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Nitrogen Use Efficiency of Rice (*Oryza sativa*) in Systems of Cultivation with Varied N Levels Under ^{15}N Tracer Technique

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Abstract: A pot culture experiment was conducted at the Tamil Nadu Agricultural University, Coimbatore, to study the Nitrogen Use Efficiency (NUE) of rice under different eco-systems. The different eco-systems of rice cultivation evaluated in the study were i) direct seeding of sprouted seeds under puddled condition, direct seeding of ii) sprouted and iii) dry seeds under unpuddled condition and iv) transplanting of rice seedlings under unpuddled condition. In the puddled soil condition pots, 5 cm depth of water was maintained throughout the crop growing period. In respect of unpuddled condition pots, 5 cm depth of irrigation was given at 80% of the available soil moisture condition. The nitrogen levels were 50, 75, 100, 125 and 150% of recommended dose of nitrogen. Nitrogen tracer (^{15}N) technique is an accurate tool to assess the absorption and distribution of added N in the soil crop environment, as influenced by the nitrogen levels. Assaying on ^{15}N tracer added as labelled urea in rice brought out valid information in the present study on quantity of N derived as crop recovery (N use efficiency). The N use efficiency under ^{15}N study was higher in direct seeding of sprouted seeds under puddled condition. Among the different N levels, increasing the N level up to the recommended level (100%), the N use efficiency was increased. Further, increasing the N levels to 125 and 150%, the N use efficiency was decreased under all the systems of cultivation. It may be due to the application of excess nitrogen, which was not effectively utilized by the crop and the rate of production was lesser per unit of N application.

Key words: Rice (*Oryza sativa*), puddled condition, unpuddled condition, N levels, ^{15}N tracer technique, N use efficiency

INTRODUCTION

Rice is the prime source of food for nearly half of the World's population and it is one of the most important major food crops. In India, Tamil Nadu is one of the major rice growing states and rice is grown in 2.4 million ha. The irrigated rice area (around 2.2 million ha), account for 60% of the total irrigated area of the state. Rice, occupying such a prime position among food crops, is grown under diversified agro-ecological situations. As the rice production systems of Asia undergo major adjustments in response to the increasing scarcity of land, labour, capital and water, major adjustments are to be ushered in the method of crop establishment (Pandey and Velasco, 1999). Another major concern in rice production systems is the dwindling trend of availability of water resources. In water scarce areas, the farmers prefer direct seeding method as an alternative to traditional method of transplanting during the period of delayed receipt of water in the canal (Dubey, 1995). Nitrogen is the most important primary nutrient for sustained higher productivity of rice crop and is often reserved to as the king-pin among the major nutrients. Attempts are being made to raise the crop in pot culture under different systems of rice cultivation to maintaining the puddled and unpuddled soil conditions

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with varied nitrogen levels. The objective of this study is to evaluate the non-conventional rice cultivation systems in a given environment and to work out the optimum quantity of nitrogen utilized and recovered. Nitrogen tracer (^{15}N) technique is an accurate tool to assess the absorption and distribution of added N in the soil crop environment, as influenced by the nitrogen levels. The labelled N also accumulated in straw and grain in higher concentration occupying nearly 30% of the total N uptake (Bindu, 2002). Assaying on ^{15}N tracer added as labelled urea in rice brought out valid information in the present study on quantity of N derived as crop recovery (N use efficiency).

MATERIALS AND METHODS

A pot experiment was conducted during Kharif 2002, at the Tamil Nadu Agricultural University, Coimbatore to study the Nitrogen Use EFFICIENCY (NUE) of rice under different eco-systems. Six kilogram of air dried, powdered and 4 mm sieved soil was filled into mud pots of 30 cm diameter to a depth of 35 cm. The experiment was a Complete Randomized Design (CRD) in a factorial arrangement with two replications. The short duration rice variety CO-47 was raised in pot culture during the pot culture the Kharif season. Pots were kept in the green house and the treatments imposed were, direct seeding of sprouted seeds under puddled condition, direct seeding of sprouted seeds under unpuddled condition, direct seeding of dry seeds under unpuddled condition and transplanting of rice seedlings under unpuddled condition. In the pots with puddled soil, 5 cm depth of water was maintained throughout the crop growing period. In the pots with unpuddled soil, 5 cm depth of irrigation was given at 80% of the available soil moisture condition. The nitrogen levels were 50, 75, 100, 125 and 150% of recommended dose of nitrogen. Prior to sowing, the required quantity of P_2O_5 (as single super phosphate) and K_2O (as muriate of potash) were added and mixed well with the soil. Twenty five percent of N through labelled urea (5.024 atom % ^{15}N excess) was applied to the respective pots at the seedling stage. The remaining 75% was top dressed in three equal splits at active tillering, panicle initiation and heading stages of the crop growth. After harvesting, the plant samples were shade dried, grounded and used for the ^{15}N assay utilizing Mass Spectrometer.

RESULTS AND DISCUSSION

Grain and Straw Yield

The direct seeding of sprouted seeds under puddled condition (M_1) recorded higher grain and straw yield of 13.22 g pot^{-1} and 22.67 g pot^{-1}, respectively.

Table 1: Grain and straw yield of rice (CO-47) in labelled ^{15}N pot culture experiment (g pot^{-1})

	Grain yield					Straw yield				
Treatments	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
N_1	11.23	9.21	9.08	8.21	9.43	19.83	18.29	17.49	16.01	17.91
N_2	12.55	10.63	10.37	9.33	10.72	21.92	20.61	19.59	17.11	19.81
N_3	13.32	12.42	11.79	9.96	11.87	23.57	21.52	20.75	18.78	21.16
N_4	14.21	13.11	12.14	10.32	12.45	23.93	22.64	20.79	18.86	21.56
N_5	14.48	13.76	12.72	10.87	12.96	24.12	23.11	21.62	19.41	22.07
Mean	13.22	12.05	11.48	9.72	11.62	22.67	21.23	20.05	17.93	20.50
Source	SEd		CD (p = 0.05)			SEd		CD (p = 0.05)		
M	0.21		0.42			0.24		0.50		
N	0.41		0.86			0.43		0.88		
M x N	0.31		0.62			0.33		0.67		

M_1 – Direct seeding of sprouted seeds under puddled condition
M_2 – Direct seeding of sprouted seeds under unpuddled condition
M_3 – Direct seeding of dry seeds under unpuddled condition
M_4 – Transplanting under unpuddled condition

N_1 – 50% of recommended dose of nitrogen
N_2 – 75% of recommended dose of nitrogen
N_3 – 100% of recommended dose of nitrogen
N_4 – 125% of recommended dose of nitrogen
N_5 – 150% of recommended dose of nitrogen

This may be due to the favourable moisture condition and uptake of nutrients which improved the growth and yield parameters of rice. Higher N levels resulted in higher yields. The favourable effect of higher levels of N on growth and yield parameters resulted in significant increase in economic yield (Jaiswal and Singh, 2000). This was followed by the direct seeding of sprouted seeds under unpuddled condition (M_2). The lowest grain and straw yield was recorded by transplanting the seedlings under unpuddled condition (M_4). Increasing the N levels increased the grain and straw yield. Though the recommended dose of N at 150 (N_5) % recorded higher grain and straw yield per plot it was comparable with 125% (N_4) and 100% (N_3) recommended dose of N. This may be due to rate of increase in yield per unit of N applied was less. The interaction between the systems of cultivation and N levels were found to be significant. The direct seeding of sprouted seeds under puddled condition with 150% of recommended dose of nitrogen (M_1N_5) recorded the higher grain (14.48 g pot^{-1}) and straw yield (24.12 g pot^{-1}), which was on par with the treatment of M_1N_4 (14.21 g pot^{-1} of grain and 23.93 g pot^{-1}of straw yield) and M_1N_3 (13.32 g pot^{-1} of grain and 23.57 g pot^{-1}of straw yield) (Table 1).

Nitrogen Use Efficiency (NUE)

The results emanated from ^{15}N urea to study the N use efficiency in rice as influenced by the systems of cultivation with levels of N revealed that, the treatment effects were more conspicuous on derivation of applied labelled N in grain and straw at harvest stage. The results on the crop recovery of grain, straw and total N use efficiency are presented in Table 2 and 3. Direct seeding of sprouted

Table 2: Recovery of ^{15}N labelled urea by rice in pot culture experiment

	Grain recovery (%)					Straw recovery (%)				
Treatments	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
N_1	10.21	9.13	8.86	8.07	9.07	15.17	14.13	13.76	13.10	14.04
N_2	12.13	10.61	9.98	9.43	10.54	17.73	16.28	14.77	14.14	15.73
N_3	14.29	13.70	13.19	11.86	13.24	19.96	19.17	18.48	17.80	18.85
N_4	13.19	12.72	11.78	10.17	11.97	17.79	17.18	15.99	15.26	16.55
N_5	11.91	11.28	10.72	9.77	10.92	15.56	15.35	15.20	14.65	15.19
Mean	12.35	11.49	10.91	9.86	11.15	17.24	16.42	15.64	14.99	16.07
Source	SEd		CD (p = 0.05)			SEd		CD (p = 0.05)		
M	0.51		0.79			0.53		0.81		
N	0.66		1.02			0.71		1.23		
M x N	1.13		2.08			1.16		2.11		

M_1 – Direct seeding of sprouted seeds under puddled condition
M_2 – Direct seeding of sprouted seeds under unpuddled condition
M_3 – Direct seeding of dry seeds under unpuddled condition
M_4 – Transplanting under unpuddled condition
N_1 – 50% of recommended dose of nitrogen
N_2 – 75% of recommended dose of nitrogen
N_3 – 100% of recommended dose of nitrogen
N_4 – 125% of recommended dose of nitrogen
N_5 – 150% of recommended dose of nitrogen

Table 3: Total recovery (Nitrogen Use Efficiency) of ^{15}N labelled urea by rice (Grain +Straw)

	N use efficiency (%)				
Treatments	M_1	M_2	M_3	M_4	Mean
N_1	25.38	23.26	22.62	21.17	23.12
N_2	29.86	26.89	24.75	23.57	26.27
N_3	34.25	32.87	31.67	29.66	32.11
N_4	30.98	29.90	27.77	25.43	28.52
N_5	27.47	26.63	25.92	24.42	26.11
Mean	29.59	27.91	26.55	24.85	27.23
Source		SEd		CD (p = 0.05)	
M		0.68		1.21	
N		0.71		1.74	
M x N		1.04		1.98	

M_1 – Direct seeding of sprouted seeds under puddled condition
M_2 – Direct seeding of sprouted seeds under unpuddled condition
M_3 – Direct seeding of dry seeds under unpuddled condition
M_4 – Transplanting under unpuddled condition
N_1 – 50% of recommended dose of nitrogen
N_2 – 75% of recommended dose of nitrogen
N_3 – 100% of recommended dose of nitrogen
N_4 – 125% of recommended dose of nitrogen
N_5 – 150% of recommended dose of nitrogen

seeds under puddled condition (M_1) registered higher N use efficiency of 12.35, 17.24% in grain and straw, respectively, with a total N use efficiency of 29.59% compared to other systems of cultivation. This was followed by direct seeding of sprouted seeds under unpuddled condition (M_2) (80% of available soil moisture) with a total efficiency of 27.91%.

The N use efficiency under ^{15}N study was higher in direct seeding of sprouted seeds under puddled condition. Since, rice is a crop suitable for submerged condition and it absorbs N primarily in ammonical form and the application of urea under puddled condition was effective as a N supplier by ammonification process. In unpuddled conditions, there was a possibility of nitrification, denitrification and leaching. Due to that the ammonia concentration would have been less. This would have probably reflected in the lower N use efficiency under unpuddled conditions.

Among the different N levels, increasing the N level up to the recommended level (100%) (N_3), the N use efficiency was increased. Further, increasing the N levels, the N use efficiency was decreased in all the systems of cultivation. It may be due to the application of excess nitrogen, which was not effectively utilised by the crop and the rate of production was lesser per unit of N application. The variation in the level of efficiency for the rice tested is in good agreement with the results reported by Lu *et al*. (1998) and Bindu (2002). The interaction between the systems of cultivation and N levels were found to be significant. The direct seeding of sprouted seeds under puddled condition with 100% of recommended dose of N resulted, higher N use efficiency of 34.25%.

CONCLUSION

The ^{15}N study indicated higher N use efficiency in the rice cultivation system involving direct seeding of sprouted seeds under puddled condition. As regard to N rates, 100% of recommended dose of nitrogen resulted in higher N use efficiency. Further increasing the N levels, the N use efficiency was decreased.

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