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RESEARCH ARTICLE

Optimizing the nitrogen fertilizer requirement for pre-release short duration rice cultures in North Eastern zone of Tamil Nadu

■ C. Muralidaran, S. Malathi and S. Banumathy

SUMMARY

Field experiments were conducted for two years during 2017 and 2018 at Rice Research Station, Tirur to optimize nitrogen fertilizer requirement for pre-release rice cultures TM10085, TM 07335, TM 07030 along with the check variety CO51. The trial was conducted in split plot design with three replications and the main plot consisted of three pre-released rice cultures along with one check variety. The sub plot consisted of three fertilizers doses *viz*., 150-50-50 NPK kg/ha, 175-50-50 NPK kg/ha and 125-50-50 NPK kg/ha. In this experiment, the rice culture TM10085, along with fertilizer application of 150-50-50 NPK kg/ha recorded the highest grain yield of 5505 kg/ha during 2018. This treatment also registered highest growth, yield attributes and benefit cost ratio in Tirur, Tiruvallur district of North Eastern Zone, Tamil Nadu.

Key Words : Rice, Fertilizer dose, Nitrogen requirement, Pre-release cultures

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Rice is one of the important staple food which is consumed by large population in the world and fulfil the food security. Rice is cultivated in the area of 44.6 million hectares in India through the year in diversified ecological conditions with a production of 106 million tonnes of rice with an average productivity of 2.6 tonnes per hectare (Yogendra *et al*., 2014). In India, rice is majorly grown in the states of West Bengal, Uttar Pradesh, Andra Pradesh, Tamil Nadu, Punjab, Bihar, Madhya Pradesh and Chhattisgarh. Rice is predominantly grown by transplanting the seedlings into puddled (wet-tillage) soil and field is continuously flooded for much of the growing season (Chauhan *et al.,* 2012).

Humphreys *et al*. (2010) revealed that over-exploitation of groundwater resources due to cultivation

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of rice has caused an alarming fall of water table in many parts of North Western India. Therefore, a need has been realized throughout Asia to explore rice production technologies that will eliminate puddling, require less water, save labour for transplanting, maintain rice yield potential and eco-friendly. Belder (2005) revealed that in rice production Nitrogen (N) is the most limiting nutrient and yield of rice grown under aerobic conditions is more limited by N than yield under irrigated conditions.

Xing and Zhu (2000) reported that the N losses from puddled, flooded soils are often large, through ammonia volatilization which accounts for 40% to 60%. Moreover, the denitrification losses from flooded puddled soils depending on the rate of N fertilizer application. The variation in crop growth patterns and soil N transformations between flooded rice and non flooded rice may result in different N fertilizer management strategies (Mahajan *et al*., 2012).

Mahajan and Timsina (2011) reported that the yield of rice increased with N rate up to 120 kg N ha^{-1} in Punjab, India. In a recent study from Bangladesh, Ahmed *et al*. (2016) reported that grain yield of rice increased significantly upto 160 kg N ha^{-1} for Aman rice and 180 kg N ha^{-1} for Boro rice. Application of optimum quantity of N at the right time is one of the most important factors to realize high yield and N use efficiency in rice. Furthermore, optimum rate and time of fertilizer N application for rice may depend on soil type, climate and genetic potential of rice cultivar.

The probability of increasing rice production sturdily depends on the ability to incorporate a better crop management for the different varieties into existing cultivation systems (Mikkelsen *et al.,* 1995). Nitrogen is the most essential element in determining the yield potential of rice and the nitrogenous fertilizer is one of the major inputs for rice production (Mae, 1997). Almost every farmer has propensity to apply costly N fertilizer excess to get a desirable yield of rice (Saleque *et al.,* 2004), but imbalance use of N fertilizer causes harm to the crop and decreases grain yield. Keeping the above points in view, the present investigation was conducted at Rice Research station, Tirur during 2017-2018 to optimize the nitrogen level for the pre-release rice cultures, to optimize the nitrogen level for the pre-release rice cultures to high yield short duration pre-release cultures to observe the influence of Nitrogen fertilizer on grain yield.

MATERIAL AND METHODS

The field experiments were conducted during 2017 and 2018 at Rice Research Station, Tirur, Tamil Nadu. The experiment was conducted in split plot design with three replications in sandy loam calcareous light brown soil. The main plot consisted of three prerelease cultures of rice developed from Rice Research Station, Tirur *viz*., TM 10085, TM 07335, TM 07030 which was compared with the check variety CO 51. Subplot treatments consisted of three different fertilizer doses *viz.*, 150-50-50 NPK kg/ha (S_1), 175-50-50 NPK kg/ha (S_2) and 125-50-50 NPK kg/ha (S_3).

RESULTS AND DISCUSSION

Nitrogen is the most yield limiting nutrient in rice production worldwide and N fertilizer is often applied to get a desirable grain yield. The main and sub plot treatments had significant effect on plant height which is recorded higher in the rice culture TM 10085 (104 cm) followed by TM 07030. In the sub plot treatments S_1 recorded highest plant height of 97.15 cm followed by S_2 which recorded 94.8 cm during 2018. The highest productive tillers was observed TM 10085 culture with fertilizer dose of 150-50-50 NPK kg/ha.

Mahajan *et al.* (2012) reported that rice did not respond to fertilizer N beyond 120 kg N ha^{-1}. Another study by Hirzel *et al.* (2011) showed that flooded rice responded fertilizer N application upto 120 and 140 kg N ha^{-1} at two locations. Aman (rainy season) rice has a higher N fertilizer requirement than the recommended rate for transplanted rice (Ahmed *et al.,* 2016). Fageria and Baligar (2001) reported that rice grain yield increased with increased N supply but to a certain limit and that a quadratic yield response to N is considered the most appropriate model in determining N rate for maximum economic yield. The increased yield from applied N in rice was attributed to the improvement in panicle density and number of grain per panicle.

Corresponding N supply to crop N requirement is an important component of improving crop N management and one common way to accomplish this match is split application of N (Ruiz-Diaz and Sawyer, 2008). Similar to our findings, Sharma *et al.* (2007) also observed significantly higher grain yield in rice when N was applied in three split doses delaying first dose by 20 days (50% at 20 DAS, 25% at tillering and 25% at PI) than when first dose was applied at sowing (50% at sowing, 25% at tillering and 25% at PI) resulting in higher

N uptake and improved yield attributes. The application of N either in three equal splits (sowing, tillering and panicle initiation) or in two equal splits (sowing and panicle initiation) were equally efficient in increasing grain yield of flooded rice (Hirzel *et al.,* 2011)

The application of N fertilizer more than that required to produce economic yields which leads to high N losses and low N use efficiencies (Fageria *et al*., 2008). The low N use efficiencies in our study suggested significant N losses or immobilization. The top dressing of fertilizer application probably resulted in much of the urea N being located on or near the soil surface, with high potential for leaching and volatilization losses of N in this slightly alkaline coarse-textured soil.

There was a significant variation between various treatments on number of panicles/m^2 and panicle length in the main plots. The culture TM 10085 recorded highest number of panicles/m^2 (351) and panicle length of 27.10 cm during 2018. In the sub plots treatments the fertilizer dose of 150-50-50 NPK kg/ha recorded the highest

Table 1: Influence of treatments on growth and productive tillers/hill of rice

Treatments	Plant height (cm)		No of productive tillers/hill	
Main plots		Year		
Rice culture	2017	2018	2017	2018
TM 10085	100.00	104.00	21.00	23.00
TM 07335	92.00	101.60	17.00	19.00
TM 07030	92.00	94.20	15.00	17.00
CO 51	89.00	88.80	17.50	18.50
SED	2.28	2.60	2.80	1.26
CD (0.05)	4.50	5.60	4.0	4.01
Sub plots		Year		
Fertilizer dose (NPK kg/ha)	2017	2018	2017	2018
S_1 (150-50-50)	93.25	97.15	17.63	19.38
S_2 (175-50-50)	92.70	94.68	17.10	18.88
S_3 (125-50-50)	87.72	90.14	14.60	15.80
S.E.±	0.63	0.62	1.06	1.20
C.D. (P=0.05)	1.32	1.96	1.06	1.20

Table 2: Effect on treatment on number of panicles/m^2 and panicle length of rice

Treatments	Number of panicles/m^2		Panicle length (cm)	
Main plots		Year		
Rice culture	2017	2018	2017	2018
TM 10085	345.00	351.00	26.30	27.10
TM 07335	313.00	319.00	22.70	25.40
TM 07030	283.00	285.00	21.20	23.90
CO 51	250.00	254.00	20.30	22.80
SED	14.10	17.00	0.21	0.80
CD (0.05)	28 .00	34.60	0.68	2.40
Sub plots		Year		
Fertilizer dose (NPK kg/ ha)	2017	2018	2017	2018
S_1 (150-50-50)	297.75	302.25	23.45	25.50
S_2 (175-50-50)	281.25	285.25	22.95	24.80
S_3 (125-50-50)	242.75	272.25	21.86	24.50
S.E.±	12.00	0.62	0.15	0.80
C.D. (P= 0.05)	24.20	21.75	0.31	1.70

number of panicles (302.25) and panicle length of 25.50 cm was observed.

The effect of treatments on grain and straw yield was found to be significant in both the years. In the main plots TM10085 recorded the highest grain yield of 5305 kg/ha and 5505 kg/ha during 2017 and 2018 respectively and the same trend was observed in the straw yield. The fertilizer dose 150-50-50 NPK kg/ ha recorded the highest grain yield in both the years 5043 kg/ha and 5161 kg/ ha, respectively.

During 2017 the rice culture TM 10085 recorded highest net income of Rs. 42,022 and benefit cost ratio of 2.51 while the benefit cost ratio during 2018 was 2.68. In the sub plots also a fertilizer dose of 150-50-50 NPK kg/ha registered the highest benefit cost ratio of 2.47.

The economically feasible range of N use indicates that return from additional N use in the crop cultivation is greater than the additional cost of Nitrogen. The total economic return increased upto certain level of N rate and emissions intensity then started to decrease with increase in N rate. Based on this analysis N rate of 120-200 kg N ha^{-1} for rice is agronomically viable and environmentally sustainable for wheat Indo-gangetic plains of India. Grain production increased almost linearly with the amount of N applied levelling off only at higher yield levels (Shibahara *et al.,* 1999)

Development of rational methods for fertilizer application and soil management to reduce environmental pollution and to minimize production costs. Because rice yield is considerably affected by the N uptake, the

Table 3: Influence of treatments on grain yield (kg/ha) and straw yield (kg/ha) of rice

Treatments	Grain yield (kg/ha)		Straw yield (kg/ha)	
Main plots		Year		
Rice culture	2017	2018	2017	2018
TM 10085	5305	5505	6900	7154
TM 07335	5150	5260	6665	6865
TM 07030	4880	4956	6200	6586
CO 51	4750	4900	6150	6394
S.E.±	9.0	26.0	39.0	43.0
C.D. (P= 0.05)	29.0	81.0	125.0	126.0
Sub plots		Year		
Fertilizer dose (NPK kg/ ha)	2017	2018	2017	2018
S_1 (150-50-50)	5043	5161	6479	6750
S_2 (175-50-50)	5021	5155	6473	6673
S_3 (125-50-50)	4851	5084	6350	6573
S.E.±	29.0	9.0	13.0	11
C.D. (P= 0.05)	61.0	18.0	27.0	23

Table 4 : Impact of treatments on gross income, net income and benefit cost ratio of rice

Treatments	Gross income (Rs.)		Net income (Rs.)		B: C ratio	
Main plots			Year			
Rice culture	2017	2018	2017	2018	2017	2018
TM 10085	67022	59496	42022	33496	2.51	2.68
TM 07335	61408	65286	36408	39286	2.29	2.46
TM 07030	56092	51174	31092	25174	2.08	2.24
CO 51	53148	54092	28148	28092	1.97	2.13
Sub plots			Year			
Fertilizer dose (NPK kg/ha)	2017	2018	2017	2018	2017	2018
S_1 (150-50-50)	61592	58568	36592	32568	2.28	2.47
S_2 (175-50-50)	57268	55268	32748	29748	2.17	2.34
S_3 (125-50-50)	52538	52732	28018	27312	2.07	2.14

productivity of a paddy field has been evaluated on the basis of the N fertility of the soil. To meet such demands it is, therefore, important to accurately estimate the fertilizer N rate required to produce a target yield.

In the present investigation the short duration pre-release culture TM 10085 along with fertilizer application of 150-50-50 kg/ha is best suitable for the North Eastern Zone of Tamil Nadu in that gives highest growth yield attributes, grain yield, straw yield and highest benefit cost ratio.

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