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EFFECT OF NITROGEN MANAGEMENT PRACTICES ON AMMONIA VOLATILIZATION LOSSES IN TRANSPLANTED RICE

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Abstract: Field experiments were conducted in kharif and rabi seasonsto study the volatilization losses under different nitrogen management practices in transplanted rice. The treatments receiving application of urea 111 three splits and the combined application of urea and green leaves in 1:1 proportion on N basis recorded the lowest N loss through volatilization in both seasons. Seventy five per cent of ammonia volatilization was recorded within 6 days after fertilization. The loss was more during rabi season and the losses significantly increased with increase in pH, HCO_3^- and NH_4-N content of flood water.

Key words : Ammonia volatilization, N management, transplanted rice.

INTRODUCTION

The majority of rice grown are under flooded lowland conditions and urea is the most popular N source for rice farming. It is well known that the efficiency of N under such condition is very low ranging from 30 to 50% (Prasad and Subbiah, 1982). Among the N loss mechanisms operating in the rice field, volatilization as ammonia is considered to be an important pathway. This loss has been reported to increase with an increase in pH, ammoniacal N and bicarbonate level of flood water (Mahapatra *et al.* 1991). To increase the efficiency of urea and reduce losses under lowland condition, slow release N carriers, nitrification inhibitors and split application of urea have been found useful. Therefore, the present investigation was carried out to study N loss through ammonia volatilization under different N management practices and to establish relationship between flood water parameters and ammonia loss in transplanted rice in an acid laterite soil.

MATERIALS AND METHODS

The field experiments were conducted during kharif and rabi season at the Regional Agricultural Research Station, Pattambi, Kerala on sandy loam acid laterite (Fluventic Dysteropepts) soil having pH 5.4 - 5.6, organic C 1.38 - 1.58%, total N 0.12 - 0.15%. There were eight treatments viz., no nitrogen (control), prilled urea applied in three splits i.e., 50% as basal, 25% each at 20 and 40 days after transplanting (PU split), prilled urea all applied as basal (PU basal), deep placement of urea supergranules at 10 cm depth (USG), neem coated urea (NCU), combined application of daincha (*Sesbania aculeata*) and prilled urea in 1:1 proportion of N basis (D+PU), gypsum coated urea (GCU) and rock phosphate coated urea (RPCU). GCU and RPCU could not be included in kharif season due to non-availability of these materials in time. In all the treatments involving N application, the N fertilizers were added to supply 90 kg N ha^{-1}. A uniform dose of each of 45 kg P_2O_5 and K_2O per ha was applied as basal dressing. The experiment was laid out in randomised block design with Jaya as the test variety.

The volatilization traps consisting of cylindrical frame of 12.5 cm diameter and 35 cm height, covered with polythene bag were installed between rows of rice plants immediately after N application. Petridish of 12 cm diameter with 50 ml of 0.1 normal H_2SO_4 was suspended in the trap at 10 cm above the flood water, and replaced at three days interval by fresh acid. The ammonia absorbed was distilled with MgO suspension in a semi-micro kjeldahl distillation apparatus (Jackson, 1958). The volatilization loss was calculated on area basis for 15 days after basal application and after every top dressing.

The pH of flood water above the soil surface was taken *in situ* at 8 a.m. and 2 p.m. daily from the next day of transplanting up to 15 days. Samples of flood water were also collected at the same interval and analysed for HCO_3^- and NH_4-N content (Jackson, 1958).

RESULTS AND DISCUSSION

pH of flood water

The pH values of flood water at 3 day intervals only are presented (Table 1). The pH of flood water increased over control in both seasons under different N management practices. In the kharif season, the mean values for over all treatments at 8 a.m. increased from 5.41 on the 3rd day following N application to 5.84 on the 9th day, then decreased. The diurnal pH variation was maximum on the 3rd day (1.38 unit) then decreased to the minimum variation on 12th day (0.22 unit) and again increased. In the rabi season, the pH values were higher than that of kharif season, where the pH mean for over all treatments at 8 a.m. recorded maximum on 9th day (7.18), then decreased. Eventhough the diurnal variation in pH was maximum on 6th day (0.97 unit), the difference from the 9th day was only 0.07 units, thereafter remained more or less unchanged on 12th and 15th day after transplanting. Mahapatra *et al.* (1991) reported that the flood water pH of wet acid soil increased initially with submergence and urea application, then decreased slightly. Mikkelsen *et al.* (1978) also indicated that pH of flood water increased by 1.5 unit which followed a rhythmic pattern of diurnal pH variation after 24 h of fertilizer application, increasing by mid-day and decreasing at night.

Bicarbonate content of flood water

In both the seasons addition of fertilizer N increased HCO_3^- content of flood water over control (Table 2). This can be attributed to the increased biotic activity in flood water following fertilizer application. In the case of PU split, there was less availability of N in flood water due to application of only half of N dose at transplanting which did not support much of biotic growth, recorded lowest HCO_3^- content in flood water in both the seasons. But PU basal and RPCU recorded higher concentration of HCO_3^- in flood water during kharif and rabi season respectively. Similar results were also obtained by Mahapatra *et al.* (1991). The HCO_3^- content was comparatively higher during rabi season.

Ammoniacal nitrogen content

Flood water NH_4-N content was maximum during initial periods, following fertilizer application and thereafter decreased progressively (Table 2). This might be due to gaseous and aqueous losses, immobilisation by a algal mass and exchange reactions in the clay complex of the soil. In both the seasons, addition of fertilizer increased NH_4-N concentration over control in all the periods observed up to 15 days after transplanting. The NH_4-N concentration recorded during rabi season was more than double of that of kharif season. PU basal application recorded significantly higher NH_4-N concentration during kharif season, while this treatment was on par with USG, NCU, GCU and RPCU during rabi season. The NH_4-N content was lowest with PU split and D+PU treatments due to the application of only half of N dose (45 kg N ha^{-1}).

Ammonia volatilization

Ammonia volatilization losses from different N treated plots were measured till the values were comparable with the control and the data are presented in Table 3. The volatilization loss of applied N was more in the rabi season than kharif season.

This might be due to the higher pH, HCO_3^- and NH_4^+ concentration in flood water in rabi season, which had a positive correlation with ammonia volatilization (Mahapatra *et al.*, 1991). In both the seasons, the volatilization rate increased and reached the maximum on 6th day, after which decreased steadily and levelled with control. On an average, 75% of N loss through volatilization was recorded within 6 days after transplanting.

Table 1. Changes of flood water pH under different N management practices in kharif and rabi seasons

Treatment	Days after transplanting									
	3		6		9		12		15	
	8 a.m.	2p.m.	8 a.m.	2p.m	8 a.m.	2 p.m	8 a.m.	2p.m.	8a.m.	2 p.m..
Kharif										
Control	3.96	5.38	4.92	5.00	5.03	5.03	4.84	4.70	5.32	5.24
PU split	5.40	6.75	5.73	6.12	5.79	5.90	5.33	5.57	5.49	6.01
PU basal	5.93	7.10	5.91	7.37	6.02	6.67	5.72	5.64	5.59	6.54
USG	5.55	7.01	5.93	6.96	5.91	6.24	5.62	5.70	5.80	6.05
NCU	5.88	7.55	5.72	7.39	6.09	6.37	5.52	6.14	5.56	5.69
D+PU	5.72	6.95	5.87	7.21	6.17	6.96	5.38	5.94	5.71	6.33
Mean	5.41	6.79	5.68	6.68	5.84	6.20	5.40	5.62	5.58	5.98
CD(0.05)	0.43	0.82	0.61	0.44	0.27	0.54	NS	0.55	0.30	0.61
Rabi										
Control	6.46	7.00	6.59	7.22	6.91	6.58	6.20	6.64	6.26	6.54
PU split	6.91	7.94	6.95	8.05	7.09	6.93	6.52	6.96	6.48	6.91
PU basal	7.22	8.15	7.20	8.14	7.22	7.22	6.65	7.38	6.66	7.51
USG	7.15	8.15	7.08	8.02	7.24	7.23	6.68	7.50	6.65	7.43
NCU	7.17	8.06	7.10	8.03	7.22	7.30	6.68	7.55	6.67	7.43
D+PU	7.01	7.92	7.00	8.02	7.16	7.06	6.58	7.13	6.55	7.30
GCU	7.25	8.14	7.01	8.06	7.25	7.17	6.68	7.42	6.64	7.59
RPCU	7.25	8.20	7.18	8.31	7.35	7.41	6.65	7.40	6.67	7.50
Mean	7.05	7.95	7.01	7.98	7.18	7.11	6.58	7.25	6.57	7.27
CD(0.05)	0.16	0.36	0.16	0.35	0.11	0.27	0.10	0.27	0.12	0.50

NS = Not significant

During kharif season the highest amount of volatilization loss was recorded with NCU (5.03 kg N ha^{-1}). These results corroborate with the observations of Mahapatra *et al*. (1991). They reported a 6.8 kg N ha^{-1}. D + PU recorded less volatilization than other treatments. On the other hand, in the rabi season, RPCU recorded highest loss (10.20 kg N ha^{-1}), followed by GCU and PU basal. PU split and D+PU recorded lowest rate of loss during rabi season.

Table 2. Changes of flood water bicarbonate and ammoniacal-nitrogen content under different N management practices in kharif and rabi seasons

	NH_4-N ppm					Bicarbonate, me/1				
	Days after transplanting					Days after transplanting				
	3	6	9	12	15	3	6	9	12	15
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Control	0.07	0.11	0.17	0.23	0.26	0.11	0.09	0.10	0.08	0.11
PU split	11.71	5.58	2.77	2.12	1.06	0.26	0.21	0.21	0.16	0.16
PU basal	20.51	7.31	5.51	3.84	3.56	0.86	0.33	0.25	0.21	0.28
USG	14.23	7.31	5.00	5.65	2.91	0.49	0.28	0.28	0.23	0.23
NCU	14.23	6.30	5.36	4.20	1.28	0.81	0.29	0.31	0.21	0.21
D+PU	14.94	6.01	3.76	2.47	1.25	0.94	0.61	0.44	0.30	0.28
Mean	12.62	5.44	3.76	3.09	1.72	0.58	0.30	0.27	0.20	0.21
CD(0.05)	4.61	2.23	1.02	2.05	1.70	0.25	0.10	0.08	0.10	0.07
Rabi										
Control	1.92	1.92	2.11	1.15	1.73	0.18	0.13	0.23	0.28	0.28
PU split	21.53	13.46	8.07	7.88	4.42	0.73	0.70	0.67	0.50	0.70
PU basal	39.60	23.65	14.23	12.30	8.27	1.77	1.27	0.10	1.07	0.90
USG	32.88	20.96	15.57	13.84	9.23	1.30	0.97	0.97	0.90	0.93
NCU	39.99	23.27	14.99	12.49	8.27	1.83	1.27	1.07	0.93	0.90
D+PU	23.65	12.88	7.69	7.69	4.81	1.13	1.03	0.97	0.87	0.80
GCU	42.68	25.19	15.19	12.30	8.08	1.57	1.00	0.97	0.97	0.93
RPCU	37.11	21.53	13.84	13.26	7.69	1.77	1.23	1.10	1.07	0.93
Mean	29.92	17.86	11.46	10.11	6.56	1.29	0.95	0.76	0.82	0.80
CD(0.05)	6.45	3.74	2.51	1.26	1.48	0.35	0.22	0.22	0.14	0.17

In PU split treatment, 25% of urea top-dressed at 20 and 40 days after transplanting recorded only negligible ammonia loss owing to the increased plant canopy (0.665 and 0.920 kg N ha^{-1} during kharif and rabi season respectively). Rao (1987) found that application of urea in splits reduced loss, due to the reduced

NH_4-N content in flood water. In addition to PU split, the D+PU treatment also showed less amount of volatilization loss, owing to immobilization of N by soil micro-organisms responsible for decomposition of green matter providing lower concentration of NH4-N in flood water during the initial period (Bhagat *et al.*, 1988).

The results of simple correlation (Table 4) show that ammonia volatilization significantly increased with increase in pH at 2 p.m., HCO_3^- and NH_4-N content of flood water during kharif season; and pH at 8 a.m. and 2 p.m., HCO_{3-} and NH_4-N content of flood water during rabi season. Multiple regression equation revealed that the parameters accounted for 66 and 80% variation in the loss of N due to ammonia volatilization in kharif and rabi seasons respectively. Eventhough the parameters accounted only for 66 and 80% of variation, analysis of variance of regression showed significance at 1% level. Similar results were also obtained earlier by Saravanan *et al.* (1988) and Mahapatra *et al* (1991) in Typic Chromusterts and Aerie Haplaquept respectively. However, they could explain 84 to 98% of the variation in ammonia loss taking pH , HCO_{3-} and NH_4-N of flood water into consideration.

Table 3. Ammonia volatilization losses under different N management practices in kharif and rabi seasons, kg N ha^{-1}

Treatment	Kharif							Rabi						
	Days after transplanting					CL	% loss	Days after transplanting					CL	% loss
	3	6	9	12	15			3	6	9	12	15		
Control	0.039	0.157	0.002	0.018	0.010	0.226	-	0.21	0.16	0.11	0.08	0.12	0..68	-
PUsplit	0.255	0.188	0.073	0.051	0.047	1.279	1.17	0.67	1.74	0.43	0.25	0.27	4.28	4.00
PUbasal	0.756	1.216	0.381	0.244	0.136	2.733	2.79	1.85	4.75	1.23	0.52	0.34	8.69	8.90
USG	0.281	0.526	0.229	0.112	0.079	1.227	1.11	1.42	3.88	0.72	0.83	0.51	7.3 6	7.42
NSU	2.565	1.524	0.285	0.310	0.347	5.031	5.34	2.11	4.26	1.12	0.61	0.36	8.46	8.64
D+PU	0.351	0.348	0.184	0.095	0.025	1.003	0.86	1.44	3.10	0.68	0.34	0.27	5.83	5.73
GCU	-	-	-	-	-	-	-	2.46	4.10	1.44	0.86	0.34	9.20	9.47
RPCU	-	-	-	-	-	-	-	2.64	5.29	1.39	0.66	0.28	10.26	10.64
Mean	0.708	0.660	0.192	0.138	0.107	-	-	1.60	3.41	0.89	0.52	0.31	-	-
CD (0.05)	NS	0.974	0.208	NS	NS	-	-	1.01	2.53	0.57	NS	NS	-	-

CL = Cumulative loss NS = Not significant

Table 4. Relationship of ammonia volatilization (y) with pH at 8 a.m. (x_1), pH at 2 p.m. (x_2), bicarbonate (x_3) and ammoniacal nitrogen (x_4) of flood water in kharif and rabi seasons

Regression equation	Correlation coefficient (r)
Kharif	
$y = -2.45 + 0.450x_2$	0.649"
$y = -0.03 + 1.272x_3$	0.525**
$y = 0.06 + 0.056x_4$	0.529"
$y = -2.10 + 3.79x_2 + 1.44x_3 + 0.01x_4$	$R^2 = 0.655$
Rabi	
$y = -17.37 + 2.720x_1$	0.603"
$y = -14.86 + 2.157x_2$	0.753"
$y = -0.49 + 1.934x_3$	0.547**
$y = 0.16 + 0.078x_4$	0.615"
$y = -25.31 + 1.62x_1 + 2.18x_2 - 0.70x_3 - 0.01x_4$	$R^2 = 0.795$

**Significant at 1% level

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