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Studies on Nutrient Uptake, Use Efficiency and Yield in Different Rice (*Oryza sativa* L.) Establishment Methods under Nutrient Management Practices

K. Poojitha [a*] and G. R. Denesh [b#]

[a] College of Agriculture, V. C. Farm, Mandya, India.
[b] AICRP on Rice, ZARS, V. C. Farm, Mandya, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

The experiment was conducted at Zonal Agricultural Research Station, Vishwesharaiah Canal Farm, Mandya during 2018-19 to study the nutrient uptake (NPK), use efficiency and grain yield of rice (*Oryza sativa* L.) in different establishment methods under varied nutrient management practices. The experiment was laid out in a split plot design with three replications. The main plot comprised of three establishment methods *viz*., semi dry rice, drum seeded rice and transplanted rice and whereas the subplot had five nutrient management practices. The nitrogen, phosphorous and potash uptake by rice plant in grain, straw and total was statistically on par among establishment methods. Further, the application of 150% Recommended dose of inorganic fertilizers (RDIF) recorded significantly higher total nitrogen, phosphorus and potassium uptake. Among establishment methods, significantly higher Nitrogen Use Efficiency (NUE) was recorded in transplanted rice (64.40 kg kg^{-1}), but Phosphorus Use Efficiency (PUE) (88.38 to 101.72 kg kg^{-1}) and Potassium Use Efficiency (KUE) (114.76 to 129.82 kg kg^{-1}) recorded were statistically at par between establishment methods. The significantly higher NUE (90.73 kg kg^{-1}) in Leaf Color Chart (LCC) based nitrogen management, PUE (108.36 kg kg^{-1}) in nutrient management as per UAS (B) package of practices and KUE (149.16 kg kg^{-1}) in 100% RDIF treatments. The grain yield recoded was at par among rice establishment methods (5521 to 6242 kg ha^{-1}), however was superior in nutrient management with 150% RDIF (6687 kg ha^{-1}).

[#] Professor (Agronomy) and Scheme Head;
**Corresponding author: E-mail: poojitha054@gmail.com;*

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ABBREVIATIONS

RDIF : Recommended Dose of Inorganic Fertilizers
LCC : Leaf Color Chart
NUE : Nitrogen Use Efficiency
PUE : Phosphorus Use Efficiency
KUE : Potassium Use Efficiency,

1. INTRODUCTION

Rice is an important cereal food crop and it is the primary source of energy for over half of the world's population. Traditional method of rice establishment through transplanting is becoming difficult due to acute shortage of laborers, especially during the peak periods of operation. Besides, higher labour wages and reduced efficiency makes the transplanting the main cause for higher cost of rice cultivation. Direct seeding is becoming a popular alternative to transplanting system as it reduces labour requirement, cost of cultivation, shortens the duration of production by 7-10 days and provide comparable grain yield compared to transplanting [1]. Direct wet seeding of rice under puddle condition is also viable alternative technique for transplanting [2].

To achieve better growth and higher yield, requires balanced fertilization right from the very beginning of crop growth [3]. Application of optimum dose of nutrients is indispensable in crop production as it insures maximum economic benefit to the individual farmers as well as to the country [4]. Nutrient requirement may differ under various seeding methods. Hence, there is a need to evaluate alternate systems of rice crop establishment through direct seeding together with optimal nutrient dose to realize the production potential.

2. MATERIALS AND METHODS

The experiment was conducted at Zonal Agricultural Research Station, Vishwesharaiah Canal Farm, Mandya during 2018-19 to study the Nutrient uptake of rice (*Oryza sativa* L.) as influenced by different establishment methods and nutrient management practices. The location was situated at coordinates, 12° 57' N Latitude and 76° 82' E Longitude, with an Altitude of 757.10 m above mean sea level. The experimental soil was red sandy loam in texture with an average particle content of 53.45 per cent coarse sand, 14.78 per cent fine sand, 16.58 per cent silt and 15.19 per cent clay. The soil was neutral in reaction (pH 6.97), organic carbon content was medium (0.66%) with the electrical conductivity of 0.25 dSm^{-1}. The soil was low in available nitrogen (225.79 kg ha^{-1}) and high in available phosphorus (69.25 kg ha^{-1}) and medium in available potassium (276.26 kg ha^{-1}).

The experiment was laid out in a split plot design with three replications. The main plot comprised of three establishment methods *viz*., Semi dry rice, drum seeded rice and transplanted rice and whereas the subplot had five nutrient management practices *viz*.,100% Recommended dose of inorganic fertilizers (RDIF) (120:60:40 kg N: P_2O_5: K_2O ha^{-1}) as per National recommendation, 75% (RDIF) + 25% N equivalent FYM, 150% (RDIF), LCC based nitrogen application and Nutrient management as per UAS (B) package of practice (100:50:50 kg N: P_2O_5: K_2O ha^{-1}).

Semi dry rice was sown at the spacing of 25 X 10 cm as dry direct seeding in un-puddled soil, whereas spacing for drum seeding was 20 X 10 cm, sown by using sprouted seed in puddled soil. While traditional transplanting was planted by using 21 days aged seedlings from nursery with a spacing of 20 X10 cm. As per the treatment, full dose of phosphorus and potassium were applied as basal dose. Whereas, nitrogen was applied in 3 spits as half of the recommended dose at basal and remaining as top dress in two equal splits at 50 and 75 days as per the treatments. While, in LCC based nitrogen management after basal application, the first dose of 25 kg/ha nitrogen was supplied at 21 days in direct seeded rice and 14 days in transplanted rice when 6 of 10 LCC readings below the critical value of 4 and 3, respectively at an interval of 10 days up to flowering. The nutrient use efficiency of nitrogen, phosphorous and potash were separately worked out by using grain yield produced per kg of nutrient applied.

3. RESULTS AND DISCUSSION

3.1 Nitrogen, Phosphorous and Potash Uptake

The nitrogen, phosphorous and potash uptake by rice plant in grain, straw and total was statistically on par among establishment methods (Table 1). However, higher total nitrogen, phosphorous and

potash uptake by rice was found in the block with transplanting method establishment (123.24, 34.71 and 93.39 kg ha^{-1}, respectively). Different management practices produced statistically significant variations in the nitrogen, phosphorus and potassium uptake by the rice plant observed in the grain, straw and total. Application of 150% RDIF recorded significantly higher total nitrogen, phosphorous and potash uptake (133.3, 37.55 and 99.71 kg ha^{-1}, respectively) as compared to rest of the nutrient managements except with 100% RDIF for total phosphorous and potash uptake (34.28 and 95.20 kg/ha, respectively) (Table 1).

Between methods of rice establishment, the different land preparation, planting and submergence did not cause significant differences in uptake of nitrogen, phosphorus and potassium by rice crop. This might be due to the fact that uptake mechanism of nutrients by rice was not significantly affected by soil or establishment manipulation, and it was mainly dependent on varietal or crop characteristic. These results are in line with Sandhya et al. [5,6].

Further, the application of 150% RDIF recorded significantly higher total nitrogen, phosphorus and potassium uptake as compared to rest of the nutrient management practices but was statistically similar with 100% RDIF except for total N uptake. The higher nutrient uptake with 150% RDIF was due to addition of 60 to 80 kg ha^{-1} of nitrogen, 30 to 40 kg ha^{-1} of phosphorus, 10 to 20 kg ha^{-1} of potassium in excess as resulted in adequate availability from the soil for plant uptake and therefor by higher accumulation in the plant. The results are in conformity with Murthy et al. [7] and Ghansham et al. [8]. The application of 100% RDIF (120:60:40 kg N: P_2O_5: K_2O ha^{-1}) also provided higher uptake of phosphorus and potassium that was statistically comparable to the 150% RDIF. This indicates that the quantity of nutrient uptake was basically decided by plant ability to absorb and accumulate nutrients from the soil rather than from the excess application. The results obtained are in line with Sandhya et al. [5,6]. The establishment methods and nutrient management practices did not have influence on nitrogen, phosphorus and potassium uptake in grain, straw and total of rice plant (Table 1).

3.2 Nitrogen Use Efficiency (NUE) (kg kg^{-1})

Among establishment methods, higher nitrogen use efficiency was recorded in transplanted rice (64.40 kg kg^{-1}), followed by drum seeded rice (54.95 kg kg^{-1}), and was significantly superior over semi dry rice (47.02 kg kg^{-1}), This might be due to puddling of land in transplanted and drum seeded rice which created an ideal rhizosphere environment for rice crop to uptake more nitrogen and produce higher biomass yield as resulted in higher nitrogen use efficiency. These results obtained are in line with Ali et al. [9].

Among nutrient management practices, significantly higher nitrogen use efficiency was recorded in LCC based nitrogen management (90.73 kg kg^{-1}) as compared to the other nutrient management practices (37.15 to 54.18 kg kg^{-1}) while, 150% RDIF recorded lowest N use efficiency (37.15 kg kg^{-1}) in the experiment. Also, interaction effect of LCC based nitrogen application with transplanted rice, showed statistically higher nitrogen use efficiency (120.48 kg kg^{-1}) as compared to the rest of the interaction effects (36.10 to 88.66 kg kg^{-1}). This could be because lower total average nitrogen of 70 kg ha^{-1} was used for precision N management with LCC chart as compared to the rest of the treatments where total nitrogen used was 100 to 180 kg ha^{-1}. The similar results were also reported by Prakhar et al. [10].

3.3 Phosphorous Usze Efficiency (PUE) (kg kg^{-1})

There was no significant difference between establishment methods (88.38 to 101.72 kg kg^{-1}) and interaction effect between establishment methods and nutrient management practices (72.20 to 107.83 kg kg^{-1}) with respect to phosphorus use efficiency as due to not much variation in paddy yield for applied phosphorous fertilizer under different land preparation, planting and submergence in establishment methods. These results are in line with Sandhya et al. [5,6].

Nutrient management UAS (B) package of practice showed significantly higher phosphorus use efficiency (108.36 kg kg^{-1}) compared to the rest of the treatments (74.30 to 99.44 kg kg^{-1}). This was because of lower application of 50 kg P_2O_5 ha^{-1} under this treatment, might be sufficient for the crop to absorb adequate quantity and meet requirement during the growing period to produce comparable grain yield as compared to rest of the treatments where phosphorus was applied at 60 to 90 kg P_2O_5 ha^{-1}. The similar results were also reported by Dwivedi and Singh [11].

Table 1. Nitrogen, phosphorus and potassium uptake by rice plant (grain, straw and total) at harvest as influenced by establishment methods and nutrient management practices

Treatment		Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Main plot: Establishment methods (M)										
M_1	Semi dry rice	67.49	44.64	112.14	20.84	10.65	31.49	18.76	68.38	87.14
M_2	Drum seeded rice	71.03	46.69	117.72	21.97	11.10	33.06	19.73	71.73	91.45
M_3	Transplanted rice	76.22	47.03	123.24	23.56	11.15	34.71	21.15	72.24	93.39
S.Em ±		2.17	1.61	4.41	0.92	0.66	1.57	0.89	1.78	3.33
CD (p=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot: Nutrient management practices (S)										
S_1	100% RDIF	74.90	48.10	123.00	22.80	11.48	34.28	20.60	74.60	95.20
S_2	75% RDIF+ 25% N equivalent FYM	66.40	43.30	109.70	21.80	9.76	31.56	18.67	70.40	89.07
S_3	150% RDIF	82.10	51.20	133.31	24.20	13.35	37.55	23.40	76.30	99.71
S_4	LCC based N application	70.20	45.40	115.60	22.30	10.95	33.25	19.43	62.70	82.13
S_5	Nutrient management as per UAS (B) POP	64.30	42.60	106.90	19.50	9.30	28.80	17.30	69.90	87.20
S.Em ±		1.60	1.24	3.11	0.74	0.66	1.39	0.70	1.93	2.59
CD (p=0.05)		4.67	3.63	9.09	2.15	1.92	4.05	2.04	5.62	7.57
Interaction										
S.Em ±		3.29	2.51	6.53	1.46	1.21	2.67	1.40	3.47	5.22
CD (p=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Grain and straw yield, Nitrogen, phosphorus and potassium use efficiency of rice as influenced by establishment methods and nutrient management practices

Treatment		Nitrogen use efficiency (kg grain kg^{-1} N)	Phosphorus use efficiency (kg grain kg^{-1} P_2O_5)	Potassium use efficiency (kg grain kg^{-1} K_2O)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Main plot: Establishment methods (M)						
M_1	Semi dry rice	47.02	88.38	114.76	5521	6682
M_2	Drum seeded rice	54.95	94.28	120.73	5815	6964
M_3	Transplanted rice	64.40	101.72	129.82	6242	7000
S.Em ±		3.04	3.89	5.12	248	434
CD (p=0.05)		11.92	NS	NS	NS	NS
Sub plot: Nutrient management practices (S)						
S_1	100% RDIF	49.72	99.44	149.16	5966	6864
S_2	75% RDIF+ 25% N equivalent FYM	45.50	95.79	95.79	5460	6134
S_3	150% RDIF	37.15	74.30	111.45	6687	8451
S_4	LCC based N application	90.73	96.06	144.09	5764	6868
S_5	Nutrient management as per UAS (B) POP	54.18	108.36	108.36	5418	6093
S.Em ±		3.25	2.96	4.08	186	242
CD (p=0.05)		9.48	8.63	11.92	542	706
Interaction						
S.Em ±		5.88	6.01	8.14	380	537
CD (p=0.05)		16.43	NS	NS	NS	NS

RDIF: Recommended dose of inorganic fertilizers

3.4 Potassium Use Efficiency (KUE) (kg kg^{-1})

There was no significant difference between establishment methods (114.76 to 129.82 kg kg^{-1}) and interaction between establishment methods and nutrient management practices (85.81 to 158.44 kg kg^{-1}). In respect to the potassium use efficiency, there was no significant variation in grain yield. Our results are in line with Sandhya et al. [5,6].

Among the nutrient management practices, 100% RDIF showed significantly higher potassium use efficiency (149.16 kg kg^{-1}) over other treatments (95.79 to 111.45 kg kg^{-1}), but was on par with LCC based nitrogen application (144.09 kg kg^{-1}). This was mainly contributed to lower application @ 50 kg K_2O ha^{-1} . Under these treatments, it might be sufficient to soil saturation for adequate availability and optimum uptake to produce comparable grain yield of rice. The results are in line with Dwivedi and Singh [11].

3.5 Grain and Straw Yield (kg ha^{-1})

Transplanting method of rice establishment provided higher grain and straw yield (6242 and 7000 kg ha^{-1}, respectively). However, statistically, there was no significant difference compared to drum seeding and semidry rice due to plasticity of rice to adjust varied aerobic and anaerobic soil condition for nutrient uptake for the production of similar levels of growth and yield parameters. The results are in conformity with Sandhya et al. [5,6].

Among nutrient management practices, application of 150% RDIF recorded significantly higher grain and straw yield (6687 and 8451 kg ha^{-1}, respectively) as compared to rest of the nutrient management practices (5418 to 5996 and 6093 to 6868 kg ha^{-1}, respectively) (Table 2). This could be attributed to the additional application of 60 to 80 kg N ha^{-1}, 30 to 40 kg P_2O_5 ha^{-1}, 10 to 20 kg K_2O ha^{-1} in the treatment makes the adequate available of soil nutrients for uptake of rice plant throughout the crop growth stages, especially for nitrogen, which intern resulted in higher and optimum photosynthetic activity in the plant for the production of growth and yield parameters. The overall effect contributed for superior grain and straw yield production with 150% RDIF. The results are in conformity work of Priyanka et al., [12] for phosphorous usage and Murthy et al. [7] for other elements.

Statistical analysis of the interaction effect between establishment methods and nutrient management practices for grain and straw yield is presented in (Table 2) [13].

4. CONCLUSION

From this study it can be inferred that, rice establishment either with drum seeding (wet direct seeding) or semi dry (dry direct sowing) or transplanted rice could not cause significant variation in nutrient uptake, use efficiency and grain yield, except for higher nitrogen use efficiency in transplanted rice. Further, no doubts on nutrient management with 150% RDIF for significant influence on nutrient uptake and grain yield of rice, but was not superior in nutrient use efficiency.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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