rooting losses, rotting losses and total loss in weight of bulb, but did not influence the moisture content in the bulb during storage. It may be due to the fact that increasing interval of spraying of MH is directly associated with the absorption and utilization of MH sprayed over the foliage. More the quantity of absorbed MH more would be the effect, since the absorption is higher in green foliage as compared to dry foliage and therefore, there was more effect of MH when interval of spraying before harvest was more. The application of MH before harvest reduced the loss, maximum, when spray was done 21 days before harvest followed by 14 and 7 days, consequently reduction of sprouting, rooting and rotting losses. With the advance of storage period the total loss increased. This may be due to the fact that all total loss which included sprouting loss, rotting loss, rooting loss and moisture loss increased and hence resulted in total loss.

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EFFICIENCY OF NITROGEN SOURCES IN WET LAND RICE SOIL DURING DIFFERENT CROP SEASONS

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ABSTRACT

Three field experiments were conducted during summer (February-May), *kuruvai* (July-October) and *thaladi* (November- February) seasons of 1985-'86 with different sources of N,viz., prilled urea, ammonium chloride, neem cake coated urea, coal tar coated urea, lac coated urea and urea supergranule, each with four levels, viz., 0, 51, 102 and 153 kgN/ha to study the use efficiency (NUE) and apparent recovery (ANR) of the applied N in wet land rice. The results indicated that the yield, uptake of N, the NUE and ANR in rice were higher under urea supergranule followed by lac coated urea than prilled urea in all the three crop seasons. Application of ammonium chloride also registered higher grain yield and NUE over prilled urea during *thaladi* season.

Due to cost escalation of N fertilizers, there is always a compelling need to evolve sutiable fertilizer N management strategies in order to reduce the losses of applied N and to increase the N use efficiency. With a view to evaluate the efficiency of different N fertilizers and their effect on the yield and uptake of nutrients in rice in different growing seasons, the present investigation was carried out. The results are presented in this paper.

MATERIALS AND METHODS

Three field experiments were conducted in Tamil Nadu Rice Research Institute, Aduthurai during summer (Feburary-May), *kuruvai* (July-October) and *thaladi* (November-February) seasons of 1985'86, to study the influence of different sources and levels of applied N on the yield and uptake of nutrients by rice and to work out the efficiency of the applied N during the different crop seasons. The soil of the experimental field was a deep grey brown river alluvium with clay loam texture and belonged to Adanur series (Entic Chromustert). The soil was non calcareous, neutral in reaction, low in available N (270 kg KMno4-N per ha), medium in available P (16.2 kg Olsen-P per ha) and high in available K (286 kg NH_4OAc-K per ha) with an organic carbon content of 0.81 per cent and CEC of 26.4 C mol (P*) /kg.

The treatments included four levels of N, *viz.*, 0, 51, 102 and 153 kg/ha and six sources of N, *viz.*, prilled urea (PU), ammonium chloride (AC), neem cake coated urea (NCA), coal tar coated urea (CTU), lac coated urea (LUC) and urea supergranule (USG). There were 24 treatment combinations replicated twice in a factorial randomized block design. In all the treatments except USG, nitrogen was applied by broadcast in three splits *viz.*, 50 per cent basal, 25 per cent at

Table 1. Effect of sources and levels of N on the yield and N uptake of rice during different crop seasons.

	Grain yield (kg/ha)			Straw yield (kg/ha)			N uptake (kg/ha)		
	Summer	*Kuruvai*	*Thaladi*	Summer	*Kuruvai*	*Thaladi*	Summer	*Kuruvai*	*Thaladi*
N sources									
PU	3744	5557	4522	4379	5645	5220	62.5	79.6	63.2
AC	3805	5827	4976	4548	5686	5264	61.5	81.9	66.1
NCU	3788	5714	4674	4457	5755	5565	65.6	86.9	69.9
CTU	3765	5586	4714	4521	5628	5565	63.5	84.2	68.1
LCU	3884	6058	5080	4638	5653	5656	68.1	87.9	74.8
USG	4070	6168	5631	5066	6168	5709	78.4	93.7	82.8
SE	91	168	146	104	241	174	2.6	3.9	2.1
CD (5%)	189	347	302	215	NS	359	5.3	8.1	4.4
N levels									
N_0	2810	3965	3003	3712	4482	3262	47.9	57.2	42.1
N_{51}	3713	5462	4465	4565	5149	4797	64.9	76.7	64.8
N_{102}	4381	6734	5968	4997	6284	6619	74.3	98.9	84.6
N_{153}	4467	7107	6074	5131	7111	7308	79.3	110.0	91.7
Mean	3843	5817	4933	4601	5759	5497	66.7	85.7	70.8
SE	74	137	119	85	197	142	2.1	3.2	1.7
CD (5%)	154	287	247	176	407	293	4.3	6.6	3.6

tillering and 25 per cent at panicle initiation stage. Urea super granules of 0.5 and 1.0 g size were used to supply the required dose of N and point placed at 8-10 cm soil depth in alternate row and hill spacings at the centre of four rice hills in two splits, *viz.*, 50 per cent at planting and the rest 50 per cent at 22 DAT for short duration rice variety (ADT 36)during summer and *kuruvai* seasons and at 27 DAT for medium duration rice variety (CO 44) during *thaladi* season. All the treatments including control received uniform dose of 50 kg P_2O_5 and K_2O /ha.

The field was thoroughly tractor ploughed, levelled and plots were laid out as per the design during summer season. The layout was kept undisturbed and the plots were prepared by mummutty digging and puddled in the subsequent seasons. A continuous shallow submergence with about 5 cm of standing water was maintained during the growth period of rice, by providing tube well irrigation in summer season and canal irrigation during *kuruvai* and *thaladi* seasons.

The yield of grain and straw was recorded at harvest of each crop season. Samples of grain and straw were collected from the harvested produce. Ground samples of whole grain and straw were analysed for total N content and from the data of dry weights of crop produce and their N content the N uptake was computed.

The nitrogen use efficiency (NUE) was calculated from the formula:

$$NUE = \frac{Y_t - Y_o}{X} \times 100$$

where,

Y_t = Grain yield of treated plot (kg/ha)

Y_o = Grain yield of control (kg/ha)

X = Level of applied N (kg/ha)

The apparent N recovery (ANR) was calculated from the formula:

$$ANR = \frac{N_t - N_o}{X} \times 100$$

where,

N_t = N uptake in treated plots (kg/ha)

N_o = N uptake in control (kg/ha)

X = Level of applied N (kg/ha)

The data on the yield of grain and straw, total N uptake of the crop, NUE and ANR were statistically analysed and the results are presented here under.

Table 2. Nitrogen use efficiency (NUE) in rice.

Comparison of Seasons x N sources

Seasons / N sources	Summer	*Kuruvai*	*Thaladi*	Mean
PU	12.5	23.1	19.9	18.5
AC	12.9	25.6	30.5	23.0
NCU	13.7	24.6	25.6	21.3
CTU	14.2	23.5	23.1	20.2
LCU	16.3	23.4	29.4	24.4
USG	18.2	29.9	35.0	27.7
Mean	14.6	25.7	27.2	22.5

	SE	CD(5%)
Seasons	0.98	2.0
N sources	1.38	2.8
Interaction	2.39	NS

Comparison of Seasons x N levels

Seasons / N sources	Summer	*Kuruvai*	Thaladi	Mean
N_{51}	17.7	29.3	32.9	26.7
N_{102}	15.4	27.1	28.7	23.8
N_{153}	10.8	20.5	20.1	17.1
Mean	14.6	25.7	27.2	22.5

	SE	CD (5%)
Seasons	0.98	2.0
N Levels	0.98	2.0
Interaction	1.69	NS

Comparison of N sources x N levels

N levels / N sources	N_{51}	N_{102}	N_{153}	Mean
PU	21.8	18.2	15.5	18.5
AC	28.5	22.9	17.6	23.0
NCU	24.3	21.6	18.0	21.3
CTU	23.4	21.5	15.8	20.2
LCU	29.8	25.6	17.7	24.4
USG	32.1	32.6	18.3	27.7
Mean	26.7	23.8	17.1	22.5

	SE	CD (5%)
N sources	1.38	2.8
N Levels	0.98	2.0
Interaction	2.39	NS

RESULTS AND DISCUSSION

The grain yield of rice under different sources and levels of N during the three crop seasons are presented in Table 1. The grain yield of rice was in the range of 2730 - 4768, 3858 - 7868, 2803 - 7420 kg/ha with mean values of 3843, 5817 and 4933 kg/ha during *summer, kuruvai* and *thaladi* seasons, respectively. The different sources of N as well as the levels of N tried had marked influence on the grain yield of rice at all the three seasons of experimentation, but the interaction of the levels of N with sources of N attained significance only during the *thaladi* season.

Application of USG recorded higher grain yield of rice than other N sources during *thaladi* season. This source also registered higher yield over AC, NCU, CTU and PU during summer and NUC, CTU and PU during *kuruvai*. Lac coated urea was in general the next best source and superior to PU though comparable to the rest of the N sources. The superiority of USG in recording higher yield over PU was seen at all levels of N. In all the three crop seasons, the main effect of NCU and CTU were comparable with PU. Ammonium chloride was on a par with PU during summer and *kuruvai* seasons and registered markedly higher yield than PU during *thaladi* season. The slow release of N from USG which was point placed at 8-10 cm of soil depth caused prolonged availability and uptake of applied N by rice crop. This has ultimately resulted in higher grain yield compared to the other N sources. Increased rice yields due to USG application has been reported by Velu and Ramanathan (1985) and Sahu and Pal (1987). The performance of lac coated urea, which was next best to USG and superior to PU, was due to the presence of a thick coating of shellac acting as a physical barrier and restricting the solubility of this source, thus making the availability of the applied

Table 3. Apparent N recovery (per cent) in rice

Comparison of Seasons x N sources

Seasons / N sources	Summer	*Kuruvai*	*Thaladi*	Mean
PU	23.5	32.0	29.3	28.3
AC	21.2	31.0	34.8	29.0
NCU	22.0	35.2	36.0	31.1
CTU	23.8	39.0	36.8	33.2
LCU	26.2	37.3	44.3	35.9
USG	42.7	54.2	54.3	50.4
Mean	26.6	38.1	39.1	34.6

	SE	CD(5%)
Seasons	2.1	4.1
N sources	3.0	5.9
Interaction	5.1	NS

Comparison of Seasons x N levels

Seasons / N sources	Summer	*Kuruvai*	Thaladi	Mean
N_{51}	33.3	38.3	44.4	38.7
N_{102}	25.8	41.1	40.9	35.9
N_{153}	20.6	34.9	32.5	29.3
Mean	26.6	38.1	39.3	34.6

	SE	CD (5%)
Seasons	2.1	4.1
N Levels	2.1	4.1
Interaction	3.6	NS

Comparison of N sources x N levels

N levels / N sources	N_{51}	N_{102}	N_{153}	Mean
PU	29.3	28.7	26.8	28.3
AC	29.5	30.2	27.3	29.0
VCU	33.8	31.3	28.0	31.1
CTU	40.2	33.0	26.5	33.2
LCU	39.5	38.5	29.8	35.9
USG	59.7	54.0	37.5	50.4
Mean	38.7	35.9	29.3	34.6

	SE	CD (5%)
N sources	3.0	5.9
N Levels	2.1	4.1
Interaction	5.1	NS

N to the crop for a longer period as reported by Bandyopadhyay and Biswas (1982) and Velu *et al.* (1988).

The performance of AC was encouraging only during *thaladi* season as it recorded higher grain yield over PU. Slow mineralisation of the soil and fertilizer N in the prevailing cold weather conditions of *thaladi* season compared to other crop seasons had created a demand for NH_4-N from this source by rice (Dei and Yamasaki, 1979). Under such circumstances, application of a ammoniacal form of N was reported to have a direct bearing on rice growth and yield (Mengel *et al.*, 1986).

A general increase in the grain yield of rice was observed with increasing levels of applied N in all the three crop seasons. However, during *summer* and *thaladi* the grain yields at higher levels of N (N_{102} and N_{153}) were comparable. The same trend was seen under PU, AC, CTU and LCU during *thaladi* season and the levels behaved independently under NCU and USG.

The straw yield of rice varied between 3552-5799, 4167-7789 and 2932-7544 kg/ha during summer, *kuruvai* and *thaladi* seasons, respectively (Table 1). The different sources of N tried had significant effect on the straw yield of rice during summer and *thaladi* seasons only. Application of USG and LCU recorded higher straw yield than PU while the rest of the N sources, *viz.*, NCU, CTU and AC were on a par with PU. The straw yield of rice increased with increasing levels of N in all the three crop seasons except during summer, where the straw yields at higher levels of N (N_{102} and N_{153}) were comparable.

The nitrogen uptake in grain and straw of the rice crop ranged from 45.8 - 93.3, 54.6 - 119.2 and 39.1 and 107.1 kg/ha during summer, *kuruvai* and *thaladi* seasons, respectively (Table 1). Among the

N sources, USG and LCU recorded markedly higher N uptake over PU at all the three crop seasons. The other N sources, *viz.*, NCU and CTU were on a par with PU during summer and *kuruvai* seasons and superior during *thaladi* season. With increasing levels of applied N, a progressive increase in the N uptake of the crop was noticed at all the crop seasons.

The nitrogen use efficiency (NUE) of the rice crop ranged from 10.0 - 23.9, 19.2 - 37.4 and 15.7 - 41.7 kg rice grain/kg N applied with a mean value of 14.6, 25.7 and 27.2 during summer, *kuruvai* and *thaladi* seasons, respectively (Table 2). The NUE in *thaladi* and *kuruvai* seasons were comparable and superior to that in summer season. Among the N sources, USG recorded the highest NUE of 27.7 which was significantly superior to all other N sources. Lac coated urea was the next best source recording a NUE value of 24.4 which was on a par with AC (23.0). In turn both these sources were superior to PU (18.5). The NUE of NCU and CTU was on a par with AC and comparable with that of PU. A significant decrease in the NUE was observed with every increase in the levels of applied N.

The apparent nitrogen recovery (ANR) in rice ranged from 18.0 - 58.0, 31.5 - 60.5 and 28.5 - 61.0 per cent with mean values of 26.0, 38.1 and 39.3 per cent for summer, *kuruvai* and *thaladi* seasons, respectively (Table 3). The ANR in *thaladi* and *kuruvai* seasons were comparable and both were superior to that of summer season. Irrespective of the seasons and levels of N application, USG recorded significantly higher ANR (50.4 per cent) over the rest of the N sources. The performance of LCU was comparable with CTU and NCU. The latter two sources were on a par with AC and PU. Application of N at N_{51} and N_{102} recorded higher ANR than N_{153}.

Computation of NUE and ANR with the available data was aimed to predict the relative performance of different sources and levels of N. In the present investigation, the NUE and ANR decreased correspondingly with every increase in the N levels applied irrespective of the crop seasons. This could be attributed to the decline in the incremental grain yield and N uptake for the successive increments in the fertilizer N.

Further, the NUE and ANR also varied among the crop seasons studied. Both the parameters showed a marked increase from summer to *kuruvai* and a further marginal increase in *thaladi* season. Since the control plots did not receive fertilizer N for all the three consecutive seasons, the relative yield and N uptake of control plots compared to that of the N applied declined with successive cropping seasons. Thus the difference between control and N applied plots widened from first experimental crop to the third crop leading to the increase in the NUE and ANR in rice with the successive cropping seasons.

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