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EFFECT OF NITRIFICATION INHIBITORS AND SLOW RELEASE NITROGENOUS FERTILIZER ON NITROGEN USE EFFICIENCY AND YIELD OF PADDY

SARITA SINGH AND BIMLESH KUMAR
Department of Chemistry, Pandit Prithivi Nath College, Kanpur-208 001(U.P.)
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ABSTRACT

In green house and laboratory studies various sources of nitrogenous fertilizers were evaluated at varying N levels. Maximum fertilizer use efficiency was obtained with urea incorporation N-serve followed by D.C.D., neemcake coated urea, mahuacake coated urea, Oxamide and uncoated prilled urea. The maximum amount of ammoniacal nitrogen in soil was found under N-Serve treatment at different intervals. Performance of N-Serve treated urea was best with respect to grain and straw yield of paddy as well as test weight of paddy grains. Fertilizer use efficiency declined with increasing doses of nitrogen application but grain yield increased linearly.

Keywords: Nitrification inhibitors, slow release nitrogenous fertilizer, nitrogen use efficiency, yield, paddy

INTRODUCTION

Nitrogen is extremely dynamic in soil always changing or moving. Hardly, 30-40 % of the applied N is actually utilized by the crops.There is imperative need to minimize this loss to increase the efficiency of fertilizer inputs to a considerable extent. Nitrification inhibitors and slow release nitrogenous fertilizers may play a dual role by safe guarding environment and increasing fertilizer use efficiency. These materials check the nitrification process and are very slowly soluble in water. Rice is a staple food of large population of India. Its production is very low due to largely spread deficiency of soil nitrogen and poor utilization efficiency of applied fertilizer nitrogen by way of leaching losses of urea and nitrate nitrogen, volatilization losses of NH_3 from standing water and denitrification losses under reduced conditions (Chalam et al. 1989). Denitrification causes major loss under waterlogged transplanted paddy cultivation (Ponnamperuma, 1972). In the present investigation an attempt has, therefore, been made to see the effect of indigenous and synthetic sources of nitrification inhibitors and slow release nitrogenous fertilizers on constantly sustained availability of ammoniacal nitrogen in soil for longer period to obtain higher yield of paddy.

MATERIALS AND METHODS

A pot experiment was conducted during kharif season of 2003 and 2004 on paddy crop (Sarju 52) at Kanpur.The treatments consisted of five levels of nitrogen (0, 30, 60, 90 and 120 mg kg^{-1}) and six sources of nitrogenous fertilizers containing synthetic and indigenous sources of nitrification inhibitors, slow releasing fertilizer and normal uncoated -urea viz, T_1 - urea uncoated, T_2 - urea coated neemcake and T_3 - mahua cake, T_4 - oxamide, T_5 - N-Serve (2 chloro- 6 trichloro methyl pyridine) and T_6 - D.C.D (Dicyandiamide). The experiment was laidout in completely randomized design with three replications. Texture of soil was loam having pH 7.5, EC 0.22 dSm^{-1}, C.E.C. 9.8 c mol kg^{-1} and organic carbon 4.6 g kg^{-1}. Available N, P, K contents were 85.9, 6.9 and 144.0 mg kg^{-1}, respectively. Incubation study was also carried out to find the impact of nitrification inhibitors and slow release nitrogenous fertilizers on sustained availability of NH_4-N in soil under waterlogged condition at various time intervals. Fertilizer use efficiency i.e. response ratio (kg grain/ kg applied N) was calculated by the formula: Grain yield in g/pot with treatment - grain yield in control pot /applied N in g/pot .Soil analysis was carried out by the methods prescribed by Jackson (1973).

RESULTS AND DISCUSSION

Fertilizer use efficiency refers to the proportion of applied nutrients recovered by the crop. A recent review of worldwide data on nitrogen use efficiency for urea crops reported that single year fertilizer N recovery efficiencies

averaged 65% for corn, 57% for wheat and 46% for rice (Ladha et al. 2005). It is apparent from the data (Table 1) that the test weight showed remarkable and significant increase with increasing doses of nitrogen, being lowest at control and highest at 120 mg N $kg^{-1.}$ On an average, test weights recorded at 120 mg N kg^{-1} soil were 24.1 and 25.4% higher than the lowest test weight in control. Nitrogen inhibitors also have significant effect and N-Serve exhibited higher ability of nitrification inhibition property as compared to others and made an impact on test weight.

Table 1: Effect of nitrogen levels and nitrification inhibitors on test weight (g) of rice crop

N levels (mg kg^{-1})	Nitrification Inhibitors						Avg.
	T_1	T_2	T_3	T_4	T_5	T_6	
2003							
0	20.51	-	-	-	-	-	-
30	22.18	24.12	23.23	22.15	25.10	24.31	23.51
60	23.13	24.34	24.12	23.52	26.03	25.15	24.38
90	24.04	25.26	25.13	25.10	26.10	25.30	25.16
120	25.10	26.31	26.02	25.32	26.22	26.13	25.46
Average	23.61	25.00	24.62	24.03	25.86	25.22	24.63
CD(0.05)	N 0.52	-	T 0.64	-	NxT NS	-	-
2004							
0	20.63	-	-	-	-	-	-
30	22.27	24.42	24.20	23.59	26.10	25.22	24.48
60	23.40	24.42	24.20	23.59	26.10	25.22	24.48
90	24.12	25.35	25.21	25.18	26.18	25.36	25.23
120	25.23	26.10	26.03	25.42	26.29	26.18	25.88
Average	23.75	25.13	24.69	24.13	25.94	25.29	25.02
CD(0.05)	**N** 0.58	-	T 0.70	-	N x T	NS	-

The grain and straw yields increased in linear fashion with increase in nitrogen doses. Highest grain and straw yields were obtained with 120 mg N kg^{-1} and lowest with control during both the years. On an average, 69.4 and 70.8% higher grain yield was obtained with 120 mg N kg^{-1} dose over control. The corresponding increases in straw yield were 86.3 and 82.8 percent. Nitrogen sources treated with nitrification inhibitors significantly increased grain and straw yield over uncoated urea. On the basis of average yield, different sources of nitrogen may be arranged in the desending order; T_5 (N Serve treated urea), > T_6 (D.C.D), >T_2 (neemcake coated urea, >T_3 urea coated with mahuacake,> T_4 oxamide)> T_1 (Uncoated urea).Thus, N Serve exhibited higher nitrification inhibition capability as compared to others. Highest grain yields were recorded at N_4 T_5 which was 82.6 and 80.7 % higher than the lowest grain yield obtained at No x T_1 during 2003 and 2004, respectively. Likewise, straw yields were 94.5 and 90.2% higher with N_4 x T_5 treatment as compared to lowest straw yield obtained with No x T_1 treatment respectively. The highest grain and straw yield obtained with N_4 x T_5 combination corresponded to highest test weight also at this combination.The performance of various nitrification inhibitor sources may be arranged in sequence of N-Serve > D.C.D> neemcake coated urea>Mahuacake coated urea. The application of lower doses of nitrogen with N Serve exhibited highest nitrogen use efficiency.

Table 2: Effect of nitrogen doses and nitrogen inhibitors on grain yield of paddy (g/pot)

N levels (mg kg^{-1})	Nitrification Inhibitors						Avg.
	T_1	T_2	T_3	T_4	T_5	T_6	
2003							
0	45.50	-	-	-	-	-	-
30	54.30	58.80	57.00	56.10	59.90	58.50	57.43
60	60.50	66.20	65.40	63.80	68.30	66.80	65.16
90	67.20	74.10	70.50	69.20	76.60	75.20	72.13
120	70.90	81.30	76.00	75.20	83.10	82.00	77.08
Average	63.22	70.10	67.22	66.07	71.97	70.62	67.95
CD(0.05)	**N 0.94**	-	**T 0.64**		**NxT 2.30**	-	-
2004							
0	47.20	-	-	-	-	-	-
30	56.80	60.00	59.70	58.00	61.80	61.00	59.53
60	63.80	69.50	68.00	65.90	70.70	69.80	67.95
90	70.30	77.20	73.20	72.10	79.50	78.10	75.06
120	74.80	83.20	78.50	78.00	85.30	84.62	80.66
Average	66.42	72.47	69.85	68.50	74.32	73.27	70.81
CD(0.05)	**N 0.70**	-	**T 0.86**	-	**NxT 1.72**	-	-

Higher test weight of paddy grain, straw and grain yield of paddy and fertilizer nitrogen use efficiency depends upon steady and sustained availability of ammoniacal nitrogen in soil for longer period. Accumulation of nitrite nitrogen in soil more than 10 ppm is toxic to plants. Nitrate nitrogen is leached and further subjected to denitrification losses. Nitrification inhibitors like N-Serve, D.C.D. and neemcake containing an alkaloid nimadin in neem kernel oil has detrimental effect on Nitrosomonas bacteria which are responsible for converting NH_4-N after urea hydrolysis in to nitrite nitrogen which is further liable to change into nitrate nitrogen and denitrified into elemental nitrogen under water logged condition. These help in maintaining higher level of ammoniacal nitrogen in soil for plants in available form.

Table 3: Effect of nitrogen doses and nitrification inhibitors on straw yield of rice (g/pot)

N levels (mg kg^{-1})	Nitrification Inhibitors						Average
	T_1	T_2	T_3	T_4	T_5	T_6	
2003							
0	53.50	-	-	-	-	-	-
30	62.40	68.00	65.30	64.60	70.10	69.50	66.65
60	73.10	81.30	79.10	77.50	83.60	81.40	79.33
90	83.20	94.00	92.40	91.30	97.00	95.80	92.28
120	90.90	101.20	100.40	99.00	104.10	102.60	99.70
Average	77.40	86.12	84.30	83.10	88.70	87.32	84.49
CD(0.05)	N 1.04	-	T 1.28	-	NxT NS	-	-
2004							
0	55.10	-	-	-	-	-	-
30	63.90	70.40	67.60	66.00	72.00	71.10	68.50
60	75.60	83.10	81.00	79.20	85.70	84.20	81.41
90	85.40	96.50	94.10	94.00	99.30	97.40	94.45
120	92.20	103.10	101.80	100.10	104.80	102.60	100.76
Average	79.20	88.28	86.12	84.82	90.45	88.82	86.28
CD(0.05)	N 0.90	-	T 1.12	-	NxT 2.23	-	-

Nitrogen availability in soil as indicated by presence of ammoniacal nitrogen at different periods was lowest at lower rate of nitrogen application and it increased with increasing dose of nitrogen. On an average, application of N-Serve as coating material maintained higher amount of NH_4-N in comparison to other nitrification inhibitors at different levels of N. Performance of various treatments in maintaining steady and sustained supply of ammoniacal nitrogen in soil was in the sequence of : N-Serve>D.C.D.>Neemcake coated urea> Mahuacake coated urea> oxamide and uncoated urea.

Table 4: Effect of nitrogen levels and nitrification inhibitors on nitrogen use efficiency of rice crop

N levels (mg kg^{-1})	Nitrification Inhibitors						Avg.
	T_1	T_2	T_3	T_4	T_5	T_6	
2003							
0	-	-	-	-	-	-	-
30	29.33	44.33	38.33	35.32	48.00	43.34	39.77
60	25.00	34.50	33.16	30.50	38.00	35.50	32.77
90	23.88	31.77	27.77	26.33	34.55	33.33	29.60
120	21.16	29.83	25.41	24.75	31.33	30.41	27.14
Average	24.84	35.10	31.16	29.21	37.97	35.63	32.32
CD(0.05)	**N 0.54**	**-**	**T 0.66**	**-**	**NxT 1.32**	-	-
2004							
0	-	-	-	-	-	-	-
30	32.00	42.66	41.66	36.00	48.66	46.00	41.16
60	27.66	37.16	34.66	31.16	39.16	37.66	34.57
90	25.67	33.33	28.89	27.66	35.89	34.33	30.96
120	23.00	30.00	26.08	25.66	31.75	30.83	27.88
Average	27.08	35.78	32.82	30.22	38.86	37.20	33.64
CD(0.05)	**N 0.58**	**-**	**T 0.70**	**-**	**NxT 2.40**	-	-

Nitrogen use efficiency was influenced significantly by nitrogen `levels, nitrification inhibitors and their interaction during both the years.

Table 5: Effect of urea blended with synthetic and indigenous nitrification inhibitors on nitrogen release pattern (NH^+_4-N) in soil at varying levels of N and incubation period

N Levels (mg kg^{-1})	Incubation period (Days)					Mean
	15	30	45	60	90	
At 30 mg N kg^{-1}						
NH_4^+-N (ppm)						
1. Control	3.0	2.0	1.0	0.50	0.2	1.34
2. Urea uncoated	9.0	7.0	3.0	1.0	0.5	4.10
3. Urea coated with Neem cake	14.0	11.0	7.0	4.0	3.0	7.8
4.Urea coated with Mahua cake	13.0	10.0	6.0	3.0	2.0	6.8
5. Oxamide	11.0	9.0	5.0	2.0	1.00	5.6
6. N-Serve	18.0	14.0	9.0	6.0	4.0	10.2
7. DCD	15.0	12.0	8.0	5.0	3.0	8.6
Mean	13.32	10.5	6.3	3.5	2.2	
At 60 mg N kg^{-1}						
1. Control	-	-	-	-	-	-
2. Urea uncoated	23.0	17.0	12.0	6.0	1.0	11.8
3. Urea coated with Neem cake	28.0	25.0	17.0	11.0	5.0	17.2
4.Urea coated with Mahua cake	26.0	23.0	15.0	9.0	3.0	15.2
5. Oxamide	24.0	20.0	19.0	8.0	3.0	13.8
6. N-Serve	34.0	28.0	15.0	13.0	7.0	20.2
7. DCD	31.0	26.0	18.0	12.0	6.0	18.6
Mean	27.60	23.1	15.8	9.8	4.1	-
At 90 mg N kg^{-1}						
1. Control	-	-	-	-	-	-
2. Urea uncoated	30.0	31.0	20.0	10.0	2.0	18.6
3. Urea coated with Neem cake	43.0	40.0	25.0	17.0	7.0	26.4
4.Urea coated with Mahua cake	38.0	37.0	23.0	16.0	5.0	23.8
5. Oxamide	34.0	35.0	22.0	14.0	4.0	21.8
6. N-Serve	50.0	46.0	28.0	20.0	9.0	30.6
7. DCD	46.0	43.0	26.0	19.0	8.0	28.4
Mean	40.1	38.6	24.0	16.0	5.8	-
At 120 mg N kg^{-1}						
1. Control	-	-	-	-	-	-
2. Urea uncoated	45.0	44.0	28.0	14.0	7.0	27.6
3. Urea coated with Neem cake	58.0	53.0	34.0	21.0	12.0	35.6
4.Urea coated with Mahua cake	52.0	51.0	32.0	19.0	10.0	32.8
5. Oxamide	49.0	48.0	31.0	17.0	9.0	30.8
6. N-Serve	66.0	56.0	37.0	24.0	14.0	39.4
7. DCD	62.0	54.0	36.0	22.0	13.0	37.4
Mean	55.31	51.0	33.0	19.5	10.8	-

Highest nitrogen use efficiency was observed at lower level of nitrogen and it declined with increasing doses. Among nitrification inhibitors, N- Serve showed highest nitrogen use efficiency. Paddy is a water loving crop and is mostly grown under submerged condition. Under this situation, two layers of different redox potential are formed. Few millimeters of surface layer is oxidized zone and lower one is reduced zone (Ponnamperuma, 1972). When urea or any ammonium containing nitrogen fertilizers are applied in water logged field, NH_4-N is easily oxidized to NO_2 - N and NO_3-N. In the upper oxidized zone NO_3 ions are not adsorbed on clay surface and are subjected to leach down in the reduced zone. In this reduced zone, oxygen of NO_3 -N is utilized by sulphur oxidising bacteria and is denitrifed to elemental nitrogen which escapes to the atmosphere. Denitrification loss is a major loss of nitrogen from water logged paddy fields. Higher nitrogen use efficiency by paddy and its effect on higher grain yield with the application of nitrification inhibitors have been noticed by Prasad (1979) and Singh (1989).

It is quite obvious that $NH4^+$-N contents released increased remarkably with increase in nitrogen doses at different incubation periods, being lowest at 30 mg N kg and highest at 120 mg N kg (Table 5). The different urea coating materials had much obvious effect on $NH4^+$-N release pattern at different nitrogen levels incubation periods and different nitrogen levels. On the basis of the average data on NH4 -N contents, the different urea coating materials could be arranged as N-Serve >DCD> urea coated neemcake >urea coated with mahua cake >oxamide > urea uncoated.

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