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Nitrogen management in rice transplanted with aged seedlings

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ABSTRACT

Different N management strategies involving the use of leaf colour chart (critical value 4), were evaluated to refine the technique of the use of (LCC) in assessing the N requirement of rice in contingencies when aged seedlings were used for transplanting. Rice variety ADT 46 during Navarai and ADT 43 during wet season were tried as the test crops. The results indicated that basal application of 35 kg N ha^{-1} is necessary to avoid the yield loss (6.5 -14.9 %) in rice when more than 35 days old aged seedlings were used for transplanting. Use of 45 days old seedlings had resulted in a marked reduction in the productive tillers (9.1 to 15.7 %) in rice under the LCC based N management where the crop did not receive any basal N. Skipping the basal N for aged seedlings had also increased the percentage of unproductive tillers and inturn decreased the grain yield. A marked reduction (11.3-14.6 per cent) in the N uptake in rice under the LCC based N management was observed when the age of the seedlings exceeded 35 days and the same could be improved by the basal application of N.

Key words: *leaf colour chart, N management, aged seedlings , transplanted rice*

Phasing of N application at critical developmental stages is very important for the efficient utilisation of the applied N by rice. This basically requires proper monitoring of N requirements of the rice crop. Farmers use rice leaf colour as a visual and subjective indicator of the rice crop's need for N fertilizer (Wells & Turner, 1984). A chart developed in Japan is used to measure the green colour intensity of rice leaves (Furuya, 1987) and has been standardised at IRRI, Philippines (Balasubramanian, 1998) as well as in Tamil Nadu (TNAU, 2003) to promote need based variable rate N application to rice crop, based on soil N supply and crop demand. Due to the failure in the monsoon rains and the consequential late release of canal water in the command areas, farmers are not able to take up planting as per the schedule and in most of the cases, aged (35–45 days old or still older) seedlings are used for planting. In such cases, the technology of using the LCC for N management wherein it is recommended to start the application of the fertilizer N at 14 days after transplanting (DAT) of the crop, may not yield satisfactory results since by the time the crop receives the first N dressing on 14 DAT as per the LCC technology, it would have crossed the active tillering phase. Late application of fertilizer N will result in reduced number of tillers, biomass as well as grain yield. Hence, it was contemplated to refine the technique of the use of LCC in assessing the N requirement of rice in contingencies when aged seedlings are used for transplanting.

MATERIALS AND METHODS

Field experiments were taken up during Navarai (Dec.-April) 2003-04, Wet season (June-Sept.) 2004 and dry season (Dec.-April) 2004-05 crop seasons at Coimbatore, with different N management strategies involving the use of LCC critical value 4 and time of first dressing of N viz., T1) Blanket N @120 kg during wet season and 150 kg during dry season in 4 equal splits, T2) LCC cv. 4 : N @ 35 kg N ha^{-1} each time starting from 14 DAT , T3) LCC cv. 4 : N @ 35 kg N ha^{-1} each time starting from 7 DAT , T4) LCC cv. 4 : N @ 35 kg N ha^{-1} each time starting from 14 DAT with a basal dose of 35 N ha^{-1} at planting and T5) LCC cv. 4 : N @ 35 kg N ha^{-1} each time starting from 7 DAT with a basal dose of 35 kg N ha^{-1} at planting and the age of the seedlings used for transplanting viz., 25,35 and 45 days in FRBD replicated thrice . Rice variety ADT 46 a spacing of 20x10 cm during dry season (1st

and 3rd crop) and ADT 43 at a spacing of 15x10 cm during wet season (2nd crop) were transplanted.

The soil of the experimental field was Noyal series clay having a pH of 8.1, EC : 0.65(dSm^{-1}), alkaline $KMnO_4$ – N : 245 kg ha^{-1}, Olsen P: 45 kg ha^{-1}, N-N-NH_4 OAc K: 520 kg ha^{-1} with an organic carbon content of 0.72 %. The nursery was raised at different time intervals so as to suit the treatment requirements of the age of the seedlings; and planting was taken up on the same day for all the treatments. Nitrogen application as urea was done as per the treatment schedule. Phosphorus as single superphosphate at 50 kg P_2O_5 , gypsum at 500 kg and $ZnSO_4$ at 25 kg ha^{-1} as all basal and potassium as muriate of potash at 50 kg K_2O_5 ha^{-1} in two splits were applied uniformly to all the treatments. The LCC values were recorded at weekly intervals from 7 days after transplanting and the application of N to T_{2-5} was taken up as and when needed. The data on the total tillers, productive tillers and grain and straw yield were recorded. The grain and straw samples were analysed for their N content and the total uptake of N in rice was computed. The partial factor productivity of nitrogen was also worked out and the results are presented in this paper

RESULTS AND DISCUSSION

The total tillers hill^{-1} was in the range of 12.2-14.7 during dry season 2003-04 (1st crop), 14.1-15.6 during wet season 2004-06 (2nd crop) and 11.8-13.7 during dry season 2004-05 (3rd crop) (Table 1). The age of the seedlings had a marked influence on the total tillers in the 1st crop alone, wherein the use of 45 days old seedlings had resulted in a marked decline in the total tillers (12.6 hill^{-1}) compared to 35 days old seedlings (13.4 hill^{-1}) and both in turn were inferior to 25 days old seedlings (14.3 hill^{-1}). The main effects of the treatments as well as their interaction with the age of the seedlings were found insignificant in all the three crops.

The productive tillers hill^{-1} ranged from 10.0 to 13.8 in the 1st crop, 10.1 to 13.4 in the 2nd crop and 9.1 to 12.6 in the 3rd crop, registering marked differences due to the age of the seedlings (Table 2). In all the three crops, the use of 45 days old seedlings had registered a marked reduction in the productive tillers compared to 25 and 35 days old seedlings which inturn were comparable among themselves in the 3rd crop while the performance of the 25 days old seedlings was the best during the 1st and 2nd crops.

Though the main effect of the different N management practices was significant only in 2nd crop, their interactions proved significant in 2nd and 3rd crop, wherein, a marked decline in the productive tillers (9.1 to 15.7 per cent) was observed in 45 days old seedlings which did not receive any basal dose of nitrogen compared to the treatments with a basal dose of 35 kg N ha^{-1}. The reduction in the number of productive tillers was made good by the basal application of N when 45 days old seedlings were used for transplanting.

The percent productive tillers (Table 3) were in the range of 82.0-94.8 in the 1st crop, 68.5-88.9 in the 2nd crop and 76.9-94.3 in the 3rd crop. The age of the seedlings had registered marked variations among themselves in all the three crops wherein the per cent productive tillers in 25 and 35 days old seedlings being comparable among themselves were higher than that of 45 days old seedlings which was the lowest, and the reduction being 3.9-9.9 per cent in dry season rice and 14.3 per cent in wet season rice. The interaction of the different N management practices with the age of the seedlings which was significant in all the three crops, indicated that the reduction in the per cent productive tillers was larger in 45 days old seedlings which did not receive any basal N (T2) and the loss was made good to certain extend in the treatments receiving a basal dose of N.

The grain yield (Table 4) ranged from 5790-6936 kg ha^{-1} in 1st crop, 3020 to 5115 kg/ha in 2nd crop and 4964 to 6629 kg ha^{-1} in the 3rd crop with marked variations for the age of the seedlings, N management practices and their interactions. In general, as the age of the seedlings increased, the grain yield of rice progressively declined and the yield decline was marked in 45 days old seedlings in 1st and 2nd crop and it was even in 35 days old seedlings in 3rd crop. Use of 45 days old seedlings registered the lowest yield in all the three crops with the magnitude of reduction being the highest in wet season rice (30.9%) compared to dry season rice (8.5 – 20.1%).

Though the different N management practices failed to produce any appreciable variations in the grain yield of rice under 25 days old seedlings, their impact was significant in 45 days old seedlings in all the three

Table 1. Total number of tillers hill^{-1} under different N management practices

Tr.no	Dry season 2003-04 ADT 46				Wet season 2004-05 ADT 43				Dry season 2004-05 ADT 46			
	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.
	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean
N @120 kg during Wet season @150 kg in dry season	14.7	13.8	12.6	13.7	15.5	14.8	15.6	15.3	13.3	13.2	13.1	13.2
LCC cv. 4 : N @ 35 kg ha^{-1} from 14 DAT	14.2	13.5	12.2	13.3	15.1	14.6	14.7	14.8	13.1	13.5	11.8	12.7
LCC cv. 4 : N @ 35 kg ha^{-1} from 7 DAT	14.5	13.5	13.0	13.7	15.4	14.1	15.5	15.0	12.9	12.9	12.4	12.7
T_2 + 35 kg N ha^{-1} at planting	14.2	13.5	12.5	13.4	14.8	15.5	15.2	15.2	13.0	13.6	12.8	13.2
T_3 + 35 kg N ha^{-1} at planting	14.1	13.2	12.6	13.3	14.2	14.4	15.3	14.6	13.3	13.7	13.1	13.4
Mean	14.3	13.4	12.6	13.4	15.0	14.7	15.3	15.0	13.1	13.4	12.6	13.0
Results of statistical analysis												
		Tr	S	Tr x S		Tr	S	Tr x S		Tr	S	Tr x S
SE		0.40	0.31	0.69		0.24	0.31	0.54		0.42	0.32	0.72
CD (P=0.05)		NS	0.7	NS		NS	NS	NS		NS	NS	NS

Table 2. Total number of productive tillers hill^{-1} under different N management practices

Tr.no	Dry season 2003-04 ADT 46				Wet season 2004-05 ADT 43				Dry season 2004-05 ADT 46			
	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.
	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean
N @120 kg during Wet season @150 kg in dry season	13.3	12.0	11.3	12.2	13.2	12.4	11.7	12.4	12.3	11.7	10.8	11.6
LCC cv. 4 : N @ 35 kg ha^{-1} from 14 DAT	13.1	11.7	10.0	11.6	13.2	11.8	10.1	11.7	11.9	12.5	9.1	11.2
LCC cv. 4 : N @ 35 kg ha^{-1} from 7 DAT	13.8	11.9	11.0	12.2	13.0	11.9	10.8	11.9	11.8	12.2	9.9	11.3
T_2 + 35 kg N ha^{-1} at planting	12.8	12.3	11.2	12.1	13.0	13.4	11.2	12.5	12.0	12.6	10.8	11.8
T_3 + 35 kg N ha^{-1} at planting	12.4	11.6	11.3	11.8	12.6	12.6	11.4	12.2	12.6	12.6	11.1	12.1
Mean	13.1	11.9	11.0	12.0	13.0	12.4	11.0	12.2	12.1	12.3	10.3	11.6
Results of statistical analysis												
		Tr	S	Tr x S		Tr	S	Tr x S		Tr	S	Tr x S
SE		0.28	0.22	0.50		0.26	0.20	0.44		0.42	0.32	0.72
CD (P=0.05)		NS	0.5	NS		0.5	0.4	0.9		NS	0.7	1.5

Table 3. Per cent productive tillers hill^{-1} under different N management practices

Tr.no	Dry season 2003-04 ADT 46				Wet season 2004-05 ADT 43				Dry season 2004-05 ADT 46			
	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.
	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean
N @120 kg during Wet season @150 kg in dry season	90.8	86.7	90.0	89.2	85.2	84.3	74.9	81.5	92.6	88.4	82.3	87.8
LCC cv. 4 : N @ 35 kg ha^{-1} from 14 DAT	91.9	86.7	82.0	86.9	88.0	80.4	68.5	79.0	91.2	92.5	76.9	86.8
LCC cv. 4 : N @ 35 kg ha^{-1} from 7 DAT	94.8	87.8	84.6	89.1	84.2	85.2	71.0	80.2	91.3	94.3	80.4	88.7
T_2 + 35 kg N ha^{-1} at planting	90.5	90.7	90.0	90.4	87.7	86.4	73.9	82.6	92.5	92.5	84.6	89.9
T_3 + 35 kg N ha^{-1} at planting	88.0	91.6	90.0	89.9	88.9	87.4	74.3	83.6	94.3	92.3	84.7	90.4
Mean	91.2	88.7	87.3	89.1	86.8	84.8	72.5	81.4	92.4	92.0	81.8	88.7
Results of statistical analysis												
		Tr	S	Tr x S		Tr	S	Tr x S		Tr	S	Tr x S
SE		1.46	1.13	2.53		1.33	1.03	2.31		1.38	1.07	2.39
CD (P=0.05)		NS	2.4	5.4		2.7	2.1	4.7		2.8	2.2	4.9

Table 4. Grain yield (kg ha^{-1}) under different N management practices

Tr.no	Dry season 2003-04 ADT 46					Wet season 2004-05 ADT 43					Dry season 2004-05 ADT 46				
	N dose kg ha^{-1}& applied	Age of seedlings (S) 25 days	35 days	45 days	Tr. Mean	N dose kg ha^{-1}& applied	Age of seedlings (S) 25 days	35 days	45 days	Tr. Mean	N dose kg ha^{-1}& applied	Age of seedlings (S) 25 days	35 days	45 days	Tr. Mean
N @120 kg during Wet season @150 kg in dry season	150 (4)	6895	6730	6383	6669	120 (4)	5074	4828	3642	4514	150 (4)	6779	6192	5565	6178
LCC cv. 4 : N @ 35 kg ha^{-1} from 14 DAT	140 (4)	6751	6629	5790	6390	105 (3)	4951	4419	3028	4133	140 (4)	6697	6042	5046	5928
LCC cv. 4 : N @ 35 kg ha^{-1} from 7 DAT	140 (4)	6936	6813	6301	6683	105 (3)	4869	4460	3437	4255	140 (4)	6629	5810	4964	5801
T_2 + 35 kg N ha^{-1} at planting	140 (4)	6772	6690	6383	6615	105 (3)	5074	4992	3560	4542	140 (4)	6547	6219	5401	6056
T_3 + 35 kg N ha^{-1} at planting	140 (4)	6833	6629	6424	6629	105 (3)	5115	4828	3642	4528	140 (4)	6492	6055	5510	6019
Mean	—	6837	6698	6256	6597	—	5016	4705	3462	4394	—	6629	6064	5297	5996
Results of statistical analysis															
		Tr	S	Tr x S		Tr	S	Tr x S		Tr	S	Tr x S			
SE		90	70	156		125	150	217		96.6	75	167.5			
CD (P=0.05)		194	150	336		258	415	448		197	153	343			

crops, wherein a marked reduction in the grain yield was observed in the treatments which did not receive basal N compared to treatments with basal N application. The magnitude of yield reduction being 6.5 to 9.3 per cent in dry season medium duration rice and 14.9 per cent in wet season short duration rice which could be made good by the basal application of 35 kg N ha^{-1}. This trend of results was observed in 35 days old seedlings also in the 2nd and 3rd crops.

When aged seedlings of 45 days old were used for transplanting, by the time the crop received fertilizer N supply as per the current recommendation of LCC based N management practice, the crop had crossed the maximum tillering phase (59 days) and the late formed tillers had resulted only in an increased straw yield leading to a drastic reduction in the percent productive tillers and partial factor productivity of N as was observed in the present investigation. Rao *et al* (1994) had also reported that delaying the N supply beyond active tillering stage of the crop radically reduced the grain yield due to reduction in the number of panicles. De Datta (1986) emphasized that rice plants required as much N as possible at early and mid tillering to maximize the total tillers and panicle number.

The age of the seedlings had a reverse trend on the straw yield (Table 5) wherein, a marked increase was observed when aged seedlings were used for transplanting. Use of 45 days old seedlings had registered higher straw yield over 25 days old seedlings in all the three crops and the trend was noticed even for the 35 days old seedlings in *Navarai* crop. The different N management options as well as their interactions with the age of seedlings failed to produce any appreciable variation in the straw yield.

The N uptake of the crop (Table 6) ranged from 113-131 in the 1st crop, 86-111 in the 2nd crop and 106-128 kg ha^{-1} in the 3rd crop with marked variations due to the age of the seedlings in the 2nd and 3rd crop and its interaction with the N management practices in the 2nd crop only. Use of 45 days aged seedlings had resulted in a marked reduction (11.3-14.6 per cent) in the N uptake of the crop compared to 25 and 35 days old seedlings. The interaction of the age of the seedlings with the N management practices in the 2nd crop indicated that the reduction in the N uptake of rice was marked in plots which did not receive any basal N particularly in 45 days old seedlings only while the effect

Table 5. Straw yield (kg ha^{-1}) under different N management practices

Tr.no	Dry season 2003-04 ADT 46				Wet season 2004-05 ADT 43				Dry season 2004-05 ADT 46			
	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.
	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean
N @120 kg during Wet season @150 kg in dry season	7471	9723	9870	9021	9532	9672	10366	9856	8231	8762	9170	8721
LCC cv. 4 : N @ 35 kg ha^{-1} from 14 DAT	7814	9498	8979	8764	9141	9298	10640	9693	7682	8044	9567	8431
LCC cv. 4 : N @ 35 kg ha^{-1} from 7 DAT	7647	8626	9302	8525	8499	9537	10278	9438	7875	9018	8482	8458
T_2 + 35 kg N ha^{-1} at planting	7275	9645	9870	8930	9602	9217	10424	9747	7747	8365	8190	8101
T_3 + 35 kg N ha^{-1} at planting	8010	8284	9929	8741	9327	9823	10342	9831	7467	8727	9007	840
Mean	7643	9155	9590	8796	9220	9509	10410	9713	7800	8583	8883	8422
Results of statistical analysis												
		Tr	S	Tr x S		Tr	S	Tr x S		Tr	S	Tr x S
SE		525	407	910		268	208	464		434	336	751
CD (P=0.05)		NS	874	NS		NS	445	NS		NS	721	NS

Table 6. Nitrogen uptake of rice crop (kg ha^{-1}) under different N management practices

Tr.no	Dry season 2003-04 ADT 46				Wet season 2004-05 ADT 43				Dry season 2004-05 ADT 46			
	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.
	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean
N @120 kg during Wet season @150 kg in dry season	126	130	126	127	111	107	96	105	128	121	116	122
LCC cv. 4 : N @ 35 kg ha^{-1} from 14 DAT	126	129	113	122	107	102	86	98	124	119	106	116
LCC cv. 4 : N @ 35 kg ha^{-1} from 7 DAT	129	129	124	127	106	103	93	101	127	120	106	118
T_2 + 35 kg N ha^{-1} at planting	124	131	127	127	110	108	95	104	121	121	109	117
T_3 + 35 kg N ha^{-1} at planting	128	125	129	127	111	107	95	104	121	119	114	118
Mean	127	129	124	126	109	106	93	103	124	120	110	118
Results of statistical analysis												
		Tr	S	Tr x S		Tr	S	Tr x S		Tr	S	Tr x S
SE		3.00	2.32	5.20		2.21	1.71	3.83		4.59	3.56	7.96
CD (P=0.05)		NS	NS	NS		NS	3.7	8.2		NS	7.6	NS

Table 7. Partial factor productivity of nitrogen (kg rice / kg applied N) in rice under different N management practices

Tr.no	Dry season 2003-04 ADT 46				Wet season 2004-05 ADT 43				Dry season 2004-05 ADT 46			
	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.	Age of seedlings (S)			Tr.
	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean	25 days	35 days	45 days	Mean
N @120 kg during Wet season @150 kg in dry season	46.0	44.9	42.6	44.5	42.3	40.2	30.4	37.6	45.2	41.3	37.1	41.2
LCC cv. 4 : N @ 35 kg ha^{-1} from 14 DAT	48.2	47.4	41.4	45.6	47.2	42.1	28.8	39.4	47.8	43.2	36.0	42.3
LCC cv. 4 : N @ 35 kg ha^{-1} from 7 DAT	49.5	48.7	45.0	47.7	46.4	42.5	32.7	40.5	47.4	41.5	35.5	41.4
T_2 + 35 kg N ha^{-1} at planting	48.4	47.8	45.6	47.3	48.3	47.5	33.9	43.3	46.8	44.4	38.6	43.3
T_3 + 35 kg N ha^{-1} at planting	48.8	47.4	45.9	47.3	48.7	46.0	34.7	43.1	46.4	43.3	39.4	43.0
Mean	48.2	47.2	44.1	46.5	46.6	43.7	32.1	40.8	46.7	42.7	37.3	42.2

was insignificant when 25 and 35 days old seedlings were used for transplanting.

The partial factor productivity for applied nitrogen (Table 7) is a useful measure of nitrogen use efficency because it provides an integrative index that quantifies total economic output relative to utilisation of N in the system including the indigenous N supply and applied N. The partial factor productivity of applied nitrogen ranged from 41.4- 49.5 in 1st crop, 28.8- 48.7 in 2nd crop and 35.5- 47.8 kg rice per kg N applied in 3rd crop with appreciable variations due to the age of the seedlings wherein the partial factor productivity of N in rice showed a progressive decline with the age of the seedlings and the impact was found marked in 45 days old seedlings in all the three crops. The negative impact of skipping basal N could be seen more particularly when 45 days old seedlings were used for transplanting. This is in line with the observations made by Thiyagarajan et al (1994) who reported that delaying the N supply beyond 40 days of seedling age, decreased the N use efficiency.

From the results, it could be concluded that basal application of 35 kg N ha^{-1} is necessary to avoid the yield loss in rice when more than 35 days old seedlings were used for transplanting. Use of 45 days old seedlings had resulted in a marked reduction in the productive tillers in rice under the LCC based N management where the crop did not receive any basal N. Skipping the basal N for aged seedlings had also increased the percentage of unproductive tillers and inturn decreased the grain yield. A marked reduction in the N uptake in rice under the LCC based N management was observed when the age of the seedlings exceeded 35 days and the same could be improved by the basal application of nitrogen.

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