IMPACT OF CROP GEOMETRY AND INTEGRATED NUTRIENT MANAGEMENT ON NPK UPTAKE AND NITROGEN USE EFFICIENCY OF RICE

Rex Immanuel, R., M. Thiruppathi, M. Saravanaperumal, G. Murugan and G.B. Sudhagar Rao,
Department of Agronomy, Faculty of Agriculture, Annamalai University,
Annamalainagar, Tamilnadu, India – 608002

***Abstract*:** Field experiments were undertaken at Experimental Farm, Department of Agronomy, Annamalai University, Annamalai Nagar during Thaladi (Sep. to Jan.) and Navarai seasons (Jan. to Apr.) to findout the impact of crop geometry and green leaf manuring in combination with chemical fertilizers on uptake of N, P and K, nitrogen use efficiency (NUE) and economic nitrogen use efficiency (ENUE) of rice in lowland ecosystem. Different treatments consisting of crop geometry and combined application of green manuring with chemical fertilizers significantly influenced the nutrient uptake, NUE and ENUE compared with control. Among the treatments tested, the crop raised by adopting 30 × 30 cm spacing along with integrated application of 50 per cent N *via.*, *Albizia lebbeck* and remaining with 50 per cent N *via.*, urea recorded the highest N, P and K uptake, NUE of 26.98 kg ha^{-1} and ENUE of ₹ 4.51 ha^{-1} for Thaladi season. Where as in Navarai season, rice planted by adopting 25 × 25 cm spacing along with integrated application of 50 per cent N *via.*, *Albizia lebbeck* and remaining 50 per cent N *via.*, inorganic fertilizer gave maximum N, P and K uptake, NUE (29.72 kg ha^{-1}) and ENUE (₹ 4.97 ha^{-1}).

Keywords: direct sown rice, green leaf manuring, integrated nutrient management, nitrogen use efficiency

1. INTRODUCTION

In India lower productivity of rice is a major distress for food and nutritional security of more than 70 per cent population which is dependent on rice. Uncertainties of rainfall together with long dry spell, increasing scarcity of water, seasonality of labour demand are increasingly becoming a severe alarm for the timely transplanting of rice (Rex Immanuel *et al*., 2018a). In rice growing tail end coastal regions of Cauvery delta, there is an acute shortage of water for raising nursery and delayed transplanting, which caused reduced crop yield as well as failure of second crop. As a result, conventional transplanting is becoming difficult in terms of economics. To overcome these difficulties wet spot seeded rice in puddled soils can be a substitute for sustaining the small and marginal farmer's livelihood (Rex Immanuel *et al*., 2018b). The wet spot seeding of rice practices includes placing of single seeds in a widely spaced square pattern, weed management through mechanical means and water application as wet and dry cycles ultimately produce higher yields under resource constraint situation.

Inappropriate and unbalanced use of chemical fertilizers in cropping system leads to inconsistent nutrient availability and adverse effect on physico-chemical properties of soil which also leads to decline in crop yields. The integrated use of locally and cheaply available organic manures such as green leaf manures along with chemical fertilizers helps to maintain optimum crop yields and required soil nutrient pool on a sustained basis. Nutrient use efficiency (NUE) is a significantly important concept in the evaluation of crop production systems. It can be greatly impacted by fertilizer management as well as by soil and plant water management. The objective of nutrient use is to increase the overall performance in crop cultivation by providing economically optimum nourishment to the crop while minimizing nutrient losses from the field. Thus, there is a vast scope for increasing nutrient supply through use of green leaf manures and inorganic nutrients to improve the productivity of wet spot seeded rice.

2. MATERIALS AND METHODS

The field experiments were conducted at wetland block of Annamalai University Experimental Farm, Department of Agronomy, Annamalai University, Annamalainagar. The experimental farm is situated at 11°24′ North latitude, 79°44′ East longitude and at an altitude of +5.79 m above the mean sea level. The weather at Annamalainagar is moderately warm with hot summer months. The experiments were conducted during two seasons *viz.*, Thaladi (Sep. to Jan. 2010) and Navarai (Jan. to Apr 2011.). Thaladi season received a rainfall of 1121.95 mm distributed over 43 rainy days and Navarai season received 127.0 mm distributed over 6 rainy days. The experimental site also experiences, mean maximum temperature of 31.5°C and mean minimum temperature of 23.4°C with an average relative humidity of 89 per cent during Thaladi season while, the mean maximum temperature of 33°C, mean minimum temperature of 25.8°C and average relative humidity of 85 per cent during Navarai season. According to FAO/UNESOC (1974) the soil of the experimental farm is taxonomically classified as Udic Chromustert (clay). The soil is deep, moderately saline (7.2 and 8.3), EC (0.56 and 5.37 dSm^{-1}) low in organic carbon (0.23 and 0.47 %) and available nitrogen (227 and 213 kg ha^{-1}), medium in available phosphorus (17 and 18.5 kg ha^{-1}) and high in available potassium (346 and 298 kg ha^{-1}) in the first and second experiment, respectively.

The treatments comprised of four crop geometry in main plots (M_1: 40 × 40, M_2: 35 × 35, M_3: 30 × 30 and M_4: 25 × 25 cm) and four integrated nutrient management in sub plots (S_1: control, S_2 - 50 % N *via*., *Pongamia pinnata* and 50 % N *via*., urea, S_3: 50 % N *via*., *Albizia lebbeck* and 50 % N *via*., urea and S_4: 50 % N *via*., *Azadirachta indica* and 50 % N *via*., urea). The experiments were laid out in a split plot design and replicated thrice. Two rice varieties *viz*., CO 43 (medium duration) and ADT 43 (short duration) were used as test variety for Thaladi and Navarai season, respectively.

Azadirachta indica, *Albizia lebbeck and Pongamia pinnata* were selected as green leaf manuring species depending upon its easy availability in study area. The green foliage was obtained from the trees grown on the field bunds of the Experimental Farm and incorporated in the experimental plots as per the treatment schedule before puddling (15 DBS). As per the Tamil Nadu state government fertilizer recommendation (medium duration crop – 150 : 50 : 50 and short duration – 120 : 38 : 38 N, P_2O_5 and K_2O kg ha^{-1}, respectively) the required quantity of inorganic fertilizers worked out and applied in the form of urea, single super phosphate and muriate of potash. Nitrogen inorganic fertilizer was applied at three splits *viz*., 20 per cent at the appearance of 2^{nd} tiller, 40 per cent at maximum tillering and 40 per cent at panicle initiation stage, while the entire doses of phosphorus and potassium were applied at 15 DAS.

The seed rate used for treatments M_1, M_2, M_3 and M_4 were 12, 9, 6 and 5 kg ha^{-1}, respectively for Thaladi season (CO 43) and 7.5, 5, 4 and 3 kg ha^{-1}, respectively for Navarai season (ADT 43). The seeds were soaked in water for 24 hours and incubated in dark room for 24 hours. The sprouted seeds were used for sowing. Sprouted seeds were carefully spot sown @ 3 seeds per hole in the field with a thin film of standing water as per the treatment schedule. Depending on weather conditions plots were kept under a non-saturated condition during the vegetative phase (alternate wetting and drying method - application of 2 cm depth of water after the formation of hairline crack) was followed. Irrigation was withheld 12 days before harvest. Three series of weeding were done with a mechanical rotary weeder (cono weeder) on 15 DAS followed by 14 days interval. Need based plant protection measures were carried out based on the economic threshold level of insect pests and diseases.

Nitrogen use efficiency (NUE) was calculated in terms of seed yield per kg of nitrogen fertilizer applied. Economic nitrogen use efficiency (ENUE) was calculated in terms of seed yield $rupee^{-1}$ invested on nitrogen fertilizers. These were computed by using the formula suggested by Mikkelsen (1987).

3. RESULTS AND DISCUSSION

The uptake of nutrients *viz.*, N (110.36 and 104.98 kg ha^{-1}), P (36.56 and 34.44 kg ha^{-1}) and K (132.52 and 122.65 kg ha^{-1}) were significantly influenced by spot seeding of rice at 30 x 30 cm (M_2) spacing in Thaladi and 25 x 25 cm (M_1) spacing in Navarai season, respectively over other spacing's adopted. Optimum planting configuration enhanced the superiority of the growth characters such as LAI, root proliferation and finally DMP of the crop which facilitated higher accumulation of N, P and K in the foliage, reflecting better uptake of the

nutrients and higher nitrogen use efficiency. Similar findings were also reported by Baloch *et al*. (2002), Ranjitha *et al*. (2011) and Hardev Ram *et al*. (2014).

In respect of INM treatments, the experimental results revealed that green leaf manuring (GLM) treatments had noticeably increased the N, P and K uptake by rice over control. Among the different GLM treatments, the maximum uptake of nutrients (N: 110.01 and 105.65 kg ha^{-1}, P: 37.07 and 34.57 kg ha^{-1} and K: 134.83 and 123.31 kg ha^{-1} during Thaladi and Navarai seasons, respectively) was valued in integrated application of 50 per cent N *via.*, *Albizia lebbeck* and remaining 50 per cent N through urea fertilizer (S_3). The application of GLM reduces N losses and conserves soil N by mineralization and thus maintaining a continuous availability of N in the entire life cycle of rice plant which would resulted in enhanced total N uptake.

Table 1. Effect of crop geometry and integrated N management on nitrogen uptake of rice (kg ha^{-1})

Treatments	Thaladi (CO 43)					Navarai (ADT 43)				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
S_1	86.33	88.11	85.70	76.77	84.23	81.95	80.63	74.42	69.17	76.54
S_2	109.30	120.58	97.41	95.98	105.82	114.25	104.50	93.25	88.63	100.16
S_3	117.21	127.49	98.71	96.62	110.01	121.56	112.62	95.76	92.66	105.65
S_4	106.71	105.27	96.16	94.76	100.72	102.15	102.60	91.15	87.15	95.76
Mean	104.88	110.36	94.50	91.03		104.98	100.09	88.65	84.40	
	S. Ed		CD (0.05)			S. Ed		CD (0.05)		
M	2.63		5.27			2.06		4.12		
S	1.93		3.89			2.08		4.17		
MS	3.21		6.45			0.56		5.12		

Table 2. Effect of crop geometry and integrated N management on phosphorus uptake by rice (kg ha^{-1})

Treatments	Thaladi (CO 43)					Navarai (ADT 43)				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**	**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
S_1	18.27	18.82	15.51	11.42	16.01	17.12	16.58	13.21	9.58	14.12
S_2	38.16	44.38	26.59	24.66	33.45	41.64	35.56	26.12	23.64	31.74
S_3	43.94	49.13	29.35	25.88	37.07	45.85	40.12	27.85	24.45	34.57
S_4	36.28	33.89	25.26	23.98	29.85	33.15	34.18	24.40	22.74	28.62
Mean	34.16	36.56	24.18	21.49	29.10	34.44	31.61	22.90	20.10	
	S. Ed		CD (0.05)			S. Ed		CD (0.05)		
M	1.16		2.32			1.26		2.52		
S	1.48		2.99			1.37		2.74		
MS	2.00		4.01			1.64		3.31		

Further GLM enhanced the greater availability of P which enhanced the cambial activity of root hairs, involved in root cell development and enhanced the root proliferation and root biomass. It helps to allowing the plants to absorb higher quantity of essential nutrients such as N, P and K from applied and soil sources. Further, application of GLM's along with chemical fertilizer accelerates the microbial activity, increases nutrients use efficiency and enhanced the availability of the native nutrients to the plants resulting higher nutrient uptake was reported by Selvi *et al*. (2005), Banik *et al*. (2006), Gautam *et al*. (2008), Anitha and Mathew (2010) and Balaji (2012).

The results evidently indicated that interaction effect of different spacing adopted along with the integrated N treatments enhanced N, P and K uptake by rice. Among the treatment combinations, spot seeding of rice at 30 × 30 cm in Thaladi season and adopting 25 × 25 cm spacing in Navarai season along with integrated application of 50 per cent N *via.*, *Albizia lebbeck* GLM and 50 per cent N *via.*, urea fertilizer (M_1S_3) enhanced the uptake of major nutrients. Optimum spacing enhanced the architecture of shoots as well as roots to harvest the available resources. Moreover, incorporation of GLM along with split application of N, constantly supplied adequately all essential macro and micronutrients in the way of decomposition and release of fixed P and K from the clay micelle. These results also hold well with the views of Zoysa (1990), Mandal *et al*. (1992), Selvi and Kalpana (2009) and Ranjitha *et al*. (2011).

Table 3. Effect of crop geometry and integrated N management on potassium uptake by rice (kg ha^{-1})

Treatments	Thaladi (CO 43)					Navarai (ADT 43)				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	113.59	118.33	108.30	105.57	111.45	101.13	99.54	94.37	89.15	96.05
S_2	133.53	137.93	131.58	126.87	132.48	130.54	124.16	114.32	107.16	119.05
S_3	136.27	140.57	131.92	130.56	134.83	136.45	129.15	116.00	111.64	123.31
S_4	133.38	133.23	129.62	126.12	130.59	122.47	123.64	107.85	105.87	114.96
Mean	129.19	132.52	125.36	122.28		122.65	119.12	108.14	103.46	
	S. Ed		CD (0.05)			S. Ed		CD (0.05)		
M	1.49		3.00			1.48		2.96		
S	0.92		1.84			1.79		3.58		
MS	0.29		2.58			2.13		4.26		

Table 4. Effect of crop geometry and integrated N management on nitrogen use efficiency and (kg ha^{-1}) Economic Nitrogen Use Efficiency (Rs. ha^{-1})

Treatments	Nitrogen Use Efficiency (kg ha^{-1})		Economic Nitrogen Use Efficiency (Rs. ha^{-1})	
	Thaladi (CO 43)	Navarai (ADT 43)	Thaladi (CO 43)	Navarai (ADT 43)
M_1S_1	0.0	0.0	0.0	0.0
M_1S_2	17.32	24.08	2.89	4.02
M_1S_3	22.28	29.72	3.72	4.97
M_1S_4	16.50	16.01	2.76	2.67
M_2S_1	0.0	0.0	0.0	0.0
M_2S_2	23.32	20.45	3.90	3.42
M_2S_3	26.98	23.90	4.51	3.99
M_2S_4	14.28	19.97	2.38	3.34
M_3S_1	0.0	0.0	0.0	0.0
M_3S_2	12.98	15.41	2.17	2.57
M_3S_3	13.47	16.84	2.25	2.81
M_3S_4	11.41	12.86	1.90	2.15
M_4S_1	0.0	0.0	0.0	0.0
M_4S_2	14.41	15.95	2.41	2.66
M_4S_3	15.57	17.53	2.60	2.93
M_4S_4	13.76	13.10	2.30	2.19

In general, different crop geometry and integrated N management treatments had exhibited substantial difference in NUE and ENUE. Among the treatments tested, the crop raised by adopting 30 × 30 cm spacing along with integrated application of 50 per cent N *via., Albizia lebbeck* and remaining 50 per cent N *via.,* urea fertilizer (M_2S_3) recorded the highest NUE (26.98 kg ha^{-1}) and ENUE (₹ 4.51 ha^{-1}) for Thaladi season. This was followed by M_2S_2 (30 × 30 cm spacing with application of 50 % N *via., Azadirachta indica* with 50 % N *via.,* urea fertilizer). During Navarai season, crop planted by adopting 25 × 25 cm spacing along with application of 50 per cent N *via., Albizia lebbeck* and remaining 50 per cent N *via.,* urea fertilizer (M_1S_3) gave maximum NUE and ENUE by registering 29.72 kg ha^{-1} and ₹ 4.97 ha^{-1}, respectively. This might be due to the congenial environment in green leaf manuring for soil organisms involved in nutrient transformation which has increased the available nutrient status and retention capacity of nutrients and there by total nitrogen uptake by rice plant.

4. CONCLUSION

The rice crop raised by adopting spacing of 30 × 30 cm in Thaladi and 25 × 25 cm spacing in Navarai along with integrated application of 50 per cent N *via., Albizia lebbeck* and remaining 50 per cent N *via.,* urea fertilizer resulted maximum N, P and K uptake, nitrogen use efficiency and economic nitrogen use efficiency. This treatment combination paves way for sustainability in terms of higher economic nutrient use of wet spot seeded rice in Cauvery deltaic region under resource constraint situation.

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