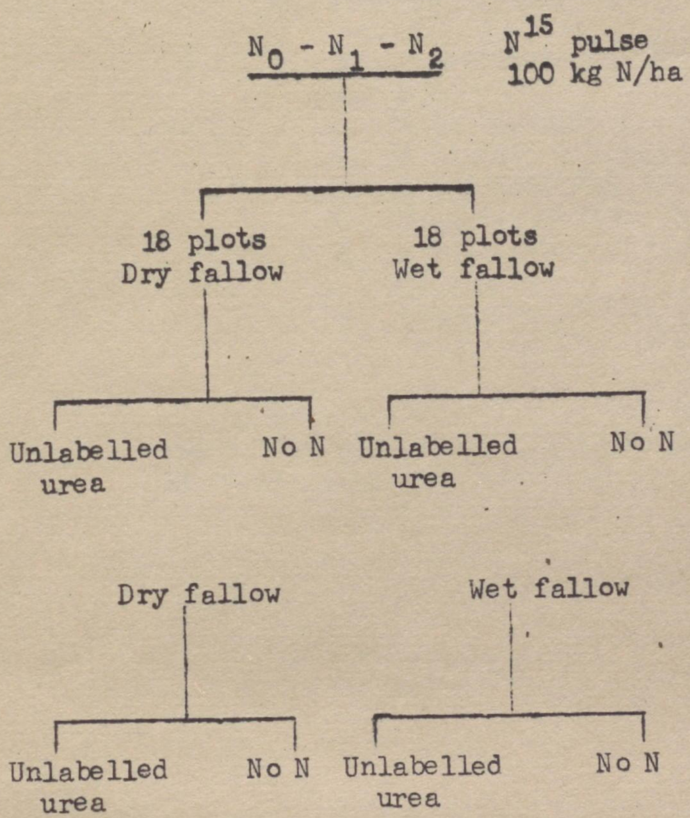
Experiments under FAO/IAEA/GSF research coordination programme on N residue, Hyderabad, India.

1. Long-term field experiments to follow the fate of an initial N-15 pulse in flooded rice soils.

Layout: Split plot

Plot size:
(a) N-15 plots: 0.07 sq.m.
(b) Yield plots: 13.75 sq.m.

Treatments:
1. Control, No N (N_0)
2. Basal application of 100 kg N/ha (N_1)
3. Neem cake (residue of *Azadirachta indica* seeds after extraction of oil) 250 kg/ha + basal application of 100 kg N/ha (N_2)



1st crop - wet season
July - October, 1976
Tr. x Rep. = Total plots
3 x 12 = 36

1st fallow: 60 days
October - December, 1976
Tr. x Rep. = Total plots
6 x 6 = 36

IInd crop - Dry season
February - May, 1977
Tr. x Rep. = Total plots
12 x 3 = 36

II Fallow = May - June, 1977
Tr. x Rep. = Total
12 x 3 = 36

III Crop - Wet season
July - October, 1977
Tr. x Rep. = Total
12 x 3 = 36

Dry fallow = After harvest of the crop the soil will be allowed to dry naturally and then rewetted for planting the succeeding crop.

Wet fallow = After harvest of the crop the soil will not be allowed to dry by continuing irrigation (about 2 cm of flood water over the soil surface).

Observations:-

(a) Hydrological parameters

1. Irrigation water
2. Precipitation
3. Evapotranspiration
4. Percolation

(b) Nitrogen parameters

1. N in irrigation water
2. N in rain
3. N in leachate
4. N in ground water
5. N in harvested crop
6. N in volatilization loss
7. Total soil N (Kjeldahl)
8. Mineral N
9. Non-exchangeable-N
10. Fractionation of organic N

Destructive soil sampling layer by layer will be done at the end of the experiment. Soil samples after each harvest or fallow will be drawn using the Nylon bags.

2. The transformation of N^{15}-urea in rice - wheat cropping system with reference to N balance. (The standard or the 'Zemun' experiment).

<u>Experimental plan</u>

Season	Year	A		B		C	
Wet	1977	Rice*	~~Fallow~~ Rice	Rice*	~~Fallow~~ Rice	Rice*	~~Fallow~~ Rice
Dry	1977	Wheat	Wheat*	Wheat^{x}	Wheat*	Wheat^{x}	Wheat*
Wet	1978	D	Rice	Rice^{x}	Rice^{x}	Rice^{x}	Rice^{x}
Dry	1978		D	Wheat^{x}	Wheat^{x}	Wheat^{x}	Wheat^{x}
Wet	1979			D	Rice^{x}	Rice^{x}	Rice^{x}
Dry	1979				D	Wheat^{x}	Wheat^{x}
Wet	1980					D	Rice^{x}
Dry	1980						D

* Application of N^{15}-urea

x Application of unlabelled urea

Group A = N^{15}- urea of 5% atom excess

Group B and C = N^{15}- urea of 10% atom excess

D = Destructive soil sampling

Rice will be grown under flooded condition (5 cm depth) and wheat at approximately field capacity moisture.

Group A will have 8 replications and B and C 4 each.

The treatments would be

N_0 = No N

N_1 = 80 kg N/ha in 3 splits for rice and 2 splits for wheat.

Plot size

(a) N^{15}- microplot = 0.25 sq.m.
(b) Yield plot = 13.75 sq.m.

Observations:-

1. Recovery of fertilizer N in the crop
2. Loss of N through leaching
3. Loss of N through volatilization and denitrification
4. Fertilizer N in ground water
5. Fertilizer N in soil in Kjeldahl, mineral and organic forms at different depths.
6. Meteorological observations
7. N added through rainfall or irrigation.

4. Long-term field experiment to follow the transformation of N^{15}- labelled rice straw and FYM.

Lay out : RBD

Treatments:
1. Control
2. N^{15}-urea
3. N^{15}-straw
4. N^{15}-FYM
5. N^{15}-straw + unlabelled urea
6. N^{15}-FYM + unlabelled urea
7. Unlabelled straw + N^{15}-urea

Rate of application:

N = 100 kg/ha

Straw = 2 t/ha

FYM = 2.2 t/ha

Analysis of materials:

1. Straw:
   (a) N^{15}-labelled = Total N 0.88%, Org.C. 36.03%, C/N ratio 40.94, N-15 atom excess 22.42%.
   (b) Unlabelled = Total N 0.75%, Org. C. 33.90, C/N ratio 45.20.
2. FYM = Total N 1.698%, Org. C. 20.47%, C/N ratio 12.05, N-15 atom excess, 0.357%
3. Urea = N-15 atom excess 10.4%

Matured rice straw chopped into 2-3 cm pieces was used. FYM was prepared from N^{15}-labelled rice straw. For the 1st crop (Dry season 1977) the straw and FYM were incorporated upto 5-8 cm depth and allowed to incubate for 15 days under 5 cm flooded condition before application of urea or transplanting. Urea was applied all basal and incorporated upto 5-8 cm depth. All treatments were replicated 6 times.

For the 2nd crop (Wet season 1977) 3 replicates of each treatment, except the control, received unlabelled urea @ 100 kg N/ha in 3 splits. Similar pattern will also be followed for subsequent crops.

Soil samples will be drawn at the end of the 2nd and subsequent crops to follow the transformation of labelled organic N in various fractions of the soil N.

Reprinted from *J. Nuclear agric. biol.*, Vol. 6, No. 4, December 1977, pp. 139- 141

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Evaluation of Indigenous Sources of Slow-Release N for Flooded Rice Using ^{15}N

C. U. M. RAO AND J. E. SHINDE*

Central Rice Research Institute, Cuttack

ABSTRACT

Among slow-release N sources, sulphur coated urea produced by TVA, has been most widely tested in flooded rice culture. An attempt was made to prepare slow-release N sources from urea or ammonium sulphate, rice straw and husk. A mixture of carbonaceous materials and inorganic ^{15}N to give a C/N ratio of 12 : 1 was kneaded with sufficient water and soil, shaped into a ball form and air-dried.

The balls were placed at 8 cm depth in between rows of flooded rice at the time of transplanting. The performance of the indigenous sources was compared with basal application of urea, ammonium sulphate, sulphur coated urea and neem extract treated urea. The results of two field experiments showed that the indigenous materials, particularly the one prepared from urea and rice husk, performed better than sulphur coated urea and basal applications of both urea and ammonium sulphate.

Fertilizers which release their N content slowly or at a rate commensurate with the requirement of the crop have been known to be more effective than ordinary materials. Although nearly 30 or more different slow-release N materials have been developed, only sulphur-coated urea (SCU) has so far been widely evaluated under conditions of flooded rice culture. At present, SCU is imported entirely for research purposes. Development of slow-release materials which do not need factory processing and can be prepared by the farmers themselves using locally available ingredients may appear to be a more realistic approach than importing the technology to produce SCU. This paper describes the development

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of slow-release materials from straw waste, rice husk and urea/ammonium sulphate and their evaluation under field conditions.

Materials and Methods

Preparation of slow-release sources :

(1) Mud balls—Carbonaceous material in the form of ground rice straw or husk, ^{15}N-labelled urea/ammonium sulphate in solution form to give a C/N ratio of 12 : 1 ignoring about 0.4 per cent N in the former, and sufficient soil were intimately mixed. The mixture was kneaded using additional soil or water as required and then shaped into a ball form of approximately 4 cm diameter. The soil was used to provide a cohesive matrix. A small quantity of single superphosphate to provide P_2O_5 equivalent to 50 per cent of fertilizer N was also included in the mixture to minimize volatilization losses during the process of sun-drying. The dried balls were strong enough to withstand rough handling.

(2) Urea coated with *neem* extract—the ethanol extract of the *neem* oil from the fruit of *Azadirachta indica* (sp. gr. 0.99) was used at the rate of 0.23 ml per g of urea. The *neem* extract dissolved in ethanol was added to urea and well mixed. The mixture was allowed to dry at 50°C with constant agitation until the urea granules were uniformly coated with a black resineous material. It was checked that this treatment did not cause any loss of urea-N.

Experimental procedure :

The field experiments were conducted on a sandy loam soil of pH 5.5. The ^{15}N materials were used in micro-plots, while bigger plots were employed for yield data using equivalent but unlabelled sources. Basal application of 40 kg each of P_2O_5 and K_2O/ha was given taking into account the superphosphate added through the mud balls.

The indigenous slow-release sources were compared with basal application of urea and ammonium sulphate at 80 kg N/ha level in the dry and 40 kg N/ha level in the wet season. Urea and ammonium sulphate of 10 per cent ^{15}N atom excess was used for all the treatments except that of SCU. In the wet season, basal application of ^{15}N-labelled SCU (TVA product; N, 39.1 per cent; ^{15}N atom excess, 9.9 per cent; dissolution rate, 28 per cent in 7 days; total coating, 16 per cent; conditioner, 2 per cent; wax, 3 per cent; sulphur, 11 per cent) was also included.

For basal application of urea, ammonium sulphate, SCU, and *neem* extract coated urea, these materials were incorporated upto 5 cm depth of the puddled soil just before transplanting. The mud balls were pushed down to 8 cm depth in between rows a day after transplanting so as to obtain a distribution of one ball at the centre of four hills planted at 10×10 cm spacing.

Rice seedlings (var. Supriya) were transplanted and the crop was raised under 8 cm flood water in both seasons. During the dry season, leachate samples were drawn weekly throughout the crop growth using the technique described by Shinde and Vamadevan[1]. The cumulative loss of NH_4+NO_3-N through leaching as per cent of added N was calculated from the isotopic dilution formula :

$$\text{Percent contribution of fertilizer N} = \frac{\%\ ^{15}\text{N atom excess of sample}}{\%\ ^{15}\text{N atom excess of fertilizer}} \times 100$$

After harvest, rough rice and straw samples were separately analyzed for total N and $^{15}N/^{14}N$ isotopic ratio following standard procedures. Per cent recovery of fertilizer N was calculated by both '^{15}N-method' and the commonly used 'difference method'. However, the results obtained from the more reliable '^{15}N method' have only been discussed.

TABLE 1 : *Yield of rough rice and recovery of fertilizer N in rice crop (rough rice+straw) as affected by N levels and sources*

Treatment	80 kg N/ha, Dry season 1975			40 kg N/ha, Wet season 1975		
	Rough rice yield, t/ha	% Recovery		Rough rice yield, t/ha	% Recovery	
		^{15}N method	Diff. method		^{15}N method	Diff. method
Control	3.1	—	—	3.1	—	—
Urea	7.7	43.8	73.4	5.1	44.5	74.9
Ammonium sulphate (AS)	7.8	39.9	64.3	5.6	50.6	113.2
Sulphur coated urea	—	—	—	4.7	45.5	51.8
Indigenous slow-release sources						
Straw+urea	7.4	52.5	91.5	4.9	42.8	63.8
Straw+AS	7.3	55.9	95.2	5.4	48.0	79.0
Husk+urea	9.2	61.4	97.0	6.1	58.4	106.8
Husk+AS	9.0	62.2	97.0	5.0	54.6	79.4
Neem extract coated urea	8.2	43.4	73.3	4.7	36.1	70.4
L.S.D. (0.05)	1.6	—	—	N.S.	—	—

Results and Discussion

The performance of indigenous materials in terms of yield and recovery of applied N is shown in Table 1. In the dry season, the recovery of ammonium sulphate- and urea-N was about 40-44 per cent, but when the same fertilizers were used in combination with carbonaceous materials and placed at 8 cm depth in the form of mud balls, much higher recoveries were recorded. This was particularly true when rice husk was used. The yield of rough rice also increased by 1.2 to 1.5 t/ha over basal application of ammonium sulphate and urea, but the increase just failed to achieve significance at 5 per cent level.

At the N rate of 40 kg/ha in the wet season, only those mud balls which contained rice husk gave recovery higher than ordinary fertilizers. The recovery of N from SCU was only slightly better than urea. *Neem* extract coated urea, on the other hand, did not prove useful in any season.

Per cent fertilizer ^{15}N found in leachate (Table 2) showed that indigenous materials saved substantial losses through leaching.

TABLE 2 : *Per cent fertilizer ^{15}N found in leachate over* 11 *weeks, Dry season* 1975

Treatment	NH_4+NO_3-N
Urea	43.1
Ammonium sulphate	15.9
Indigenous slow release sources	
Straw+urea	17.6
Straw+AS	4.3
Husk+urea	13.5
Husk+AS	3.1
Neem extract coated urea	6.9

The mud ball technique, which facilitates deep placement of fertilizer N, appears to have originally been developed in Japan[2]. The Japanese mud balls contained ammonium sulphate, super phosphate and peat mixed in the ratio of 5 : 3 : 8 by weight and were mechanically shaped into egg size balls. The mud balls of IRRI[3] consist of soil shaped into 3 cm diameter balls in which the fertilizer is placed in the center. It is not certain that the benefits of this technique accrue from the deep placement, point application from which the fertilizer N has to diffuse out, or both. In the mud balls reported in this paper, carbonaceous material, rice straw or husk, was also included to obtain a C/N ratio of 12 : 1. It was hoped to achieve some immobilization of fertilizer N and consequent low rate of remineralization resulting in an overall slow-release effect. In earlier experiments with unlabelled fertilizers (unpublished work) the rate of release of N from these mud balls, as evident by plant uptake, was found to be more or less similar to that of SCU or shellac coated urea. The mud balls without carbonaceous material released N at a faster rate but left behind much less residual N in the soil. This indicated that some immobilization of fertilizer N might have occurred. Laboratory experiments with ^{15}N are currently under progress to study the transformation of fertilizer N in the mud balls with and without carbonaceous materials.

Acknowledgement

The authors wish to thank the International Atomic Energy Agency, Vienna who supported this investigation, in part, through research contract 1438/RB. Thanks are also due to Dr. S. Y. Padmanabhan, former Director, for his keen interest and encouragement.

REFERENCES

1. Shinde, J. E. & Vamadevan, V. K., *Fate and significance of nitrogen fertilizers and animal waste residdes in relation to soil, water, climate and agronomic practices.* [*In* Effects of Agricultural Production on Nitrates in Food and Water with Particular Reference to Isotope Studies. IAEA, Vienna (1974) 45-52].
2. Mitsui, S., *Inorganic nutrition, fertilization and soil amelioration for lowland rice* (Yokendo Ltd. Tokyo) (1954).
3. Annonymous, *International Rice Research Institute*, Los Banos, Philippines, Ann. Rpt. (1974).

To be returned

Synopsis of the thesis on "Transformation and turnover of ~~N in~~ Nitrogen in rice soils" to be submitted by A.M. Krishnappa for the degree of Doctor of Philosophy in Agriculture (Soil Science) of the Orissa University of Agriculture and Technology, Bhubaneswar.

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Among plant nutrients nitrogen plays an important role in determining crop yields. It is well known that in soil the added fertilizer N undergoes a multitude of complex and interlinked reactions such as mineralization, immobilization, fixation in clay-minerals and re-mineralization. These reactions not only determine the current and residual availability of fertilizer N, but also the quantum that may be lost through various pathways. A great deal of information on these complex series of reactions affecting N economy is available for well-drained arable soils but the ill-drained, flooded soils cropped to rice have generally been neglected in this respect. Whatever scanty information is available, it has mostly emerged from laboratory and greenhouse experiments often conducted under conditions that do not truly represent the actual field environment. With this in view, eight field experiments were conducted in Mahanadi delta alluviam and black clay soil to study the transformation and turnover of both inorganic and organic N under actual field conditions. N^{15}- labelled materials were used to obtain direct evidence of transformations and to distinguish between the added and the native soil N.

The experiments can conveniently be divided in two parts.

(1) The transformation of N^{15}-labelled rice straw and FYM in rice-rice rotation; and

(2) the transformation of N^{15}-labelled urea added alone or with Neem cake over 3 crop seasons.

The experiments were in specially prepared micro-plots. The turnover of N^{15}-labelled chopped rice straw and FYM added at the rates of 2 and 6 t/ha, respectively, was studied with and without application of unlabelled urea. A treatment with N^{15}-labelled urea to tive 80 kg N/ha was also included for comparison. In black soil the FYM was restricted to 2 t/ha level but N^{15}-labelled urea was added to supply 100 kg N/ha.

In the alluvial soil the straw application added 12.5 kg N/ha, of which only 18 per cent was available to the first crop of rice. However, when the straw application was followed by urea, the recovery increased to 30.7 per cent. The highest recovery of 56 per cent was recorded with F.Y.M. The recovery in the second crop was greatly influenced by the 'priming action' of the added urea-N. Thus the recovery of residual organic-N from all materials was higher in the presence of applied N. After harvest of the first crop, 13.4 and 6.7 kg of labelled N from urea and straw application, respectively, were found in the root zone. The recovery of these N residues in the succeeding unfertilized crop was small. But with N fertilization about 28 and 14 per cent of residual N of urea and straw, respectively, was available for plant uptake.

In black soil the straw added 17.6 kg of N/ha. The first crop absorbed only 5.45 per cent of the added straw N. But when the straw application was followed by urea at the rate of 100 kg N/ha, the recovery of straw-N increased to 10.68 per cent. These recoveries were much less than those recorded in alluvial soil. About 28 per cent of applied urea-N was recovered in the crop but in the presence of 2 t/ha straw application it decreased to 23 per cent. Thus about 5 per cent of the fertilizer N appeared to have been immobilized under field conditions.

The turnover of rice straw and FYM is important from the view point of nutrient recycling and possible immobilization effects. These materials at normal rates of application add small amounts of N in organic form whose contribution to N economy is usually difficult to estimate. The use of labelled materials in these experiments have thus provided unequivocal evidence of their contribution under actual field conditions for the first time.

The second part of the experiments comprised of the study of N^{15}-urea transformations. Micro-plots were used for N^{15} application and 15 m^2 plots fertilized with unlabelled urea were used to estimate the yield. The fate of a pulse of 100 kg N/ha applied through labelled urea (20 per cent N^{15} atom excess) with and without Neem cake was followed. A control was also included. Devices to draw leachate and volatilized ammonia samples were installed in the micro-plots. A specially devised method of using porous nylon bags to draw periodic soil samples without distributing the micro-plots was employed. The first rice crop was grown in the wet season of 1976. After its harvest, equal number of plots from each treatment were subjected to 60 days of wet or dry fallow before all the plots were reflooded to prepare the land for the next crop. In wet fallow plots about 2 cm of flood water was maintained, while in the dry fallow the plots were allowed to dry completely. Soil samples were drawn both at the harvest of the first crop and at the end of the same plots were used. Half of the plots under each kind of fallow received 100 kg N/ha in 3 splits through unlabelled urea, while the other half remained unfertilized. After harvest of the second crop, the same plots were again subjected to 40 days of either wet or dry fallow treatment as before. A third crop of rice was grown during the wet season of 1977. Thus the initial N^{15} pulse was subjected to 3 crop growths and 2 periods of wet or dry fallow treatments.

In the first crop, application of urea + Neem cake gave a grain yield of 4.64 t/ha as compared to 4.18 with urea alone. The increase in yield was statistically significant. The control plots yielded only 1.81 t/ha. The recovery of fertilizer N in the crop with and without Neem cake was 22 and 20 kg/ha, respectively. The loss of fertilizer N through volatilization during crop growth amounted to 6.34 and 5.33 kg/ha. Similarly, the leaching loss was found to be 8.25 and 5.30 kg N/ha. The most spectacular effect of Neem cake was, however, evident in the conservation of fertilizer N in the root zone. With application of Neem cake 41 kg of fertilizer N/ha was found in the soil as compared to 29 kg in the case of urea application alone. Thus in plots treated with Neem cake 77 per cent of the applied N was accounted for, in contrast to 59.5 per cent with urea alone.

During the first fallow period the loss of fertilizer N through volatilization amounted to 4.2 and 3.5 kg/ha in wet fallow and dry fallow plots, respectively. However, more fertilizer N was conserved in the soil in the wet rather than dry fallow.

The effect of water management during the fallow period was evident in the grain yield of the second rice crop. Thus the mean yield under wet fallow was 5.05 t/ha which was significantly higher than 4.09 obtained from dry fallow plots. The uptake of residual fertilizer N was also higher from wet fallow plots. However, the residual value of the fertilizer N did not exceed 3 kg/ha. The soil samples drawn after harvest of the 2nd crop also showed wet fallow plots to contain more residual fertilizer N than dry fallow plots. These differences probably reflect the extent of denitrification losses which are favoured by alternate wet and dry conditions provided in the dry fallow treatment.

As in the case of the 2nd crop, the 3rd crop yield also reflected the beneficial effect of the wet fallow treatment. The effect of Neem cake added at the time of the first crop was also evident.

These experiments have provided estimates of the various processes of N loss as they occur under actual field conditions. The beneficial influence of Neem cake, a cheap and easily available material, is also brought out. The effect of water management during inter-crop fallow has shown that the practice of wet fallow is beneficial from the view point of both yield and N economy.

To be returned

INTERNATIONAL ATOMIC ENERGY AGENCY
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IN REPLY PLEASE REFER TO
PRIÈRE DE RAPPELER LA RÉFÉRENCE

RC/1438-IND

1977-05-11

Dear Dr. Shinde,

Your report has now been carefully read and approved by the staff of our appropriate scientific division. Our cheque in payment of the next instalment due under the contract will therefore be sent at the time of payment indicated in the contract, unless that time is now past, in which case the cheque will be sent immediately.

A copy of the evaluation form pertaining to your report is enclosed for your information.

Yours sincerely,

Adel Talaat, Acting Chief
~~G.R.O'Neal, Chief~~
Contracts Administration Section
Division of Budget and Finance

Enclosure

Dr. J.E. Shinde
All-India Coordinated Rice Improvement Project
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Hyderabad 500 030
India

EVALUATION OF RESEARCH PROJECT REPORT

[X] Progress report

[ ] Final report

Research Contract No.: 1438/R3/GS

Period covered by report: 15/7/76 - 14/3/77

I. TECHNICAL EVALUATION OF:

A. Experimental method:

a) A laboratory experiment was conducted to study the effect of slow release materials (urea + straw, ammonium sulphate + straw, urea + husk, ammonium sulphate + husk, sulphur coated urea, urea mud balls) on N-fertilizer uptake by the rice crop.

b) A field experiment was conducted during the dry and wet seasons of 1976 to study the turnover of chopped rice straw and FYM in flooded rice soil.

c) A long-term field experiment was initiated during the wet season of 1976] to follow the fate of an initial nitrogen-pulse (100 kg N/ha, with and without addition of 250 kg/ha of Neem cake) over a three-year period in flooded rice microplots (0.07 m^2 area).

In all three experiments, N-15 labelled fertilizer was used. Soil, soil solution and crop samples were analyzed for total N, N fractions, and N-15/N-14 ratio.

B. Results:

Experiment a) - Averaged over 30, 60, and 90 days of incubation, the fertilizer-N in the soil (Kjeldahl fraction) was only 27% with sulphur-coated urea, as compared to 50-52% in straw mud balls, 45-47% in husk mud balls and 44% in urea mud balls without any carbonaceous material.

Experiment b) - Application of urea over FYM significantly increased the yield of rough rice and straw in the first crop as compared to urea alone. Highest percent fertilizer nitrogen recovery was recorded in the caseoof FYM nitrogen, both in the first and second crop.

Experiment c) - The application of Neem cake + urea increased the rough rice and straw yield significantly as compared to application of urea alone. Ther fertilizer N in the crop, however, did not vary significantly between the two treatments. The addition of Neem cake seems to reduce significantly the loss of nitrate through leaching.

C. Conclusions drawn :

Experiment a) - The results of the incubation experiment seem to confirm the assumption that the carbonaceous mud balls could immobilize part of the fertilizer-N.

Experiment b) - Although the reported data gives some useful preliminary indications, more experimental data are needed to draw conclusions.

Experiment c) - The reported data indicate that the addition of Neem cake to fertilizer urea may be an effective way to control loss of nitrate-N through leaching. However, no final conclusions can be drawn until N-15/N-14 ratio data is available.

II. ADDITIONAL COMMENTS:

Very good progress has been achieved. The scope of the work may be, however, overambitious.

III. FURTHER INFORMATION REQUIRED FROM CONTRACTOR:

To be returned 3

Progress Report for the period from 15th March 1977 to 14th September 1977

1. (a) (i) Contract No. 1438/R3/GS

(ii) Title of the Project:

The fate of applied organic and inorganic N in flooded rice soil in relation to nitrate pollution under tropical conditions (Part of a coordinated programme on agricultural N residues with particular reference to their conservation as fertilizers and behaviour as potential pollutants.

(iii) Institute where research is being carried out:

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(v) Time period covered:

15th March to 14th September 1977.

(b) Description of research work carried out:

Part 1: The long-term field experiment to follow the fate of an initial N-15 pulse in flooded rice soil already described in part 3 of the earlier progress report (for the period 15th July 1976 to 14th March 1977) was continued. The 2nd crop was harvested in May 1977. The meteorological data for the crop season is given in Table 1. Immediately after harvest the 3rd set of nylon bags were pulled out and then the plots were subjected to wet and dry inter-crop fallow for 40 days in the manner described earlier. The 4th set of nylon bags was pulled out a week after the plots were re-flooded for the next crop. The 3rd crop was transplanted in July 1977 which will be harvested in October. The losses through leaching and volatilisation as well as NH_4- and NO_3-N in ground water were continuously monitored.

The soil samples in nylon bags were subjected to kjeldahl digestion both in the wet condition as well as air-dry. The air-dry samples were ground to pass 60-mesh screen and salicylic acid modification was used to include NO_3-N that might have formed during air drying. KCl-extractable NH_4+NO_3-N was determined in air-dry, 2 mm soil samples. The acid-soluble organic N and its fractions were determined in air-dry, ~~2 mm~~ 60 mesh samples following the procedure of Bremner, 1965 (organic forms of N. In Methods of Soil Analysis, part 2 ed. C.A. Black, Agronomy No. 9, 1238-1255).

Part 2: A field experiment to follow transformation of N^{15}-labelled rice straw and FYM was initiated in February 1977. Micro-plots of 0.07 m^2 area were used. The treatments were:- (1) control, (2) N^{15}-urea, (3) N^{15}-straw, (4) N^{15}-FYM, (5) N^{15}-straw + unlabelled urea, (6) N^{15}-FYM + unlabelled urea and (7) unlabelled straw + N^{15}-urea. Urea was applied at the rate of 100 kg N/ha, straw 2 t/ha and FYM 2.2 t/ha. The analysis of materials is given in Table 2. Matured rice straw chopped into 2-3 cm pieces was used. The FYM was prepared from N^{15}-labelled rice straw. For the 1st dry season crop the straw and FYM were incorporated upto 5-8 cm. depth and allowed to decompose for 15 days under 5 cm of flood water before application of urea and transplanting. Urea was applied basal and incorporated upto 5-8 cm depth. All treatments were replicated 6 times. The crop was harvested in May 1977. The dry weights of rough rice, straw and roots + stubbles were recorded and these plant parts were separately analyzed for total N. A small quantity of root + stubbles was used for total N analysis and the rest was returned to the respective plots. A 2nd crop was transplanted in July 1977.

<u>Part 3</u>: The standard or the 'Zemun' experiment, the details of which were finalized during the 3rd research coordination meeting held at Vienna in May 1977, was initiated in July 1977. The field experiment was designed to follow the fate of N^{15}-urea in rice-wheat cropping system over a period of 3 years. The experimental plan is as follows:-

Season	Year	A		B		C	
Wet	1977	Rice*	Rice	Rice*	Rice	Rice*	Rice
Dry	1977	Wheat	Wheat*	Wheat^x	Wheat*	Wheat^x	Wheat*
Wet	1978	D	Rice	Rice^x	Rice^x	Rice^x	Rice^x
Dry	1978		D	Wheat^x	Wheat^x	Wheat^x	Wheat^x
Wet	1979			D	Rice^x	Rice^x	Rice^x
Dry	1979				D	Wheat^x	Wheat^x
Wet	1980					D	Rice^x
Dry	1980						D

* Application of N^{15}-urea, ^{x} Application of unlabelled urea

Group A = N^{15}-urea of 10% atom excess; Group B and C = N^{15}-urea of 20% atom excess; D = Destructive soil sampling.

Rice will be grown under flooded condition (5 cm depth) and wheat at approximately field capacity moisture. The 1st rice crop has been transplanted in July 1977.

Group A will have 8 replications and B and C 4 each.

The treatments are N_0 = No N; N_1 = 80 kg N/ha in 3 splits for rice and 2 splits for wheat.

Plot size:

(a) N^{15}-microplot = 0.24 sq.m.

(b) Yield plot = 8.00 sq.m.

Observations:-

1. Recovery of fertilizer N in the crop
2. Loss of N through leaching
3. Loss of N through volatilization and denitrification
4. Fertilizer N in ground water
5. Fertilizer N in soil in kjeldahl, mineral and organic forms at different depths.
6. Meteorological observations
7. N added through rainfall or irrigation.

(c) Results obtained

Part 1:- The yield of rough rice and straw is shown in Table 3. Significantly higher yields were obtained under wet fallow than the dry. Comparison of mean yields between treatments 3 and 5 and 2 and 4 showed the residual effect of the neem cake applied in the previous season. Significantly higher yield of both rough rice and straw was obtained with the neem cake irrespective of whether the 2nd crop was fertilized with urea or not. Similar trend was also seen in the total uptake of N (Table 4). The exact contribution of fertilizer N added as a 100 kg N/ha pulse in the previous season will be known when N^{15}-data are received. The distribution of soil + fertilizer N in the soil after harvest of the 2nd crop and at the end of the 2nd fallow period is shown in Tables 5 and 6 respectively.

After harvest of the 2nd crop about 872 ppm of total N (kjeldahl fraction) was present in the root zone of plots that were not subjected to drying and re-wetting cycle (Table 5). This was significantly higher than 853 ppm found under dry fallow plots which have undergone one cycle of drying and re-wetting. Similar differences also appeared in plots which underwent a second cycle of drying and rewetting, but these were not statistically significant(Table 6). The fractionation of organic N showed amino-acid N to be higher under dry than wet fallow (Tables 5 and 6). With respect to other fractions, no consistent trend was evident.

Since air- or oven-drying is likely to lead to N losses, many investigat~~xxxx~~-ors prefer to analyze the soil samples drawn from flooded rice soils in wet condition itself. It is however different to sub-sample a wet soil and grind it to 60 or 100-mesh size for kjeldahl digestion. The use of porous nylon bags, described in earlier progress report, may eliminate the need for sub-sampling. The comparative efficiency of kjeldahl digestion using unground wet and air-dry samples ground to 60-mesh size was determined. All conditions of kjeldahl digestion were kept similar except that in the case of air-dry samples the salicy~~l~~lic acid modification was adopted to include NO_3-N that might have formed during the drying process. The data from the 3rd and 4th nylon bags corrected to oven dry basis (105°C) are shown in Tables 7 and 8 respectively. It was evident that the kjeldahl-N in wet samples was underestimated, on average, by about 257 ppm. Since NO_3-N is not expected to be present in appreciable amount in fresh wet samples drawn from the ~~xxxx~~ reduced zone, the low recovery in kjeldahl fraction appeared to be related to the particle size of the sample. The effect of particle size on the recovery of fertilizer N will be known on receipt of N^{15} analysis.

Except in one case no nitrate-N was detected in ground water samples drawn during the 2nd ~~inter~~-crop season (Table 9). Similarly during the 2nd inter-crop fallow period also NO_3-N was not detected in any sample (Table not given). Ammonium + nitrate-N in leachate was detected in treatments which received unlabelled urea during the 2nd crop season but it did not exceed 3.5 ppm (Table 10 and 12). Very poor internal drainage of the heavy clay soil (about 2 mm/day) is probably responsible for the low values.

The ammonia volatilization losses are shown in Tables 11 and 13. During the 2nd crop growth period the volatilization losses from plots which have undergone one cycle of drying and rewetting (DF) appeared to be slightly higher than those found under continuously wet condition (Table 11). The flush of mineralization that occurs after dried soils are rewetted probably also caused more losses. However, this phenomenon was not noticed, during the 2nd inter-crop fallow (Table 13). Lack of moisture in the soil under dry fallow (DF) appeared to slow down the accumulation of ammonia and consequent loss through volatilization.

Part 2:- The yield of rough rice, straw and roots + stubble is shown in Table 14. It was evident that application of straw and FYM produced grain yield similar to that obtained in the control. Addition of urea over N^{15}-labelled straw did not yield more than urea alone. However in the case of unlabelled straw (Tr. 7) the grain yield was significantly lower than urea alone. The higher C/N ratio of the unlabelled as compared to the labelled straw (45.20 vs 40.94, Table 2) appeared to be responsible for immobilization of urea-N. The total N uptake from labelled and unlabelled sources (Table 15) followed the pattern similar to the grain yield. Actual mineralization of N^{15}-labelled straw and FYM would be calculated when N^{15}-data are received. In view of the emphasis in developing countries to recycle the nutrients through application of straw or FYM, this type of information would be of great practical importance.

Part 3:- The experimental crop will be harvested in October 1977 and therefore no results are yet available.

(d) Conclusions drawn:-

In the absence of N^{15} data which is awaited, the conclusions are drawn on the basis of the available information.

1. The yield and total N uptake data of the 2nd crop in the long-term field experiment to follow the fate of an initial pulse of N^{15} showed

that wherever possible it may be quite advantageous to keep a small film of water over the soil surface in between cropping seasons. This avoids denitrification losses that occur under alternate drying and wetting. This practice may also lead to more conservation of N in the soil.

2. The residual effect of the Neem cake (residue of *Azadirachta indica* seed after extraction of oil) applied during the previous season was evident in the grain yield and total N uptake.

3. Kjeldahl digestion of wet soil samples from paddy fields advocated to reduce the errors caused by N loss during air- or oven-drying, may however lead to considerable underestimation of the total soil N.

4. The volatilization loss of N appeared to be slightly higher from plots which have undergone a cycle of drying and re-wetting than those which have been kept continuously moist.

5. Nitrate-N in ground water was found below detectable level in ~~mmkxk~~ most cases, probably because of poor internal drainage.

(e) Citation of periodicals etc.:- Nil

(f) Any explanation for any significant departure from the level of activity foreseen by the contract:-

Not applicable.

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TABLE 1

MATEROLOGICAL OBSERVATIONS, AICRIP, Hyderabad

Dry Season 1977 (February-May)

Average air temperature, °C	
Maximum	35.4
Minimum	20.8
Average relative humidity (%)	47.6
Average sunshine, hours per day	9.2
Total rainfall (mm)	37.0
Average wind velocity, (Km/hr.)	6.4
Average open-pan evaporation (mm.) per day	8.0

TABLE 2

Analysis of materials (O D B)

	Straw			
	N^{15} labelled	Ordinary	N^{15}- FYM	N^{15}- Urea
Total N (%)	0.88	0.75	1.698	-
Total C (%)	36.03	33.90	20.470	-
C/N ratio	40.94	45.20	12.050	-
N^{15}- atom excess (%)	22.420	-	0.357	10.4

Table 3

Yield of 2nd crop, dry season 1977 (from yield plots)
(t/ha)

Treatment		Rough rice (14% moisture)			Straw (O D B)		
I crop	II crop	WF	DF	M (Tr.)	WF	DF	M (Tr.)
1. NO	NO	3.71	2.74	3.22	1.68	1.52	01.60
2. N-15	NO	3.99	2.88	3.43	2.61	1.79	2.20
3. N-15	N-14	6.16	5.59	5.87	4.73	3.49	4.11
4. NC + N15	NO	4.57	3.16	3.86	2.90	2.11	2.50
5. NC+N-15	N-14	6.83	6.11	6.47	5.43	4.13	4.78
6.							
	M(F)	5.05	4.09		3.47	2.61	

		Rough rice	Straw
L.S.D. (0.05)	M (F)	0.20	0.24
	M (Tr.)	0.33	0.19
	F in Tr.	NS	0.32
	Tr. in F	NS	0.26
C.V.%	M (F)	2.8	5.1
	M (Tr.)	5.8	5.1

Total N uptake by 2nd crop

Table 4

...-crop, dry season 1977 (calculated using N concentration from micro-plots and yield from macro-plots) Kg N/ha (O D B)

Treatment I Crop	Treatment II Crop	Rough rice WF	Rough rice DF	Rough rice M (Tr.)	Straw WF	Straw DF	Straw M (Tr.)	Rough rice + Straw WF	Rough rice + Straw DF	Rough rice + Straw M(Tr.)
1. N-0	N-0	26.31	18.60	22.45	8.92	8.60	8.76	35.23	27.20	31.21
2. N-15	N-0	25.89	20.07	22.98	14.47	9.28	11.87	40.36	29.35	34.85
3. N-15	N-14	43.00	36.03	39.51	23.98	18.04	21.01	66.98	54.07	60.52
4. NC + N-15	N-0	33.43	23.53	28.48	15.74	11.06	13.40	49.17	34.59	41.88
5. NC + N-15	N-14	44.13	40.42	42.27	27.94	20.84	24.39	72.07	61.26	66.66
	M (F)	34.55	27.73		18.21	13.56		52.76	41.29	
L.S.D. (0.05)	M (F)	3.25			1.76			4.90		
	M (Tr.)	3.81			0.97			4.16 4.16		
	F in Tr.	NS			2.02			NS		
	Tr. in F	NS			1.37			NS		
C.V.%	M (F)	6.7			7.1			6.6		
	M (Tr.)	10.0			5.0			7.2		

WF/DF = Inter-crop wet and dry fallow; N-15/N-14 = Application of labelled and unlabelled N @ 100 kg N/ha.

Table 5

Distribution of soil + fertilizer N in various fractions - soil sample drawn through the 3rd nylon bag after the 2nd crop harvest. ppm-N (ODB)

Treatment	I Crop N_0 / II Crop N_0 (1)	I Crop N-15 / II Crop N_0 (2)	I Crop N-15 / II Crop N-14 (3)	I Crop NC+N-15 / II Crop N_0 (4)	I Crop NC+N-15 / II Crop N-14 (5)	M(F)
(a) Total kjeldahl-N (including NO_3-N) - Air dry 60-mesh samples						
WF	828.50	846.33	892.50	880.83	911.16	871.86
DF	816.66	810.83	875.16	863.66	898.33	852.93
M(Tr.)	822.58	828.58	883.83	872.24	904.74	

L.S.D.(0.05) M(F) = 10.44, M(Tr.) = 13.64, F in Tr. = N.S., Tr. in F = N.S.

C.V. % M(F) = 1.0, M(Tr.) = 1.3

Treatment	1	2	3	4	5	M(F)
(b) Kcl-extractable NH_4-NO_3-N						
WF	5.77	6.35	10.39	9.23	10.97	8.54
DF	5.20	7.50	8.66	8.63	9.43	7.88
M(Tr.)	5.48	6.92	9.52	8.93	10.20	

L.S.D.(0.05) M(F) = N.S., M(Tr.) = 2.11, F in Tr. = 3.10, Tr. in F = N.S.

C.V. % M(F) = 11.2, M(Tr.) = 16.9

Treatment	1	2	3	4	5	M(F)
(c) Organic-N						
WF	822.73	839.98	882.11	871.60	900.19	863.32
DF	811.46	803.33	866.50	855.03	888.90	845.04
M(Tr.)	817.09	821.65	874.30	863.31	894.54	
(d) Fractions of HCl soluble organic N						
1 NH_4-N, ppm						
WF	91.66	120.00	100.00	100.00	108.33	104.00
DF	96.66	125.00	116.66	108.33	125.00	114.33
M(Tr.)	94.16	122.50	108.33	104.16	116.66	

contd...2/-

Table 5 - contd.from previous page.

	2 Hexoseamine-N					
WF	75.00	38.33	66.66	58.33	41.67	56.00
DF	78.34	50.00	50.00	33.33	33.33	49.00
M(Tr.)	76.67	44.16	58.33	45.83	37.50	
	3 Amino acid-N					
WF	58.34	75.00	83.34	83.33	83.33	76.67
DF	58.33	66.66	91.67	116.67	100.00	86.66
M(Tr)	58.33	70.83	87.50	100.00	91.66	
	4 Unidentified-N					
WF	364.14	364.24	339.14	322.24	414.73	360.90
DF	342.36	366.00	320.71	347.67	297.14	334.77
M(Tr.)	353.25	365.12	329.92	334.95	355.93	
	5 Total HCl-soluble N					
WF	589.14	597.57	589.14	563.90	648.06	597.56
DF	575.69	607.66	579.04	606.00	555.47	584.77
M(Tr.)	582.41	602.61	584.09	584.95	601.76	
	6 HCl-insoluble N					
WF	233.59	242.41	292.97	307.70	252.13	265.76
DF	235.77	195.67	287.46	249.03	333.43	260.27
M(Tr.)	243.68	219.04	290.21	278.36	292.78	
	(e) Clay fixed NH_4-N					
WF	84.16	101.00	101.00	84.16	84.16	
DF	101.00	84.16	101.00	84.16	84.16	
M(Tr.)						

Table 6

Distribution of soil + fertilizer N in various fractions, soil samples drawn through the 4th nylon bag at the end of 2nd inter-crop wet and dry fallows ppm-N (ODB)

Treatment	1 I Crop N_0 / II Crop N_0	2 I Crop N-15 / II Crop N_0	3 I Crop N-15 / II Crop N-14	4 I Crop NC+N-15 / II Crop N_0	5 I Crop NC+N-15 / II Crop N-14	M(F)
(a) Total kjeldahl-N (includes NO_3-N) Air-dry 60-mesh samples						
WF	683.41	801.25	777.70	765.90	814.21	768.49
DF	771.80	736.45	765.90	748.23	760.00	756.47
M(Tr.)	727.60	768.85	771.80	757.06	787.10	

L.S.D. (0.05) M(F) = N.S., M(Tr.) = 14.42, F in Tr. 28.95, Tr. in F = 20.39

C.V. % = M(F) = 2.1, M(Tr.) = 1.5

Treatment	1	2	3	4	5	M(F)
(b) KCl-extractable NH_4+NO_3-N						
WF	9.33	13.41	15.75	17.96	12.83	13.85
DF	7.35	6.41	8.75	9.91	10.50	8.58
M(Tr.)	8.34	9.91	11.25	13.93	11.66	

L.S.D. (0.05) M(F) = 2.89, M(Tr.) = 1.59, F in Tr. = 3.31, Tr. in F = 2.24

C.V. % = M(F) = 16.4, M(Tr.) = 11.5

Treatment	1	2	3	4	5	M(F)
(c) Organic-N, ppm						
WF	674.08	787.84	761.95	747.94	801.38	754.64
DF	764.45	730.04	757.15	738.32	749.50	747.89
M(Tr.)	719.26	758.94	759.55	743.13	775.44	
(d) Fractions of HCl-soluble organic N						
1 NH_4-N						
WF	141.66	158.33	141.66	150.00	158.33	150.00
DF	125.00	116.66	116.66	133.33	125.00	123.33
M(Tr.)	133.33	137.49	129.16	141.66	141.66	

contd...2/-

Table 6 contd. from previous page

	2 Hexose amine-N					
WF	60.00	41.67	58.34	53.33	41.67	51.00
DF	75.00	91.67	33.34	58.33	75.00	66.67
M(Tr.)	67.50	66.67	45.84	55.83	58.33	
	3 Amino-acid N					
WF	148.34	125.00	166.66	138.33	150.00	145.66
DF	141.66	150.00	216.66	183.34	133.33	165.00
M(Tr.)	145.00	137.50	191.66	160.83	141.66	
	4 Un-identified N					
WF	116.66	275.00	233.34	225.00	266.66	223.33
DF	191.67	258.33	250.00	241.66	300.00	248.33
M(Tr.)	154.16	266.66	241.67	233.33	283.33	
	5 Total HCl-soluble					
WF	466.66	600.00	600.00	566.66	616.66	570.00
DF	533.33	616.66	616.66	616.66	633.33	603.32
M(Tr.)	500.00	608.33	608.33	591.66	625.00	
	6 HCl-insoluble N					
WF	207.42	187.84	161.95	181.28	184.72	184.64
DF	231.12	113.38	140.49	121.66	116.17	144.56
M(Tr.)	219.27	150.61	151.22	151.47	150.44	
	(c) clay-fixed NH4-N					
WF	84.16	84.16	84.16	67.33	84.16	
DF	67.33	84.16	84.16	67.33	67.33	
M(Tr.)						

Table 7

Total kjeldahl N in wet and air-dry samples, 3rd nylon bag
ppm-N (ODB)

Treatment I Crop	II Crop	Wet samples (39% H_2O) WF	DF	M(Tr.)	Air-dry, 60-mesh samples* WF	DF	M(Tr.)
1 N_0	N_0	544	555	549	828	817	822
2 N-15	N_0	573	549	561	846	811	828
3 N-15	N-14	590	541	565	892	875	883
4 NC+N-15	N_0	588	579	583	881	864	872
5 NC+N-15	N-14	591	586	588	911	898	904
M(F)		577	562		872	853	
L.S.D.(0.05)	M(F) =	N.S.			10		
	M(Tr.)=	21			14		
C.V. %	M(F) =	3.3			1.0		
	M(Tr.)=	3.0			1.3		

* Includes NO_3-N

Table 8

Total kjeldahl-N in wet and air-dry samples, 4th nylon bag
ppm-N (ODB)

Treatment		Wet samples (44% H_2O)			Air-dry samples,* 60-mesh			
I Crop	II Crop	WF	DF	M(Tr.)	WF	BF	M(Tr.)	
1 N_0	N_0	540	529	534	683	772	727	
2 N-15	N_0	543	533	538	801	736	769	
3 N-15	N-14	553	539	546	778	766	772	
4 NC+N-15	N_0	546	542	544	766	748	757	
5 NC+N-15	N-14	546	542	544	814	760	787	
M(F)		546	537		768	756		
L.S.D.(0.05)	M(F) =	4			N.S.			L.S.D. 10.057
	M(Tr.)=	11			14			F in Tr. = 29
C.V. %	M(F) =	0.5			2.1			Tr. in F = 20
	M(Tr.)=	1.2			1.5			

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* Includes NO_3-N

Table 9

Soil + Fertilizer N in the ground water during 2nd crop season

	Treatment I Crop	Treatment II Crop	NH_4-N, ppm WF	NH_4-N, ppm DF	NO_3-N, ppm WF	NO_3-N, ppm DF
1	N_0	N_0	0.346	0.000	0.000	0.000
2	N-15	N_0	0.000	0.000	0.000	0.000
3	N-15	N-14	0.901	0.762	0.000	0.139
4	NC+N-15	N_0	0.000	0.000	0.000	0.000
5	NC+N-15	N-14	0.346	0.346	0.000	0.000

Table 10

NH_4+NO_3-N in leachate during the 2nd crop season

	Treatment I Crop	Treatment II Crop	WF (ppm-N)	DF (ppm-N)
1	N_0	N_0	0.000	0.346
2	N-15	N_0	0.000	0.000
3	N-15	N-14	3.257	2.425
4	NC+N-15	N_0	0.000	0.000
5	NC+N-15	N-14	1.732	1.247

Table 11

Loss of soil + fertilizer N through volatilization during the 2nd crop season. Kg N/ha

	Treatment I Crop	Treatment II Crop	WF	DF	M(Tr.)
1	N_0	N_0	1.2787	1.2413	1.2600
2	N-15	N_0	1.7815	2.1698	1.9756
3	N-15	N-14	3.9484	5.2058	4.5771
4	NC+N-15	N_0	1.6149	2.5169	2.0681
5	NC+N-15	N-14	3.3876	2.7850	3.0863
	M(F)		2.4022	2.7837	

Table 12

$NH_4 + NO_3$-N in leachate during the 2nd inter-crop fallow

	Treatment I Crop	Treatment II Crop	WF (ppm-N)	DF (ppm-N)
1	N_0	N_0	0.000	0.000
2	N-15	N_0	0.173	0.000
3	N-15	N-14	0.173	0.519
4	NC+N-15	N_0	0.000	0.000
5	NC+N-15	N-14	0.520	0.000

Table 13

Loss of soil + fertilizer N through volatilization during the 2nd inter-crop fallow. Kg N/ha

	Treatment I Crop	Treatment II Crop	WF	DF	M(Tr.)
1	N_0	N_0	1.624	1.517	1.570
2	N-15	N_0	2.694	1.354	2.024
3	N-15	N-14	3.573	2.373	2.973
4	NC+N-15	N_0	1.640	1.047	1.343
5	NC+N-15	N-14	2.373	1.559	1.966
		M(F)	2.381	1.570	

Table 14

Yield of rough rice, straw and roots + stubble
1st Crop. Dry season, 1977. g/plot(0.07 m^2).

Treatment	Rough rice (14% moisture)	Straw (ODB)	Roots+Stubble (ODB)
1 Control	19.58	12.27	4.81
2 N^{15}-urea	54.31	34.57	19.53
3 N^{15}-straw	19.96	13.01	6.30
4 N^{15}-FYM	19.54	11.60	5.64
5 N^{15}-straw + Ord. urea	54.14	34.46	17.11
6 N^{15}-FYM + Ord. urea	52.60	35.90	16.26
7 Ord. straw + N^{15}-urea	49.76	33.91	16.69
L.S.D. (0.05)	3.00	2.98	2.08
C.V. %	6.6	10.1	14.3

Table 15

Total N uptake by the Ist Crop. Dry season 1977

Kg N/ha (ODB)

	Treatment	Rough rice8	Straw	Rough rice + straw	Roots + Stubble	Total
1	Control	17.18	10.49	27.67	2.24	29.91
2	N^{15}-urea	48.24	28.94	77.18	8.81	85.99
3	N^{15}-straw	18.69	11.84	30.53	3.41	33.94
4	N^{15}-FYM	18.43	9.81	28.24	3.04	31.28
5	N^{15}-straw+Ord.urea	47.21	27.00	74.21	7.78	81.97
6	N^{15}-FYM+Ord.urea	46.77	30.66	77.43	7.50	84.93
7	Ord. straw+N^{15}-urea	43.98	26.84	70.82	7.63	78.45
	L.S.D. (0.05)	2.84	2.72	4.52	0.95	4.81
	C.V. %	7.0	11.1	7.0	12.6	6.7

To be returned

Progress Report for the period 15 July 1976 to 14 March, 1977

1. (a) (i) Contract No. 1438/R3/GS

(ii) Title of the Project:-

The fate of applied organic and inorganic N in flooded rice soil in relation to nitrate pollution under tropical conditions (part of a coordinated programme on agricultural N residues with particular reference to their conservation as fertilizers and behaviour as potential pollutants).

(iii) Institute where research is being carried out:-

Central Rice Research Institute, Cuttack, India

And

All-India Coordinated Rice Improvement Project, Rajendranagar, Hyderabad-30, A.P., India.

(iv) Chief Investigator and collaborators:-

Dr. J.E. Shinde

Mr. C.U.M. Rao

Mr. A.M. Krishnappa

(v) Time period covered:

15 July to 14 March, 1977

(b) Description of research work carried out

Part 1:- A laboratory experiment was conducted to study the transformation of slow-release materials labelled with N^{15}. The procedure was described in detail in part 3 of the earlier Progress Report for the period 15 January to 14 July, 1976. The data are now updated by including the results from N^{15} analysis.

Part 2:- A field experiment was conducted at Cuttack during the dry and wet seasons of 1976 to study the turnover of chopped rice straw (total N, 0.624%; C/N ratio, 54.50; N^{15} atom excess, 3.075%) and FYM (total N, 0.945%; C/N ratio, 33.49; N^{15} atom excess, 0.421%) in flooded rice soil. The treatments and experimental procedures have been described in part 4 of the earlier progress report. After harvest of the dry season crop, another rice crop was grown during succeeding wet season. For the 2nd crop 3 randomly selected replicates of each treatment, except the control, were fertilized at transplanting with unlabelled urea @ 80 kg N/ha (+N), while 2 replicates were kept unfertilized (-N). The data are now updated by including the results of the 2nd crop and the N^{15} analysis.

Part 3:- Long-term field experiments to follow the fate of an initial N^{15} pulse in flooded rice soil were initiated at Hyderabad during the wet season (July-October) of 1976. Metal micro-plots (0.07 sq.m. area) were installed in the field without any disturbance to the soil profile for application of N^{15}-urea. For yield data 13.75 sq.m. plots were prepared. Perforated tubes for collection of leachate and ground water samples and static traps for volatilized ammonia were installed in the micro-plots. The treatments included (1) control, No N (N_0); (2) basal application of 100 kg N/ha (N_1); and (3) Neem cake (residue of Azadirachta indica seeds after extraction of oil) 250 kg/ha + basal application of 100 kg N/ha (N_2). In the micro-plots urea of 20% N^{15} atom excess was used.

For taking representative soil samples from the root zone (0-20 cm depth) without disturbing the micro-plots, porous nylon bags (8 x 7 cm) have been used. These bags were filled with 50 g air-dry soil treated with N^{15}-urea and Neem cake to the same level as that in the root-zone soil. The open end was folded and closed with metal staples so as to obtain a cylindrical shape. After transplanting of the crop, 5 such nylon bags were pushed into the flooded soil of each micro-plot and placed in vertical position so that the upper end was just below the soil level. The nylon bags were uniformly distributed within the area of the micro-plot. Since these bags are porous and the soil was not tightly packed to avoid any alteration in the natural bulk density, it is expected that the enclosed soil will undergo transformations of similar nature and magnitude as that in the bulk of the micro-plot. Plant roots can also absorb N^{15}-N from the cylindrical nylon bags.

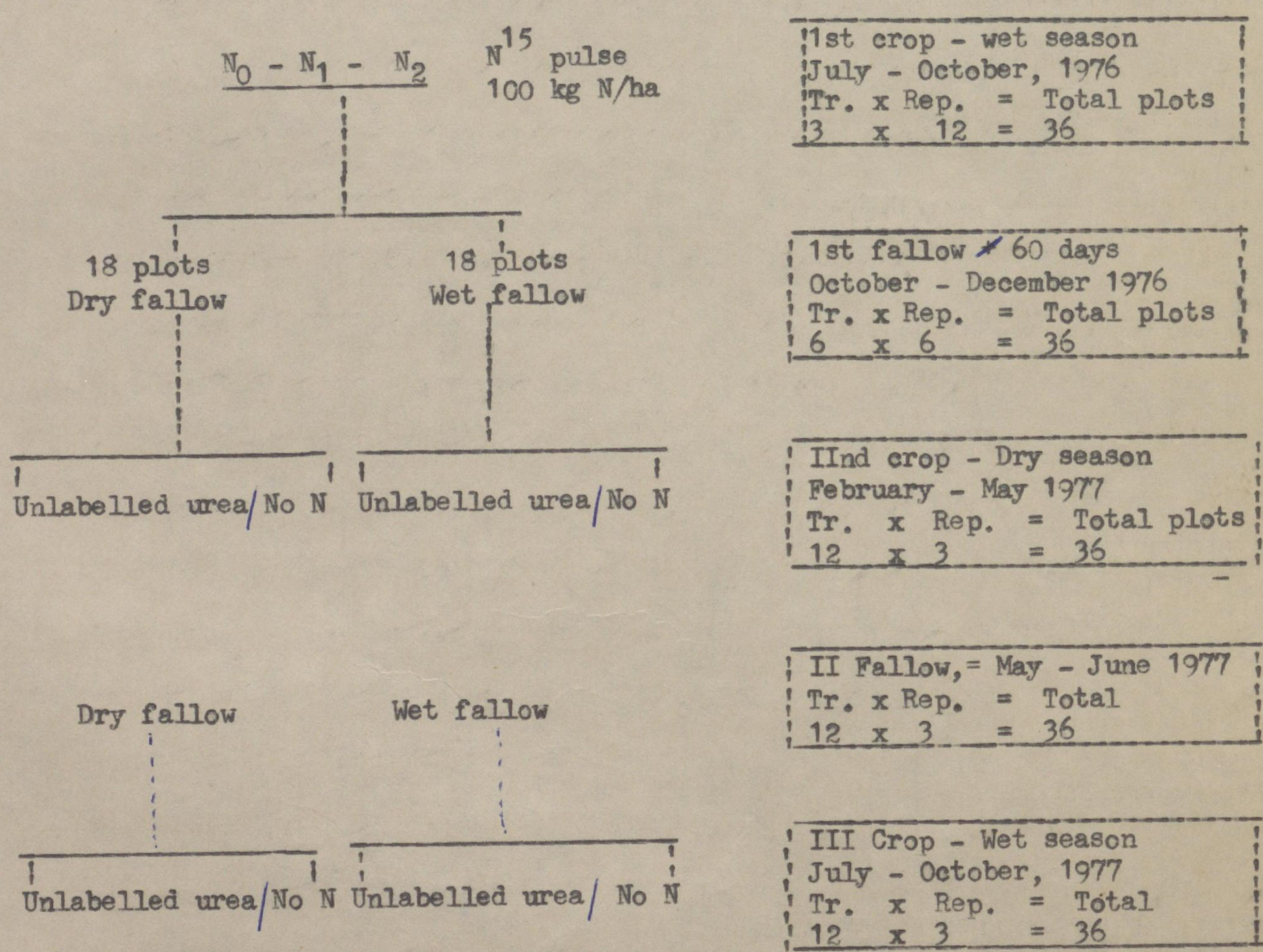
For the 1st rice crop transplanted in July, 1976 the treatments were replicated 12 times in a randomized block design. Leachate, ground water and volatilized ammonia samples were collected throughout the crop growth at weekly intervals. The crop was harvested in October 1976 and analyzed for total and N^{15}-N. One nylon bag from each replicate was pulled out, the soil was air dried and analyzed for Kjeldahl-N, KCl-extractable N, nonexchangeable NH_4-N and fractions of organic N.

After the 1st crop was harvested in October 1976, in both micro- and yield-plots, half the number of replicates of each treatment were subjected to wet and the other half to dry inter-crop fallow for a period of 60 days before all the plots were reflooded to prepare the land for the next crop. In wet fallow plots about 2 cm of flood water was maintained, while in the dry fallow the plots were allowed to dry completely. Leachate, ground water and volatilized ammonia samples were collected during the period of inter-crop fallow at 15 days interval. At the end of the inter-crop fallow, the plots were again irrigated to 5 to 8 cm depth. Six days after re-flooding, one more nylon bag from each replicate micro-plot was pulled out, and the wet soil was analyzed for different N fractions. Moisture was determined simultaneously in duplicate samples and the data were calculated on oven dry basis.

The 2nd crop was transplanted in the same plots in February, 1977. Half of the plots under each kind of fallow received 100 kg N/ha in 3 splits through unlabelled urea, while the other half were not fertilized.

After harvest of the 2nd crop in May 1977, the same plots will again be subjected to wet and dry inter-crop fallows as before. A 3rd crop will then be transplanted with and without unlabelled urea application in July, 1977. Depending upon the level of detection of N^{15} in crop, soil, and other samples, the experiment may be extended further. At the end of the experiment the micro-plots will be destructively sampled, layer by layer, to study the movement of N^{15} in the soil profile.

The entire experimental plan is schematically shown as follows:-



(c) Results obtained

Part 1:- The distribution of N^{15} in different fractions is shown in Table 1. Averaged over 30, 60 and 90 days of incubation, the fertilizer N in Kjeldahl fraction was only about 27 per cent with sulphur-coated urea as compared to 50 to 52 per in straw mud balls, 45 to 47 per cent in husk mud balls, and 44 per cent in urea mud balls without any carbonaceous material. The fertilizer N incorporated into organic fraction also showed that straw was able to immobilize more of added N as compared to other materials. The results confirmed the basic assumption that the mud balls with carbonaceous materials could immobilize a part of the fertilizer N. The consequent low rate of mineralization appeared to confer on the mud balls the overall characteristics of a typical slow-release material.

Part 2:- Application of urea over FYM significantly increased the yield of rough rice and straw in the 1st crop as compared to urea alone (Table 2). Straw application followed by urea gave higher yields than straw alone. In the 2nd crop fertilized with urea, previous FYM application gave the highest yield. However, the residual effect of FYM application on the yield of the 2nd unfertilized crop was very small.

N uptake from labelled organic sources in the above-ground portion of the 1st crop is shown in Table 3. About 11.8 kg of N/ha was available from the FYM as compared to only 2.2 kg from straw. Application of urea increased the uptake of straw-N but not of FYM - N.

The contribution of organic-N to the uptake in the 2nd crop was in all cases higher with N fertilization than otherwise (Table 4). This may be attributed to the 'priming action' of the added N.

The initial straw application added about 12.5 kg of N/ha, of which only 18 per cent was available to the 1st crop, 7.8 and 2.5 per cent to the succeeding crop depending upon whether latter was fertilized with N or not (Table 5). The 1st crop recovered 30.7 per cent of straw-N when it was supplemented with urea. The effect of urea supplement in the 1st season was also evident in the 2nd crop. The highest recovery was recorded in the case of FYM - N in both crops. Although the recoveries of N added through different materials are not strictly comparable because of varying N rate, they do indicate the extent of their mineralization in flooded soil. After harvest of the 1st crop, 13.4 and 6.7 kg of N residue per hectare was left behind in the soil arising from labelled urea and straw, respectively, (Table 6). The fraction of these residues useful to the succeeding crop depended upon whether it received N fertilization. Thus with the application of 80 kg N/ha through unlabelled urea, about 28 and 14 per cent of these N residues were in plant - available form. In the absence of N application, only about 10.9 and 4.7 per cent of the residue could be called as useful.

Part 3:- The soil characteristics and the average meteorological data are given in Tables 7 and 8, respectively. The application of Neem cake + urea increased the rough rice and straw yield significantly over that obtained by urea application alone (Table 9). The fertilizer N uptake in the crop, however, increased by only about 2 kg per hectare (Table 10). It was further evident that Neem cake could effectively control NO_3-N in the ground water (Table 11), the loss of NH_4+NO_3-N through leaching (Table 12), and ammonia volatilization (Table 13). The exact saving in the fertilizer N would, however, be known only after the N^{15} data are received.

The N residue in the soil after harvest of the 1st crop and its fractionation are shown in Table 14. Neem cake application appeared to increase the total organic N probably through greater synthesis of amino acid - N.

The effect of inter-crop fallows maintained for 60 days after harvest of the 1st crop showed that the NO_3-N in ground water was higher under the wet than the dry fallow (Table 15). However, NH_4+NO_3-N in leachate followed an apposite trend (Table 16), probably because of lesser dilution under the dry fallow. Ammonia volatilization was greater in the wet than the dry fallow (Table 17). Continued ammonium production under submergence provided by the wet fallow is likely to lead to greater losses, particularly in the absence of any growing crop. The beneficial effect of Neem cake applied earlier in the season was also evident.

The effect of wet and dry fallows on N residue is shown in (Table 18). Under all treatments the wet fallow conserved more soil + fertilizer N than the dry fallow. The soil samples in nylon bags were drawn 6 days after the plots were reflooded for land preparation. Thus unlike in the wet fallow in which continuous submergence was maintained, the dry fallow plots were subjected to 60 days of drying and 6 days rewetting cycle. The soil samples were analyzed in the wet condition immediately after collection to avoid the effect of drying and storage. The differences in the Kjeldahl - and mineral - N in the wet and dry fallows may, therefore, be assumed to reflect the extent of denitrification losses. The wetting and drying cycles are known to favour denitrification.

(d) Conclusions drawn:-

1. The results of the incubation experiment confirmed the basic assumption that the carbonaceous mud balls could immobilize a part of the fertilizer N. The immobilization and consequent low rate of mineralization may explain the behaviour of the mud balls as slow-release N sources.

2. At normal rates of application, straw and FYM contributed small amounts of N to the rice crop. However addition of fertilizer N, particularly over the straw application, may enhance the N contribution of the latter to crop growth. Similarly, N fertilization of the succeeding rice crop helped to recover more of the straw-or FYM - N applied earlier in the season.

3. The long-term field experiments on the fate of initial N^{15} pulse showed that application of Neem cake tended to improve the recovery of fertilizer N in the crop and reduce NO_3-N in the ground water. The loss of N through leaching and volatilization was also controlled leading to its enhanced conservation in the soil.

The inter-crop follow treatment showed that NO_3-N in ground water and ammonia volatilization tended to be higher in the wet than in the dry fallow. The wet fallow yet conserved more N residue as compared to the dry fallow; the difference between them may be assumed to reflect the denitrification loss.

(e) <u>Citation of periodicals etc</u>:- Nil

(f) Any explanation for any significant departure from the level of activity forseen by the contract:- Not applicable.

TABLE - 1

Transformation of N^{15}-N in slow-release materials incubated in flooded soil (30°C, 5 cm flood water). N rate = 100 ppm,

Distribution of N^{15} in different fractions, ppm. Mean of duplicate values.

N fractions	Days of incubation	Mud balls prepared from					Sulphur-coated urea
		Straw + urea	Straw + AS	Husk + urea	Husk + AS	Urea	
Kjeldahl N (including NO_3-N)	30	58.45	55.95	53.16	47.28	47.20	31.51
	60	51.81	51.31	48.79	47.78	48.50	26.94
	90	47.28	42.64	39.28	39.74	36.50	22.69
	Av	52.51	49.96	47.07	44.93	44.06	27.05
Mineral NH_4+NO_3-N	30	11.67	9.26	13.10	13.03	11.35	7.23
	60	10.33	7.41	10.14	11.24	11.41	6.09
	90	10.36	7.00	9.61	9.11	7.70	4.32
	Av	10.78	7.89	10.95	11.12	10.15	5.88
Mineralizable NH_4+NO_3-N	30	1.37	1.74	-	0.88	0.77	-
	60	0.68	0.82	-	-	-	-
	90	-	1.10	-	-	0.03	0.15
	Av	0.68	1.22	-	0.29	0.27	0.05
Total organic N	30	46.78	46.69	40.06	34.25	35.85	24.28
	60	41.48	43.90	38.65	36.54	37.09	20.85
	90	36.92	35.64	29.67	30.63	28.80	18.37
	Av	41.72	42.07	36.12	33.80	33.91	21.17
HCl-hydrolyzable organic N	30	40.04	39.57	33.95	31.81	30.12	21.39
	60	31.90	36.49	30.85	30.48	30.16	19.33
	90	29.77	29.66	27.11	26.83	23.39	16.19
	Av	33.90	35.24	30.63	29.70	27.89	18.97
HCL-nonhydrolyzable organic N	30	6.74	7.12	6.11	2.44	5.73	2.89
	60	9.58	7.41	7.80	6.06	6.93	1.52
	90	7.15	5.98	2.56	3.80	5.41	2.18
	Av	7.82	6.83	5.49	4.10	6.02	2.20

AS = Ammonium sulphate

Sulfur coated urea (TVA product), N = 39.1%, N^{15} atom excess = 9.9%, Dissolution rate = 28% in 7 days, total coating = 16%, conditioner = 2%, wax = 3%, sulfur = 11%.

Table - 2

Yield of rough rice and straw

Treatment	1st crop (Dry season 1976)		2nd crop (Wet season 1976)			
			+ N		- N	
	Rough rice	Straw	Rough rice	Straw	Rough rice	Straw
	g/plot					
Control	65.0	44.5	-	-	21.8	13.9
N^{15}-urea	78.1	60.3	73.7	30.5	32.5	21.6
N^{15}-straw	67.9	45.0	74.8	40.0	20.5	11.9
N^{15}-FYM	68.6	45.7	83.8	45.0	35.7	21.8
N^{15}-straw + unlabelled urea	82.7	62.7	75.2	38.0	37.8	19.4
N^{15}-FYM + unlabelled urea	91.5	67.8	67.4	37.0	23.5	16.9
L.S.D. (0.05)	6.3	5.4				

TABLE - 3

N uptake in the 1st crop, Kg N/ha.

Treatment	Rough rice			Straw			Rough rice + straw		
	From labelled source	From unlabelled source/s	Total	From labelled source	From unlabelled source/s	Total	From labelled source	From unlabelled source/s	Total
Control	-	59.00	59.00	-	29.30	29.30	-	88.30	88.30
N^{15}-urea	13.52	77.93	91.45	8.85	48.30	57.15	22.37	126.23	148.60
N^{15}-straw	1.53	77.77	79.30	0.72	38.83	39.55	2.25	116.60	118.85
N^{15}-FYM	7.83	69.13	76.96	3.96	37.25	41.21	11.79	106.38	118.17
N^{15}-straw + unlabelled urea	2.65	94.38	97.03	1.18	55.79	56.97	3.83	150.17	154.00
N^{15}-FYM + unlabelled urea	5.75	104.27	110.02	3.20	57.20	60.40	8.95	161.47	170.42
L.S.D. (0.05)	3.08	-	8.10	1.51	-	6.57	4.44	-	11.14

TABLE - 4

N uptake in the 2nd crop with (+ N) and without (- N) fertilization by unlabelled urea. Kg N/ha.

Treatment	Rough rice			Straw			Rough rice + straw		
	From labelled source	From unlabelled source/s	Total	From labelled source	From unlabelled source/s	Total	From labelled source	From unlabelled source/s	Total
					+ N				
Control	-	-	-	-	-	-	-	-	-
N^{15}-urea	2.90	85.23	88.13	0.83	31.40	32.23	3.73	116.63	120.36
N^{15}-straw	0.76	80.44	81.20	0.21	35.10	35.31	0.97	115.54	116.51
N^{15}-FYM	5.47	86.66	92.13	N D	35.70	35.70	5.47	122.36	127.83
N^{15}-straw + unlabelled urea	1.05	82.21	83.26	0.30	33.54	33.84	1.35	115.75	117.10
N^{15}-FYM + unlabelled urea	N D	80.49	80.49	N D	35.70	35.70	N D	116.19	116.19
					- N				
Control	-	21.76	21.76	-	13.20	13.20	-	34.96	34.96
N^{15}-urea	0.98	35.27	36.25	0.49	20.03	20.52	1.47	55.30	56.77
N^{15}-straw	0.24	21.45	21.69	0.08	10.04	10.12	0.32	31.49	31.81
N^{15}-FYM	1.22	35.63	36.85	N D	15.93	15.93	1.22	51.56	52.78
N^{15}-straw + unlabelled urea	0.40	40.38	40.78	0.13	16.93	17.06	0.53	57.31	57.84
N^{15}-FYM + unlabelled urea	N D	27.29	27.29	N D	15.25	15.25	N D	42.54	42.54

N D = N^{15} below detectable level

TABLE - 5

Per cent recovery of N added through N^{15}-labelled materials in rice crops.

Treatment	Application rate of labelled N Kg/ha	Per cent recovery in		
		1st crop	2nd crop	
			+ N	- N
N^{15}-urea	80.00	27.95	4.66	1.84
N^{15}-straw	12.48	18.03	7.77	2.56
N^{15}-FYM	21.00	56.14	26.05	5.81
N^{15}-straw + unlabelled urea	12.48	30.69	10.81	4.24
N^{15}-FYM + unlabelled urea	21.00	42.62	N D	N D

N D = N^{15} below detectable level

TABLE - 6

Per cent recovery of residual labelled soil N in 2nd rice crop

Treatment	Total residual N^{15}-N in soil + roots (Kjeldahl fraction) after harvest of 1st crop (0-20 cm depth)	Uptake of residual N by 2nd crop		% Recovery of labelled soil N in 2nd crop	
		+ N	- N	+ N	- N
	Kg N/ha				
N^{15}-urea	13.44	3.73	1.47	27.75	10.94
N^{15}-straw	6.76	0.97	0.32	14.35	4.73

Table - 7

Soil characteristics, A.I.C.R.I.P., Hyderabad

(0-20 cm depth) Air-dry basis

1	Type	Black soil
2	Texture	Clay
3	Predominent clay mineral	Montmorrillonite
4	pH (1:1.25, water)	8.10
5	Total N %	0.09
6	Organic C %	0.937
7	C/N ratio	10.89
8	C.E.C. meq/100 g	49.20
9	Available P (Olsen), ppm	5.00

Table - 8

Average meteorological data, A.I.C.R.I.P., Hyderabad

	Wet season, 1976 (July - October)	Inter-crop fallow (1) 22 October to 21 Dec., 1976
Air temperature, °C		
Max.	30.6	30.0
Min.	20.8	17.0
Sun shine, hrs.	182.1	260.4
Rainfall, mm	103.0	18.1
Relative humidity, %		
Morning	85.7	90.3
Evening	52.0	41.3

Table - 9

Yield of rough rice and straw. 1st crop,
Field experiment, Wet season 1976, Hyderabad.

N rate = 100 kg/ha

Treatment	Rough rice (14% moisture)	Straw (Oven dry)
	------ t/ha ----	
Control	1.81	1.75
Urea, basal	4.18	4.00
Neem cake + urea, basal	4.64	4.65
L.S.D. (0.05)	0.19	0.44
C.V. %	6.5	15.3

Table - 10

N uptake, kg/ha, 1st crop. Field experiment, wet season 1976. Hyderabad

N rate = 100 kg/ha   N conc. from microplot x yield from microplots

Treatment	Rough rice			Straw			Rough rice + straw		
	Fert.	Soil	Total	Fert.	Soil	Total	Fert.	Soil	Total
Control	-	20.80	20.80	-	11.44	11.44	-	32.24	32.24
Urea, basal	20.77	34.04	54.81	13.15	19.35	32.50	33.92	53.39	87.31
Neem cake+urea, basal	22.26	40.48	62.74	14.00	22.07	36.07	36.26	62.55	98.81
L.S.D.(0.05)	N.S.		5.51	N.S.		3.24	N.S.		7.98

Table - 11

Soil + Fertilizer N in ground water during 1st crop growth, Wet season 1976. Hyderabad.

N rate = 100 kg/ha

Treatment	As NH_4-N	As NO_3-N	As NH_4+NO_3-N
	------- ppm		----------
Control	0.26	0.31	0.57
Urea, basal	1.52	0.64	2.16
Neem cake + urea, basal	1.05	0.40	1.45

Table - 12

Soil + Fertilizer N in leachate during 1st crop growth, wet season 1976, Hyderabad

N rate = 100 kg/ha

Treatment	As NH_4+NO_3-N
	ppm
Control	0.09
Urea, basal	1.28
Neem cake + urea, basal	0.77

Table - 13

Loss of soil + fertilizer N through ammonia volatilization during 1st crop growth. Wet season 1976, Hyderabad.

Treatment	Kg N/ha
Control	0.67
Urea, basal	1.60
Neem cake + urea, basal	1.18

Table - 14

Residual soil + fertilizer N in soil (0-20 cm depth) after harvest of 1st crop. 1st Nylon bag

µg/g

Treatment	Kjeldahl N (includ-ing NO_3-N)	Mineral NH_4+NO_3-N	Total org. N	HCl-soluble org. N	Fractions of HCl-soluble organic N				Clay-fixed NH_4-N
					NH_4-N	Hexose amin-N	Amino acid - N	Unidentified - N	
Control	796.~~93~~ 88	11.32	785.61	404.25	46.19	19.25	140.53	198.27	105.00
Urea, basal	925.15	14.90	910.25	569.80	63.52	71.22	86.94	348.10	108.50
Neem cake + urea, basal	1013.51	14.09	999.42	542.20	55.50	34.64	162.34	289.71	90.41
LSD (0.05)	65.28	0.81							
C.V. %	8.8	7.3							

Table - 15

Soil + fertilizer N in the ground water. Cumulative data, 1st inter-crop fallow, Hyderabad.

Treatment	Wet fallow			Dry fallow		
	NH_4-N	NO_3-N	NH_4+NO_3-N	NH_4-N	NO_3-N	NH_4+NO_3-N
			ppm			
Control	1.39	1.38	2.77	1.38	-	1.38
Urea, basal	5.89	3.12	9.01	7.62	2.77	10.39
Neem cake + urea, basal	6.58	0.35	6.93	5.54	-	5.54

Table - 16

Soil + fertilizer N in leachate. Cumulative data, 1st inter-crop fallow, Hyderabad.

Treatment	Wet fallow	Dry fallow
	NH_4 +NO_3-N, ppm	
Control	1.73	3.46
Urea, basal	6.41	26.68
Neem cake + urea, basal	2.77	6.41

Table - 17

Loss of soil + fertilizer N through ammonia volatilization during 60 days of the 1st inter-crop fallow (22 October to 21 December, 1976) Hyderabad.

Treatment	Wet fallow	Dry fallow
	Kg N/ha	
Control	1.23	0.92
Urea, basal	2.27	1.45
Neem cake + urea, basal	1.71	1.17

Table - 18

Residue of soil + fertilizer N after 1st inter crop fallow,

2nd nylon bag. Mean of 6 replications

wet samples digested for Kjeldahl-N

Treatment	Kjeldahl - N ppm(ODB)		KCl-extractable NH_4+NO_3-N ppm (~~ODB~~) air-dry		Clay-fixed NH_4-N, ODB ppm	
	Wet fallow	Dry fallow	Wet fallow	Dry fallow	WF	DF
Control	584.79 ~~776.27~~	581.40 ~~756.02~~	18.48	11.55	84.16	84.00
Urea, basal	662.37 ~~858.25~~	636.36 ~~835.63~~	21.94	13.86	100.15	94.25
Neem cake + urea, basal	678.67 ~~870.00~~	676.18 ~~846.65~~	26.56	17.32	123.72	117.8[illegible]

Green Field Fertilizers

3-6-477/2, Himayatnagar,

Hyderabad - 500 029

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24.05
1737.05

449
320
129
113
242

1