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Mineralisation pattern of neem coated urea products in different soils

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ABSTRACT

Fertilizers in general and nitrogenous fertilizers in particular have made a major contribution towards agricultural productivity. Recovery per cent of applied nitrogen is only less than fifty per cent. The factors that contribute to the poor recovery of nitrogen by plants are as a result of rapid dissolution of the applied fertilizer materials and release of more mineral nitrogen than what is used by the plant or conserved by the soil in the available forms. Urea is the least efficient among the nitrogen sources. High loss and low nitrogen use efficiency demand and the factors responsible for such wastage of expensive input has to be studied. The dynamics of release of N from these fertilizers is likely to be studied. The dynamics of release of N from these fertilizers is likely to be influenced by soil characteristics as well as moisture condition. Hence, an attempt was made to compare the mineralization pattern of newly developed neem coated urea products in different soils under submerged condition. An incubation experiment was conducted with two soil series *viz.*, Noyyal series (Heavy textured) and Madukkur series (Light textured). The soil was incubated for 10 days with 200 ppm of nitrogen using different N carriers (9 Treatments *viz.*, control, 0.1, 0.2 and 0.3% neem oil and neem gold coated urea, indigenously prepared neem coated urea and prilled urea). Soil samples were collected and analysed for urea, ammoniacal and nitrate nitrogen. The results revealed that three neem coated urea products *viz.*, 0.3% neem oil, 0.1% and 0.2% neem gold coated urea were equally effective in prolonging urea release up to 10 days compared to indigenously prepared neem cake coated urea and prilled urea. Ammoniacal nitrogen release peaked at 5 DAI (days after incubation) in all neem coated urea products compared to prilled urea (peaked at 4 DAI). The lowest nitrate nitrogen content was recorded under neem coated urea products. Thus, use of neem coated urea products prolonged the nitrogen availability for the crop growth thereby minimized the losses of nitrogen and improved the nitrogen use efficiency.

Key words : Neem coated urea, Soils, Mineralisation, Neem gold.

INTRODUCTION

Fertilizers in general and nitrogenous fertilizers in particular have made a major contribution towards agricultural productivity. However, there is a continuous need to improve the efficiency of nitrogenous fertilizer in order to achieve more productivity of crops and to minimize the fertilizer related environmental problems. Results of several studies showed that only 50-60 per cent of the fertilizer nitrogen is usually recovered by crop plants. The recovery per cent of applied nitrogen to rice is generally lowers than fifty.

The factors that contribute to the poor recovery of nitrogen by plants are as a result of rapid dissolution of the applied fertilizer materials and release of more mineral nitrogen than what is used by the plant (or) conserved by the soil in the available forms. Urea is the least efficient among the ammonium containing nitrogen sources. High loss and low nitrogen use efficiency demand and the factors responsible for such wastage of expensive input has to be studied. Among the strategies explored to increase the nitrogen use efficiency, development of controlled released nitrogen carriers is one. This method aims to deliver nitrogen to the crop in a more timely and effective manner and at the same time be less susceptible to leaching, volatilization, denitrification and other mode of nitrogen loss.

Recently in Tamil Nadu, Southern Petrochemical Corporations Ltd. (SPIC) has evolved such a strategy by bringing slow release N fertilizers, which are new formulations containing N source as neem coated urea products with neem oil and neem gold. The dynamics of release of nitrogen from these fertilizers is likely to be influenced by soil characteristics as well as moisture condition. Hence, the present investigation was designed to compare the mineralization pattern of neem coated urea products in different soils under submerged condition.

MATERIALS AND METHODS

Two soil series representing the major rice growing soils *viz.*, Noyyal (Vertic Ustochrept) and Madukkur series (Udic Haplustalf) were taken up for the study. The basic properties of soils are presented in Table 1.

Table 1 : Basic soil characteristics

Soil properties	Noyyal series	Madukkur series
Textural class	Clay	Sandy loam
Taxonomy	Vertic Ustochrept	Udic Haplustalf
Organic carbon (%)	0.70	0.61
Total N (%)	0.063	0.053
Available N (kg ha^{-1})	200	195
Ammoniacal N (ppm)	35.8	30.5
Nitrate N (ppm)	8.12	7.56
CEC (c mol (p^+) kg^{-1})	21.4	10.4

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Hundred gram air dried soil was placed in 200 ml polythene container and pre – incubated for two days with 2 cm standing water. The soil was incubated for 10 days with 200 ppm of N using different N carriers. The details on the treatment schedule adopted are given below:

Factor 1 : Soil type : 1. Noyyal series
2. Madukkur series
Factor 2 : No. of Trt. : 9
T_1 : Control
T_2 : Soil + 0.1 % neem oil coated urea (P_1)
T_3 : Soil + 0.2 % neem oil coated urea (P_2)
T_4 : Soil + 0.3 % neem oil coated urea (P_3)
T_5 : Soil + 0.1 % neem gold coated urea (P_4)
T_6 : Soil + 0.1 % neem gold coated urea (P_5)
T_7 : Soil + 0.1 % neem gold coated urea (P_6)
T_8 : Soil + indigenously prepared neem coated urea (P_7)
T_9 : Soil + prilled urea (P_8)
Treatment combinations : (2 x 9) = 18

The laboratory experiment was in a Factorial Completely Randomized Design (FCRD) with three replications. Separate sets of incubations were kept for stages of sampling *viz*., 1, 2, 3, 4, 5 and 10 days after incubation (DAI). Submerged condition was maintained throughout the study period. First the flood water was carefully collected and the volume was recorded and used for analysis. The soils were thoroughly mixed and 10 g of soil samples (wet weight) were taken for extraction of mineral – N. The samples were analyzed for urea (Douglas and Bremner, 1970), ammoniacal – N and Nitrate – N (Bremner and Keeney, 1966). The values for different soil N fractions were expressed on oven dry weight basis.

RESULTS AND DISCUSSION

Dynamics of nitrogen in soil:

Urea-N content (NH_2 – N):

Application of different sources of N was found to influence the urea -N content in a significant manner. The urea-N concentration decreased from 1 DAI to 10 DAI and the highest value was recorded at first DAI. Among the soils, Noyyal soil series (S_1) recorded the maximum value from initial to 10 DAI irrespective of sources of nitrogen which was superior to Madukkur soil series. Thus, urea hydrolysis was high in clay soil, which might be due to increase in urease activity. This enzyme activity was reported to be highly correlated with total nitrogen and organic carbon. With respect to different sources of N, neem coated urea products (T_2 to T_8) releases urea-N up to 10 DAI, whereas uncoated urea (T_9) releases urea-N up to 5 DAI only (Table 2).

In both the soil series, the highest value was registered under T_4 (0.3 per cent neem oil coated urea) and the lowest value was recorded under T_1 (control). Among the different sources, application of 0.3 per cent

Table 2 : Urea - N content in soil at different days after incubation as influenced by neem coated urea products (ppm)

Treatment	Noyyal soil series (S_1)							Madukkur soil series (S_2)						
	Days after incubation (DAI)							Days after incubation (DAI)						
	1	2	3	4	5	10	Mean	1	2	3	4	5	10	Mean
T_1 - C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_2 - P_1	47.2	39.6	26.9	9.20	3.50	0.91	21.2	33.2	23.3	21.1	8.10	3.00	0.60	14.9
T_3 - P_2	47.1	39.7	27.6	9.60	3.60	1.12	21.5	33.6	23.7	21.4	8.40	3.20	0.60	15.2
T_4 - P_3	48.1	41.1	27.9	9.90	4.30	1.13	22.1	34.6	25.1	23.0	10.10	4.10	0.81	16.3
T_5 - P_4	47.6	41.4	28.0	10.0	4.10	1.22	22.1	34.9	24.9	22.8	9.71	4.00	0.84	16.2
T_6 - P_5	48.0	40.5	28.1	9.80	4.00	1.19	21.9	34.5	25.0	23.1	10.0	4.00	0.82	16.2
T_7 - P_6	47.4	39.8	27.7	9.41	3.50	1.11	21.5	33.2	23.1	21.5	8.31	3.40	0.52	15.0
T_8 - P_7	45.1	38.1	25.1	8.41	2.10	0.84	19.9	32.1	21.2	19.4	6.60	1.89	0.49	13.6
T_9 - P_8	42.7	36.2	23.4	6.90	0.96	0.00	18.4	30.6	19.8	19.6	5.10	0.66	0.00	12.6
Mean	41.5	35.2	23.9	8.14	2.90	0.84		29.6	20.7	19.1	7.37	2.69	0.52	
	1 DAI		2 DAI		3 DAI			4 DAI		5 DAI		10 DAI		
	S.E.±	C.D.	S.E.±	C.D.	S.E.±	C.D.		S.E.±	C.D.	S.E.±	C.D.	S.E.±	C.D.	
S	0.2	0.4	0.1	0.3	0.1	0.2		0.04	0.08	0.02	0.04	0.003	0.007	
T	0.4	0.8	0.3	0.6	0.2	0.5		0.09	0.18	0.03	0.07	0.01	0.02	
S × T	0.6	0.1	0.4	0.9	0.3	0.7		0.12	0.25	0.05	0.10	0.01	0.02	
C.D. (P=0.05)														

neem oil coated urea (T_4) registered higher urea-N, which was at par with T_5 and T_6, whereas, prilled urea (T_9) recorded the lowest urea-N content at all stages of incubation.

With progress of incubation period, the amount of urea – N in prilled urea treated soils decreases slowly, but coated urea products maintained a considerable amount of nitrogen in the form of urea for a longer period in both the soils as observed in the case of NCU, lac coated urea (LCU) and crotonylidene diurea (CDU) (Rajendra Prasad and Singh, 2000). With the rapid hydrolysis of urea to ammonium carbonate by urease, soil pH is raised in the site of reaction which restricts the subsequent hydrolysis of NCU, LCU and CDU. This explains the slow and prolonged release of urea – N in coated fertilizer.

application of prilled urea, whereas the release was prolonged in neem coated urea product applied treatments. This brings out the fact that these nitrification inhibitors are responsible for slower release of NH_4 ions from urea. With respect to soils, the highest NH_4-N release was found in S_1 (Noyyal soil series) and the least in Madukkur soil series (S_2). Owing to the heavy texture and high NH_2-N content this was reflected in the hydrolysed NH_4-N from urea in Noyyal soil series as compared to light textured Madukkur soil series as reported by Saravanan (1996).

Neem coated urea products maintained significantly the highest level right from second day onwards than prilled urea. This brings out the facts that nitrification inhibitory properties of neem oil are responsible for the higher soil NH_4-N. This was in accordance with the findings of Israel Vimala (1991) and Blaise and Rajendra

Table 3 : Ammoniacal - N content in soil at different days after incubation as influenced by neem coated urea products (ppm)

Treatment	Noyyal soil series (S_1)							Madukkur soil series (S_2)						
	Days after incubation (DAI)							Days after incubation (DAI)						
	1	2	3	4	5	10	Mean	1	2	3	4	5	10	Mean
T_1 - C	35.8	35.8	35.8	35.0	34.5	34.2	35.2	30.5	30.5	30.5	30.1	30.0	29.7	30.2
T_2 - P_1	42.4	53.3	66.1	87.2	89.0	77.1	69.2	38.4	42.3	48.4	71.1	75.3	70.3	57.6
T_3 - P_2	42.3	53.5	66.3	87.4	89.1	77.2	69.3	38.3	42.5	48.5	71.3	75.5	70.4	57.8
T_4 - P_3	38.4	54.3	67.1	88.1	90.1	78.4	69.4	34.1	43.1	49.1	72.1	77.1	72.8	58.1
T_5 - P_4	40.1	54.0	67.4	88.1	91.2	70.8	68.6	36.2	43.2	48.9	72.0	76.9	73.2	58.4
T_6 - P_5	42.2	54.1	67.2	88.0	91.1	79.0	70.3	38.2	43.0	49.1	72.3	77.0	72.9	58.8
T_7 - P_6	43.0	53.6	66.4	87.5	89.1	77.3	69.5	38.9	42.4	48.6	71.3	75.6	70.6	57.9
T_8 - P_7	43.1	51.2	64.3	85.4	85.8	74.5	67.4	39.1	40.7	46.1	69.1	73.2	67.9	56.0
T_9 - P_8	43.1	49.3	61.0	82.6	77.6	71.9	64.3	39.7	38.1	42.7	68.7	66.8	64.1	53.4
Mean	41.2	51.0	62.4	81.0	81.9	71.2		37.0	40.6	45.8	66.2	69.9	65.8	

	1 DAI		2 DAI		3 DAI		4 DAI		5 DAI		10 DAI	
	S.E.±	C.D.	S.E.±	C.D.	S.E.±	C.D.	S.E.±	C.D.	S.E.±	C.D.	S.E.±	C.D.
S	0.5	1.0	0.3	0.5	0.3	0.6	0.4	0.8	0.4	0.8	0.4	0.8
T	1.0	2.1	0.5	1.1	0.7	1.3	0.9	1.8	0.9	1.8	0.8	1.6
S × T	1.5	NS	0.8	1.5	0.9	1.9	1.2	2.5	1.3	2.5	1.1	2.3

C.D. (P=0.05)

Ammoniacal N content (NH_4-N) :

Significant difference was found among N sources, soil series and their interaction in NH_4-N release. Release of NH_4-N, although differ quantitatively between N sources, followed identical trend of progressive increase, attained peak at 5 DAI, thereafter decreased progressively. The highest release of NH_4-N was found at 5 DAI and the lowest was observed at 1 DAI. This might be due to the gradual release of NH_4-N, at the initial days of incubation which was subjected to nitrification, NH_3 volatilization and NH_4 fixation in the lattice of clay minerals (Table 3).

Soil NH_4 - N content was the highest on 4th after

Prasad (1996).

Nitrate N content (NO_3-N):

Nitrogen application enhanced the NO_3-N content in the soil significantly between the sources and soils. Among the soil, Noyyal soil series (S_1) recorded highest value of NO_3-N followed by Madukkur soil series (S_2) at all stages of incubation. With respect to different sources of N, prilled urea (T_9) registered the highest NO_3 - N which was at par with T_8 and the lowest NO_3 - N was recorded under T_5 (0.1 per cent neem gold coated urea) followed by T_4 (0.3 per cent neem oil coated urea) at all stages of incubation (Table 4).

Table 4 : Nitrate - N content in soil at different days after incubation as influenced by neem coated urea products (ppm)

Treatment	Noyyal soil series (S_1)							Madukkur soil series (S_2)						
	Days after incubation (DAI)							Days after incubation (DAI)						
	1	2	3	4	5	10	Mean	1	2	3	4	5	10	Mean
T_1 - C	8.1	8.1	8.1	8.0	8.0	8.0	8.1	7.6	7.6	7.5	7.5	7.5	7.5	7.5
T_2 - P_1	14.0	15.1	17.9	19.0	14.9	13.9	15.8	13.0	13.9	17.0	18.1	15.0	12.7	15.0
T_3 - P_2	13.4	14.1	17.4	18.9	14.1	13.8	15.3	12.7	13.7	16.1	17.1	14.2	11.4	14.2
T_4 - P_3	9.8	10.8	11.2	13.8	9.8	8.7	10.7	8.7	12.8	15.4	16.4	13.7	11.2	13.0
T_5 - P_4	11.2	12.3	14.5	16.3	12.1	10.9	12.9	10.4	8.8	10.4	10.8	8.2	7.1	9.3
T_6 - P_5	13.2	13.9	17.1	18.0	14.0	13.5	15.0	12.5	10.9	13.6	13.8	10.8	9.7	11.9
T_7 - P_6	13.3	14.0	17.3	18.9	14.1	13.6	15.2	12.6	12.9	16.0	17.0	14.0	11.3	14.0
T_8 - P_7	14.0	15.1	18.0	19.0	14.9	14.1	15.9	13.0	14.0	17.1	18.2	15.0	12.8	15.0
T_9 - P_8	14.1	15.2	19.9	18.1	15.0	14.2	16.1	13.2	14.1	18.4	17.3	15.1	12.9	15.2
Mean	12.3	13.2	15.5	16.9	13.0	12.3		11.5	12.1	14.5	15.3	12.6	10.7	

	1 DAI		2 DAI		3 DAI		4 DAI		5 DAI		10 DAI	
	S.E.±	C.D.	S.E.±	C.D.	S.E.±	C.D.	S.E.±	C.D.	S.E.±	C.D.	S.E.±	C.D.
S	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.1
T	0.1	0.3	0.2	0.3	0.2	0.4	0.2	0.4	0.2	0.3	0.1	0.3
S × T	0.2	NS	0.2	0.4	0.3	0.5	0.3	0.6	0.2	0.4	0.2	0.4

C.D. (P=0.05)

Maximum amount of NO_3 - N was recorded on 3rd DAI in prilled urea. This indicated the rapid hydrolysis of prilled urea. In NCU products, the highest amount was registered on 4th DAI. The inhibition of nitrification by NCU products might be attributed to the presence of the active principles like nimbin, nimbinin and nimbidin in them (Vyas *et al*., 1991).

Neem cake is known to inhibit nitrification for comparatively short periods. The meliacins (epinimbin, nimbin, desacetyl nimbin, salannin, desacetyl salannin and azadirachtin) present in neem cake are responsible for the inhibition of nitrification, meliacin at 10 ppm was 25 to 66 per cent as efficient as nitrapyrin at 5 ppm in retarding nitrification in soil (Devkumar, 1986).

Among the neem coated urea products coating of neem oil prolonged the release of nutrients compared to neem cake. When the neem oil level increased from 1.5 to 12 per cent, the nitrification rate was decreased. This is mainly due to the presence of total biter fractions, tetraterpenes and triterpenes which was most responsible for inhibition followed by sulphur containing odourescent compounds (Devaraju *et al.*, 1999). Among the neem coated urea products neem gold at lower concentration itself is effective in retarding the nitrification rate compared to neem oil because neem gold contains about 95 per cent of neem oil and 1 to 2 per cent of *Azadirachtin*, this is mainly responsible for nitrification inhibition.

Conclusion :

Three NCU products *viz.*, 0.3 per cent neem oil coated urea (P_3), 0.1 per cent neem gold coated urea (P_4) and 0.2 per cent neem gold coated urea (P_5) were equally effective in prolonging urea release up to 10 days compared to indigenously prepared neem cake coated urea (P_7) and prilled urea (P_8). Ammoniacal - N release from all the coated urea products peaked at 5 DAI (Days after incubation) compared to prilled urea which attained peak at 4 DAI and then sharply decreased. The lowest nitrate - N (NO_3 - N) content was recorded under neem coated urea products compared to indigenously prepared neem cake coated urea and prilled urea. Thus use of neem coated urea products prolonged the nitrogen availability for the crop growth thereby minimizing the risk for losses of nitrogen.

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