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Nitrogen Fertilization to Flooded Rice Through Mud Balls

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Field experiments with ^{15}N-labelled and non-labelled N showed that the dual advantage of deep placement and slow-release of fertilizer N could be achieved through the use of mud balls. In terms of yield, N uptake and recovery, the mud balls compared favourably with shellac or sulphur-coated urea. They were also found effective in reducing the loss of fertilizer N through leaching. However, the behaviour of mud balls appeared to vary depending upon the N rate, source and decomposibility of associated carbonaceous material Alternate cheap methods for mud ball application in flooded rice culture are suggested.

Various types of mud balls were tested in field experiments conducted at the Central Rice Research Institute, Cuttack during 1975. This paper deals with the yield, N uptake and recovery, residual N in soil and leaching loss.

MATERIAL AND METHODS

The field experiments were conducted in 25m² plots. Single superphosphate and muriate of potash to supply 60 kg each of P_2O_5 and K_2O/ha were applied basally in each season. Rice seedlings (Var. Supriya) were transplanted at 15×10 cm spacing and the crop was raised with 5-8 cm flood water. The mud balls were pushed down to about 8 cm depth in between rows two or three days after transplanting so as to obtain a distribution of one ball at the center of 4 hills. Shellac-coated urea (LCU) and the sulphur-coated urea (SCU) were applied a day before transplanting and incorporated into the soil.

During crop growth, a uniform number of randomly selected hills from each plot were harvested at pre-tillering, maximum tillering and flowering stages. The plant samples were dried at 70°C weighed and analysed for total N. The N uptake at these stages was computed for the entire plant population in each plot and expressed as a percentage of the combined uptake in both rough rice and straw at harvest.

The yield of rough rice was expressed at 14 per cent moisture while that of straw on oven-dry basis (70°C). N content of rough rice and straw was estimated in separate, oven-dry, sub-samples. From the combined N uptake in rough rice and straw in kg/ha, the per cent recovery of applied N was calculated by difference. In experiments utilizing ^{15}N-labelled fertilizers, the recovery was calculated directly from the isotopic dilution.

Field experiments 1975

(a) With unlabelled N ;

The mud balls were evaluated at 80 kg N/ha level both during the dry

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TABLE I Yield of rough rice and straw (t/ha) (N rate = 60 kg/ha)

Treatment	Dry season, 1975		Wet season, 1975	
	Rough rice	Straw	Rough rice	Straw
Control, No N	3.04	2.15	4.07	3.69
LCU	4.95	3.83	5.09	4.19
LCU	5.22	3.88	5.44	4.64
Mud balls				
Urea	6.52	5.63	5.78	4.84
AS	6.22	5.63	5.85	5.26
Straw + Urea	4.25	3.10	4.70	4.05
Straw + AS	6.27	5.45	5.71	5.13
Husk + Urea	5.98	5.32	5.65	4.60
Husk + AS	6.35	5.50	6.10	5.75
Kokum cake + urea	—	—	5.78	5.20
Kokum cake + AS	—	—	5.85	5.56
C.D. (0.05)	0.65	0.54	0.87	0.97

AS = Ammonium sulphate.

and wet seasons using different plots. The different methods of application and mud balls, which included placement at about 8 cm depth in between 4 hills, broadcasting on puddled soil before transplanting followed by planking and broadcasting two days after transplanting were evaluated at 60 kg N/ha level during the wet season. In another treatment included for comparison urea was applied basally and incorporated into the soil or applied in three splits (30—15—15 kg N/ha) and LCU and SCU were applied basally and incorporated. The yield was recorded and yield response to added N was calculated after subtracting the control plot yield.

(b) With ^{15}N-labelled N:

Field experiments with labelled mud balls were conducted in micro-

TABLE II. N uptake in crop (rough rice + straw) at harvest and per cent recovery of added N calculated by the difference method. (N rate = 80 Kg/ha)

Treatment	Dry season, 1975.		Wet season, 1975	
	N uptake (kg/ha)	Recovery (%)	N uptake (kg/ha)	Recovery (%)
Control. No N	47.61	—	45.52	—
LCU	80.93	41.65	79.79	42.84
SCU	91.88	55.34	88.85	54.16
Mud balls				
Urea	116.41	86.00	102.78	71.58
As	123.21	94.50	96.32	63.50
Straw + Urea	64.71	21.38	74.47	36.18
Straw + As	107.17	74.45	102.95	71.79
Husk + Urea	114.80	84.00	87.54	52.53
Husk + AS	121.02	91.76	107.11	77.00
Kokum cake + Urea	—	—	95.71	62.74
Kokum cake + AS	—	—	107.35	77.29
C. D. (0.05)	14.21	—	17.19	—

AS = Ammonium sulphate

plots of 1 m^2 at the center of 25 m^2 plots. A simple, inexpensive device consisting of a perforated hard plastic tubing (Shinde and Vamadevan, 1974) sealed at the bottom was used to draw leachate samples from 30 cm depth, which was well below the root zone. The leachate samples were drawn at weekly interval by pipetting through a long plastic tubing, filtered, if necessary, and analyzed for $NH_4 + NO_3$—N, and for isotopic ratio. The values of N concentration in ppm were pooled for the entire crop season. The cumulative loss of water through vertical percolation during the same period, obtained from the drum culture technique of Vamadevan and Dastane (1968), was 520 mm. From these values and isotopic ratio data, the loss of labelled fertilizer N was calculated and expressed as percentage of the applied N.

TABLE III Per cent uptake of N during different stages of crop growth with total uptake at harvest taken as 100. (Dry and wet seasons 1975, N rate = 80 kg/ha)

Treatment	Planting to maximum tillering		Maximum tillering to flowering		Flowering to harvest	
	D. S.	W. S.	D. S.	W. S.	D. S.	W. S.
Control, No N	33.4	28.1	19.9	28.6	46.7	43.3
LCU	47.8	40.0	11.8	27.3	40.4	32.7
SCU	20.7	43.4	35.0	18.2	44.3	38.4
Mud balls						
Urea	56.7	87.7	5.5	12.3	37.8	—
AS	62.5	83.5	—	—	37.5	16.5
Straw + Urea	26.4	40.3	24.7	13.3	48.9	46.4
Straw + AS	44.8	61.0	14.3	20.8	40.9	18.2
Husk + Urea	42.7	62.7	18.3	24.5	39.0	12.8
Husk + AS	45.1	57.7	8.5	26.4	46.4	15.2
Kokum cake + Urea	-	63.7	—	7.4	—	28.9
Kokum cake + As	—	74.0	—	5.2	—	20.8

AS = Ammonium sulphate; D. S./W. S. = Dry/Wet season.

The leaching loss was estimated only during the dry season.

The mud balls prepared from rice straw or husk using labelled urea and ammonium sulphate and superphosphate were prepared and evaluted at 80 kg N/ha level during the dry season and 40 kg N/ha level during the wet season. The basal, soil-incorporated application of labelled fertilizer was included in both the seasons, and that of labelled sulphur-coatedurea (SCU) in the wet season for comparison. The SCU was applied basally and incorporated in to the soil.

After harvest of the 1975 dry seaoon crop, the microplot soil from 0-20 cm depth was removed, air-dried, ground to 2mm size and sub-sampled. The total and labelled N in the Kjeldahl fraction were determined.

RESULTS AND DISCUSSION

In the dry season of 1975 all mud balls, except straw+urea, gave significantly higher grain yield than LCU or

TABLE IV. N uptake and per cent N derived from labelled fertilizer in rice crops (rough rice + straw)

Treatment	Dry season, 1975 N rate = 80 kg/ha		Wet season, 1975 N rate = 40 kg/ha	
	N uptake (kg/ha)	Ndff%	N uptake (kg/ha)	Ndff%
Urea, basal	24.54	30.95	12.45	19.52
AS, basal	22.37	30.17	14.17	19.01
SCU	—	—	12.75	22.25
Mud Balls				
straw + Urea	29.40	32.89	12.00	19.77
Straw + AS	31.28	34.19	13.43	20.68
Husk + Urea	34.38	37.18	16.35	22.49
Husk + AS	34.83	37.65	15.27	23.49
C.D. (0.05)	9.37	—	3.04	—

As = Ammonium sulphate.

TABLE V Balance sheet of labelled fertilizer N (dry season, 1975) (N rate = 80 kg/ha)

Treatment	Per cent recovery			
	Crop	Soil	Leachate	Total
Urea, basal	30.68	29.88	16.95	77.51
AS, basal	27.96	33.71	4.66	66.33
Mud balls				
Straw + Urea	36.75	31.89	4.40	73.04
Straw + AS	39.10	42.31	1.05	82.46
Husk + Urea	42.98	38.78	3.00	84.76
Husk + AS	43.54	36.01	0.68	80.23

AS = Ammonium sulphate.

SCU (Table I). No difference was noticed in the performance of carbonaceous and non-carbonaceous mud balls. But in the wet season, husk+AS mud balls performed better than LCU or SCU. The N uptake was also likewise higher from mud ball treatments (Table II). The recovery of fertilizer N in mud balls, except for those prepared from straw + urea, ranged from 84 to 95 per cent in the dry season as compared to 42 to 55 per cent from LCU or SCU. In the wet season more or less similar recoveries were obtained from LCU or SCU, but those from mud balls ranged from 63 to 77 per cent except in the case of straw + urea mud balls.

The rate of release of N as evident from per cent uptake in plants showed that the higher yield and N recovery from mud balls was associated with about 43 to 63 per cent N uptake in the period from transplanting to maximum tillering during the dry season and 58 to 88 per cent during the wet season (Table III). The per cent uptake during the same period from LCU and SCU lagged behind and ranged from 21 to 48 in dry and 40 to 43 in the wet season, respectively.

The data of field experiments with labelled mud balls are shown in Table IV. In the dry season, the N derived from labelled fertilizer N (% Ndff) in the rice crop was about 37 to 38 per cent with husk mud balls as compared to 30 to 31 per cent from basal application of urea or ammonium sulphate. In the wet season with lower level of N application, the husk mud balls were about as effective as SCU.

It was possible to form a balance sheet of labelled N from the dry season data (Table V). The major recovery of applied N occurred in crop and the soil and it increased with the use of mud balls. The higher recovery of about 43 per cent in the crop occurred with the use of husk + urea mud balls. The residual fertilizer N in the soil was, however, higher with straw + AS mud balls followed by husk + urea mud balls. An interesting aspect was the control of leaching loss with the use of mud balls. This was particularly evident in the case of urea where the leaching loss decreased from about 17 per cent to less than 5 per cent.

In addition to preparation, application of individual mud balls in between 4 hills at about 8 cm depth is a time – and labour – consuming process. The evaluation of cheap, alternative application methods is shown in Table VI. Although the application at 8 cm depth in between 4 hills gave the best N recovery and yield response, the other methods, viz., broadcasting before or after transplanting, did not significantly reduce the N uptake. The yield response decreased by only 7 kg with broadcasting after transplanting and, on the basis of cost benefit ratio, this method may prove useful. Observations in the field showed that in the broadcast treatments before and after trans-

TABLE VI Effect of methods of mud balls application (Wet season, 1975) (N rate = 80 kg/ha)

Treatment	N uptake (Rough rice + straw) (kg/ha)	Yield response (kg rough rice/kg of added N)	Per cent recovery of added N (Diff. method)
Control	50.38	—	—
Mud balls placed in between 4 hills at 8 cm depth after transplanting.	85.09	25.3	57.85
Mud balls broadcasted before transplanting followed by planking.	74.95	14.7	40.95
Mud ball broadcasted after transplanting, no planking.	76.65	18.2	43.78
Urea, basal, incorporated.	74.40	8.2	40.03
Urea, 3 splits.	76.07	17.8	42.82
LCU, basal, incorporated.	82.28	18.5	53.17
SCU, basal, incorporated.	77.48	15.3	45.17
C. D. (0.05)	12.59	—	—

Mud balls prepared from whole husk + urea + superphosphate were used.

planting, the placement of mud balls in the reduced zone was achieved but the distribution was not uniform.

The behaviour of mud balls appeared to vary depending upon the N rate, source and decomposability of associated carbonaceous material. Com parison with LCU and SCU has shown that the dual advantage of deep placement and slow-release can be achieved through the use of mud balls. However, the development of some simple mechanical devices for preparation as well placement in the field is required for maximum benefit from the use of the mud balls.

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