Eco. Env. & Cons. 27 (August Suppl. Issue) : 2021; pp. (S443-S448)

ISSN 0971–765X

Effect of irrigation and nitrogen management practices of rice on nutrient uptake and availability of nutrient status in the soil under different establishment methods

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(Received 12 February, 2021; Accepted 14 April, 2021)

ABSTRACT

A field experiment was conducted on a clay loam soil at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR), Rajendranagar, Hyderabad, Telangana during the *kharif* seasons of 2015 and 2016 to study the "Assessment of production potential of rice with irrigation regimes and nitrogen management practices under different establishment methods". The treatments consisted of three establishment methods Normal transplanting (NTP), Mechanized System of Rice Intensification (MSRI) and Drum seeding (DS) as main plot treatments, two irrigation regimes continuous flooding, Alternate wetting and drying at 5cm depletion as sub plot treatments and two nitrogen management practices (RDN - 100 % through inorganic and RDN - 75 % inorganic and 25 % organic) as sub-sub plot treatments summing upto 12 treatment combinations laid out in split-split plot design with three replications. At harvest significantly higher uptake of N, P and K were noticed in MSRI but on par with NTP. N uptake was not found to be significantly different between irrigation regimes at 40, 70 and 100 DAS. The grain and straw uptake of N, P and K was higher with continuous flooding but it was on par with AWD with 5cmdepletion. Among nitrogen management practices significantly higher N uptake at all the crop growth stages were recorded with organic and inorganic combinations of nitrogen. At harvest uptakes of N, P and K were higher with RDN (75 % inorganic and 25 % organic) in grain and straw than RDN through inorganic source. Higher partial factor productivity of nitrogen, phosphorus and potassium was observed with MSRI than DS but it was comparable with NTP method. Between irrigation regimes, flooding recorded significantly higher partial factor productivity of N, P and K which was comparable with irrigation at 5 cm depletion. Soil available N, P and K was not influenced by establishment methods and irrigation regimes but nitrogen management shows the significant variation in available nutrient status of soil during both years of study.

Key words : *Nutrient uptake, Soil nutrient status, DS, MSRI, NTP*

Introduction

Rice (*Oryza sativa* (L.) is one of the most important staple food crops in the world. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived prod-

ucts. In India, rice occupies an area of 44.10 million ha with an average production of 105.3 million tonnes with a productivity of 2.38 t ha^{-1} against the world's average yield of 4.36 t ha^{1} (FAO STAT, 2014). Manual transplanting is the most common practice of rice cultivation in South and South East Asia. In India, 44 per cent area (19.6 million ha) is under transplanting in irrigated lowlands. It is not only time consuming, but also laborious requiring about 30 man days ha^{-1} besides causing drudgery to women folk. To overcome these difficulties transplanting can be substituted by direct seeding which could reduce labour needs by more than 20 per cent. As a solution to labour shortages and to reduce the production costs of rice farming, mechanization is one of the solutions. Water and nitrogen are two of the most important inputs in rice production. Saving water in rice production is crucial for food security in Asia, where more than 75% of the rice comes from the irrigated system. Among the various methods of water-saving irrigation, the most widely adopted is alternate wetting and drying (AWD) irrigation (Li *et al.*, 2003). The AWD irrigation aims in reducing water input and increasing water productivity while maintaining grain yield (Tabbal *et al.*, 2002). The combined use of organic manures and inorganic fertilizers help in maintaining yield stability and application of farm yard manure (FYM) to soil improves the physical, chemical and biological properties thereby improving the nutrient availability in soils.

Materials and Methods

The field experiments were carried out during *kharif*, 2015 and 2016 at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR) farm, Rajendranagar, Hyderabad. The experimental soil was clay loam in texture, alkaline in reaction. The fertility status of the experimental soil was low in organic carbon and available nitrogen, medium in available phosphorous and high in potassium.

The experiment was laid out in a split-split plot design with three establishment methods Normal transplanting (NTP), Mechanized System of Rice Intensification (MSRI) and Drum seeding (DS) as main plot treatments, two irrigation regimes continuous flooding, Alternate wetting and drying at 5cm depletion as sub plot treatments and two nitrogen management practices (RDN - 100 % through inorganic and RDN - 75 % inorganic and 25 % organic) as sub-sub plot treatments summing upto 12 treatment combinations and replicated thrice. The experimental field was provided with irrigation channels and the individual plots were demarcated by bunds. In drum seeding sprouted seeds were sown with manually operated rice drum seeder. Mechanical transplanting requires a special method of raising seedlings called "Dapog" or "mat type" seedlings. Recommended dose of nitrogen was applied through urea as inorganic source and organic source through vermicompost. The regular common irrigation practice was followed till 40 DAS for proper establishment. After 40 DAS, the irrigation schedules were adopted as per the treatment requirements.

Results and Discussion

Nitrogen uptake (kg ha^{-1})

The nitrogen uptake increased with age of crop and the highest nitrogen uptake was observed at harvest. Mean per cent increase in uptake with MSRI was (16.46, 16.84 and 16.36 % at 70 DAS, 11.72, 12.86 and 12.28 % at 100 DAS and 14.12, 14.72 and 14.43 % at harvest during 2015, 2016 and in pooled means, respectively) over drum seeding shown in Fig. 1. In case of both grain and straw, more nitrogen uptake was observed in MSRI (60.20 and 55.28 kg ha^{-1}) as compared to NTP (56.03 and 52.03 kg ha^{-1}) and drum seeding (52.35 and 47.19 kg ha^{-1}) of pooled means. The increase in nitrogen uptake with MSRI method could be attributed to large and functional root system and also higher dry matter production per unit area. These results are in agreement with

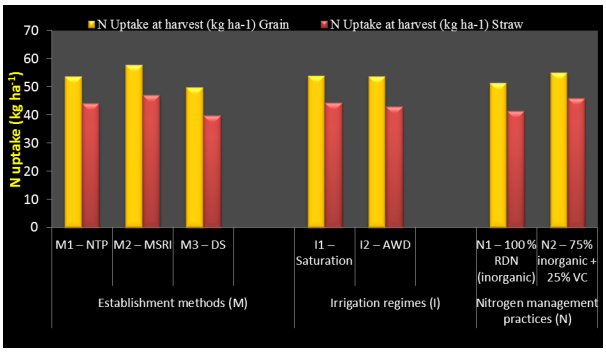

Fig. 1. N Uptake by grain and straw (kg ha^{-1}) at harvest of rice as influenced by establishment methods, irrigation regimes and nitrogen management practices during kharif pooled means

the findings of Chandrapala (2009); Hugar *et al*. (2009) and Thakur *et al*. (2013). Continuous flooding method of irrigation recorded higher N uptake but at par with irrigation at 5cmdepletion of water and at harvest (grain and straw) during both the years of study. This could be due to higher root volume which increased availability and efficient absorption from the soil and transport of nutrients from roots to shoots and grains with saturation. Similar results were observed by Kumar *et al*. (2014). Nitrogen uptake was significantly higher with RDN (75 % inorganic and 25 % organic) (104.8, 97.3 and 101.1 at harvest during both years and pooled means, respectively) over RDN through inorganic source (96.8, 88.9 and 92.8 harvest of pooled means, respectively). Similar trend of nitrogen uptake was found in both grain and straw during both the years of study and also in pooled means. Increased uptake might be due to higher availability of nutrients from the soil reserves and also from the added sources of organic manures (Priyadarsini and Prasad, 2003). These results are in tune with the findings of Kandeswari and Thava Prakash (2016).

Phosphorous uptake (kg ha^{-1})

significantly higher P uptake by grain and straw was recorded at harvest with mechanized system of rice intensification (21.78, 19.20, 15.53 and 13.73 kg ha^{-1} in grain and straw during 2015 and 2016 respectively) over drum seeding (16.01, 14.43, 11.68 and 10.93 kg ha^{-1}) in grain and straw during 2015 and 2016 respectively and on par with normal transplanting (19.69, 17.69, 14.02 and 12.85 kg ha^{-1} in grain and straw during 2015 and 2016 respectively). The higher uptake of phosphorous in MSRI was ascribed to higher root growth and greater volume soil available to individual hill to absorb water and nutrients under wider spacing (Anbumani *et al.*, 2004). Continuous irrigation method showed higher P uptake at harvest during both the years of study. Saturation (19.45 & 17.51 and 14.17 & 12.84 kg ha^{-1}) and irrigation at 5 cm depletion (18.87 & 16.70 and 13.31 & 12.15 kg ha^{-1}) during 2015 and 2016 respectively were statistically at par with each other. RDN (75 % inorganic and 25 % organic) management practice recorded significantly higher phosphorous uptake (20.03 & 18.09 and 14.70 & 13.37 kg ha^{-1} by grain and straw) during 2015 and 2016 respectively over RDN through inorganic source (18.64 & 16.44 and 13.28 & 12.12kg ha^{-1} by grain and straw) during 2015 and 2016 (Fig 2). The INM promoted nutrient utilization, accounting for better NPK uptake and NPK productivity of rice. Increased uptake might be due to higher availability of nutrients from the soil reservoir and also from the added sources of organic manures (Priyadarsini and Prasad, 2003).

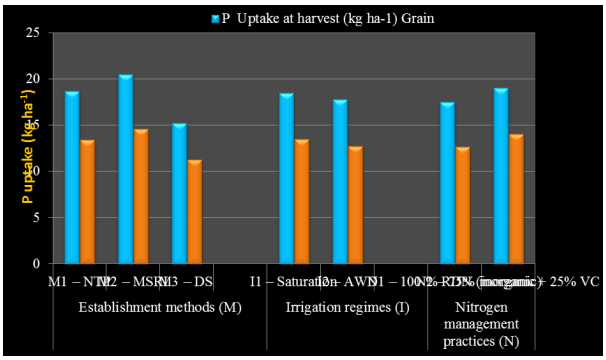

Fig. 2. P Uptake by grain and straw (kg ha^{-1}) at harvest of rice as influenced by establishment methods, irrigation regimes and nitrogen management practices during *kharif* pooled means

Potassium uptake (kg ha^{-1})

At harvest, significantly higher K uptake by grain and straw was recorded with mechanized system of rice intensification (13.03 & 11.23 and 48.36 & 44.36 kg ha^{-1} in grain and straw during 2015 and 2016 respectively) over drum seeding 10.20 & 8.80 and 40.92 & 38.42 kg ha^{-1}in grain and straw during 2015 and 2016, respectively and on par with normal transplanting (12.12 & 10.62 and 45.52 & 42.69 kg ha^{-1} in grain and straw during 2015 and 2016 respectively (Fig 3). While, significantly lower K uptake was associated with drum seeding, which was however, on par with NTP. The higher uptake of K with MSRI method might be due to the conducive physi-

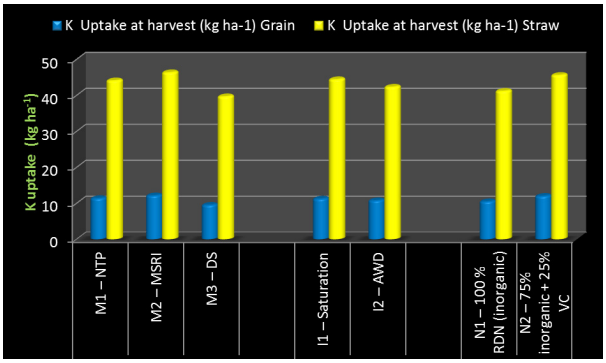

Fig. 3. K Uptake by grain and straw (kg ha^{-1}) at harvest of rice as influenced by establishment methods, irrigation regimes and nitrogen management practices during *kharif* pooled means

cal environment that was advantageous for better root growth and adsorption of native as well as applied source. Similar results were also reported by Chander and Pandey (1997), Anbumani *et al.* (2004) and Sandhya Kanthi *et al.,* 2014). The higher potassium uptake was observed in continuous flooding (12.02 & 10.45 and 45.95 and 42.90 kg ha^{-1}) at harvest by grain and straw during 2015 and 2016 respectively, which was at par with irrigation at 5cm depletion (11.55 & 9.98 and 43.92 & 40.75 kg ha^{-1}) at harvest by grain and straw during 2015 and 2016 respectively. Irrigation at 5cm with AWD might have affected some physiological processes such as transpiration rate which would decrease plant potassium uptake. Significantly higher potassium uptake was observed with RDN (75 % inorganic and 25 % organic) (12.77 & 11.20 and 47.20 & 44.03 kg ha^{-1}) at harvest by grain and straw during 2015 and 2016 respectively over 100% RDN through inorganic (11.27 & 9.69 and 42.71 & 39.64 kg ha^{-1}) at harvest by grain and straw during 2015 and 2016 respectively. The mean per cent decrease in potassium uptake with RDN was 11.74 and 13.48 %, 9.51 and 9.97 % of grain and straw as compared to RDN (75 % inorganic and 25 % organic) during 2015 and 2016 respectively. The INM promoted nutrient utilization, accounting for better NPK uptake and NPK productivity of rice.

Soil Nutrient Status

Soil available nitrogen, phosphorus and potassium were noted to vary significantly due to nitrogen management practices during both the years of study. There was no significant difference among establishment methods, irrigation regimes and interaction effect during both the years of study. Mechanized SRI method brought about little lower in residual status of nitrogen (189.2, 187.2 and 188.2 kg ha^{-1} in 2015, 2016 respectively) over NTP and drum seeding shown in Table 1.

In nitrogen management practices, application of RDN (75 % inorganic and 25 % organic) in spite of higher plant uptake recorded higher soil available nitrogen (196.8, 194.8 and 195.3 kg ha^{-1}). Vermicompost with slow release of nitrogen to the crop might have maintained a pool of soil nitrogen available to the crop. It was followed by nitrogen application of 100% RDN through inorganic (186.2, 183.0 and 184.6 kg ha^{-1}) during 2015, 2016 and in pooled means, respectively. The higher nitrogen content in vermicompost and its role in stimulating microbial activity lead to fixing atmospheric nitro-

Table 1. Available Soil nutrient status (kg ha^{-1}) after harvest of rice as influenced by establishment methods, irrigation regimes and nitrogen management practices during kharif 2015 and 2016

Treatments	Soil nutrient status (kg ha^{-1})								
	Available N			Available P_2O_5			Available K_2O		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Establishment methods (M)									
M_1 – Normal transplanting	190.0	188.8	189.4	47.6	48.1	47.9	482.4	484.1	483.3
M_2 – Mechanized SRI	189.2	187.2	188.2	49.4	49.5	49.5	488.1	490.6	489.3
M_3 – Drum seeding	191.0	188.5	189.8	47.3	47.8	47.6	480.4	482.1	481.3
S.Em±	1.8	2.3	2.0	0.9	0.7	0.8	3.9	3.8	3.8
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation regimes (I)									
I_1 – Continuous flooding	188.5	185.4	187.0	48.4	49.1	48.8	489.1	490.2	389.6
I_2 – AWD at 5cm depletion	195.0	193.0	194.0	47.8	47.8	47.8	478.2	481.0	379.6
S.Em.±	2.5	2.3	2.4	0.9	0.8	0.9	6.0	6.1	6.1
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen management practices (N)									
N_1 – 100 % RDN (inorganic)	186.2	183.0	184.6	46.7	46.7	46.7	474.1	474.1	474.1
N_2 – 75% inorganic + 25% organic	196.8	193.8	195.3	50.0	50.7	50.4	496.2	500.1	498.1
S.Em.±	3.0	2.7	2.8	1.1	1.3	1.1	8.0	8.1	8.0
C.D. at 5%	9.4	8.4	8.9	3.7	3.4	3.5	24.9	25.2	24.9
Interactions	NS	NS	NS	NS	NS	NS	NS	NS	NS
General Mean	190.9	188.5	189.7	48.2	48.5	48.4	484.1	486.0	485.0

gen and increased mineralization of organically bound soil nitrogen. Integrated use of organic manures and inorganic fertilizers is helpful in maintaining higher concentration of soil NH4+ N for a longer period and restore humus status of the soil ecosystem to holds its fertility and productivity, thus realizing higher N uptake of rice. Kabat *et al.* (2006).

Application RDN through 75 % inorganic and 25 % organic (50.07, 51.79 and 50.93 kg ha^{-1} in 2015, 2016 and in pooled means, respectively) recorded higher soil available P over other nitrogen management practices. These findings indicated that integrating the use of fertilizers with manure could enhance the available phosphorus content of soil as build up of available phosphorus. The significantly higher soil available K was recorded with RDN (75 % inorganic and 25 % organic) (496.2, 500.1 and 498.1 kg ha^{-1}in 2015, 2016 and pooled means, respectively) as compared to other nitrogen management practices. This might be due to excess quantity of K application led to increase in the available K in soil. Similar findings were also reported by Yaduvanshi (2001) and Jayadeva *et al*. (2010).

Conclusion

At harvest significantly higher uptake of N, P and K in grain and straw were noticed in MSRI but on par with NTP. N uptake was not found to be significantly different between irrigation regimes at 40, 70 and 100 DAS. The grain and straw uptake of N, P and K was higher with continuous flooding but it was on par with AWD with 5cmdepletion. Among nitrogen management practices significantly higher N uptake at all the crop growth stages were recorded with organic and inorganic combinations of nitrogen. At harvest uptakes of N, P and K were higher with RDN (75 % inorganic and 25 % organic) in grain and straw than RDN through inorganic source. Higher partial factor productivity of nitrogen, phosphorus and potassium was observed with MSRI than DS but it was comparable with NTP method. Between irrigation regimes, flooding recorded significantly higher partial factor productivity of N, P and K which was comparable with irrigation at 5 cm depletion. Soil available N, P and K was not influenced by establishment methods and irrigation regimes but nitrogen management shown the significant variation in available nutrient status of soil during both years of study.

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