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Integrated Nutrient Management with Biofertilizers in Different Genotypes of Rice Sown under Aerobic Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aerobic rice is a new way of cultivating rice that requires less water than lowland rice. A field experiment was conducted during the kharif season of 2015 to evaluate the effects of nutrient management with Biofertilizers on growth and yield attributes, yield, nutrient uptake and economics different rice cultivars. The experiment was laid out split plot design with four replications. Main plot treatments consisted of two cultivars viz., whereas, sub plot treatments comprised of nutrient management practices namely, N_1-125% RDF, N_2-125% RDF + Biofertilizers, N_3 -100% RDF, N_4 - 100% RDF + Biofertilizers, N_5-75% RDF, N_6-75% RDF + Biofertilizers. The source of biofertiliser was a combination of *Azospirillum,* Phosphorus Solubilizing Bacteria and Potassium Solubilizer applied @ 5 kg/ha^{-1}. Crop dry matter production (2582.3 g/m^2), root dry matter production (910.1 g/m^2), tillers/m^2 (566), leaf area index (4.54), panicles/m^2 (535), panicle length (23.81), panicle weight (4.56) and test weight (25.3) was higher in PA 6444 compared to DRR Dhan 44. Higher uptake of nutrients was also observed in PA 6444. Rice fertilized with 125% RDF + Biofertilizers (N_2) produced higher crop (2901.6 g/m^2) and root dry matter production (1028.1 g/m^2), tillers/m^2 (561) and leaf area index (5.19). This treatment also recorded higher yield attributes and grain yield (3.55

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t/ha). With respect to nutrient uptake, application of 125% RDF + Biofertilizers (N_2) recorded higher N, P and K uptake by grain and straw and higher profitability (1.57) than other nutrient combinations.

Keywords: Aerobic rice; nutrient management; cultivar; water saving; nutrient uptake.

1. INTRODUCTION

Rice (*Oryza sativa* L.) consumes about 90 % of the fresh water resources in Asia used for agriculture. The demand for water is expected to increase to 140 million tones by 2025 [1]. There is an urgent need to develop water effective rice technologies for sustainable crop production. A new development in this regard is the concept of “aerobic rice”. In this system, rice is grown with the use of external inputs such as supplementary irrigation and fertilizers and aiming at high yields [2] than the traditional flooded rice. It saves water by eliminating continuous seepage and percolation, reduces evaporation and eliminates wet land preparation [3]. For growing rice under aerobic conditions, there is a need to select and grow varieties which are having drought resistant capability and are suitable to be grown under water limited conditions.

Variety has a large influence on the grain yield of rice sown under dry conditions. The development of varieties which can efficiently and economically optimise applied fertilizer and enhance nutrient use efficiency is important for enhancing crop productivity and maintaining environmental sustainability [4]. Literature regarding the adaptability of irrigated lowland rice varieties with higher yield potential in direct-seeded rice system is still lacking and needs the focus of the researchers.

Nutrition is critical in yield realization of aerobic rice systems. The chemical fertilisers required for producing the crop are costlier and also N and P use efficacy (NPUE) in rice is very low. Heavy and continuous use of inorganic fertilisers create many problems like declining trend in productivity, water pollution and soil degradation etc. Hence, now emphasis is being laid on the use of nitrogenous fertiliser along with bio-inoculants/Biofertilizers such as Azotobacter and Azospirilum [5]. Further, excessive application of P fertilizers can have a negative impact on the environment, which can be avoided by applying phosphate solubilising bacteria (*Bacillus* and *Pseudomonas* spp.). Among the several plant microbes, Azotobacter and Azospirillum were found to be ideally suited as microbial inoculants for cereal crops under tropical conditions. Of later, phosphorus solubilising bacteria have also emerged as a potential source of phosphorus nutrition for plants. The study was taken up with an objective to investigate the effect nutrient management practices on different drought tolerant varieties and to understand how different nutrient management practices influenced crop growth, yield attributes, yield as well as profitability to the farmers.

2. MATERIALS AND METHODS

A field experiment was conducted during the kharif season of 2015 at the research farm of the ICAR-Indian Institute of Rice Research (IIRR), Hyderabad, Telangana State. The farm is geographically situated at an altitude of 542.7m above mean sea level on 17°19” N latitude and 78°29” E longitudes. The study was taken up on a sandy loamy in texture and alkaline in reaction (pH 8.08, EC: 0.74 dS/m). The experiment was laid out in split plot design with four replications using V_1-PA-6444 (Hybrid), V_2-DRR Dhan-44 (HYV) in main plots and six nutrient management combinations in sub plots viz., N_1-125% RDF (Recommended dose of fertilizer), N_2 -125% RDF + Biofertilizers, N_3 -100% RDF, N_4 -100% RDF + Biofertilizers, N_5-75% RDF, N_6-75% RDF + Biofertilizers during 2016. Recommended dose of fertilizers (120 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) was applied in all the treatments. Urea, Diammonium phosphate and Muriate of potash was used as a source of fertiliser. Entire dose of phosphorous and potassium and half of nitrogen were applied as basal at the time of sowing. The remaining dose of nitrogen was top dressed equally at active tillering and panicle initiation stages as per treatments. *Azospirillum,* Phosphorus Solubilizing Bacteria and Potassium Solubilizer were applied as Biofertilizers @ 5 kg/ha. The plot size was 4.5 m × 2.5 m (11.25 m^2). The rice seed was directly sown by dibbling in lines in the dry field at a depth of 3-5 cm. In Biofertilizer treatment plots, Biofertilizers treated seed was dibbled two to three seed/hill with a spacing of 20X10 cm. After sowing, immediately light irrigation was applied through border strip method. Subsequent irrigation was given as and when needed, for proper growth and development of the crop.

The growth parameters were recorded at 90 DAS of crop, yield attributes and yield were collected at the time of harvest and nutrient content in grain and straw was analysed after the harvest of the crop. The collected data was statistically analysed and presented in tables. The plant height was recorded from five hills using a meter scale from the base of the plant to the tip of the longest leaf or the panicle and expressed as centimeters. The number of tillers were counted and recorded from the five hills within the net plot area from each plot expressed as number/m^2.

The number of panicles in square meter area of each plot treatment wise was counted at maturity, averaged and expressed as number of panicles/m^2. Ten panicles were randomly selected and length of each panicle was measured from base of the primary rachis to the top most spikelet and was weighed and then mean was worked out and expressed in g. After harvest and threshing, the crop produce was sundried, cleaned, weighed and expressed in t/ha at 12 to 14 per cent moisture content in grain. Straw obtained from each net plot area after threshing was sun dried for four days and then weighed and expressed in t/ha. Dried seed samples were drawn randomly from each treatment plot produce and 100 grains were counted and their weight was recorded.

Harvest index was calculated by using the following formula

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

The gross return was obtained by converting harvest into monetary terms at the prevailing market price. Net return was obtained by deducting cost of cultivation from gross returns, whereas the B:C ratio of each treatment was calculated by dividing net returns by cost of cultivation of respective treatments.

The nutrient uptake by grain and straw was calculated by multiplying nutrient content in the grain and straw with the respective dry matter production (kg/ha) and divided by hundred and expressed in kg/ha.

The data was subjected to analysis of variance to determine the influence of treatments [6]. Data was analysed using analysis of variance (ANOVA) to evaluate the differences among the treatments. The statistical model used included sources of variation due to replication, varieties, nutrient management practices and interaction effect of varieties x nutrient management practices. Differences due to treatments were judged by least significant difference (LSD) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Maximum crop dry matter production (2582.3 g/m^2), root dry matter production (910 g/m^2), number of tillers/m^2 (566), leaf area index (4.54) was observed in PA-6444 over DRR Dhan-44 (Table 1). The number of tillers m^{-2} recorded in PA-6444 was significantly more by 25.31% over DRR Dhan-44. This can be attributed to hybrid vigour and rapid conversion of synthesized carbohydrates to increase the number and size of growing cells, resulting in increased number of tillers and is in agreement with the findings of Dinesh et al. [7]. More crop dry matter production in PA-6444 was mainly due to more number of tillers m^{-2} and higher leaf area index which increased the photosynthetic rate. PA-6444 recorded higher root dry matter production due to its hybrid vigour and synergistic relationship of the inoculated Biofertilizers, improving the root length and root weight by producing growth regulators like IAA and GA which favour better root development. Similar results were reported by Afzal and Bano [8].

Application of 125 per cent RDF + Biofertilizers (N_2) recorded significantly higher crop dry matter production (2901.6 g m^{-2}), root dry matter production (1028 g/m^2), number of tillers/m^2 (561). It was found to be on par with N_1-125 per cent RDF and N_4 -100 per cent RDF + Biofertilizers and lowest was observed in N_5-75 per cent RDF. Higher N application rates resulted in higher growth attributes but the difference between 125% RDF + Biofertilizer and 100% RDF + biofertiliser was not significant. Higher growth attributes might be due to added beneficial effect from inorganic nutrients integrated with Biofertilizers leading to continuous nutrient release through mineralization which enhanced the plant growth and canopy development as agreed by Babu and Reddy [9]. The interaction between the cultivars and treatments was found to be significant for crop dry matter production and number of tillers/m^2.

3.2 Yield Attributes

In PA 6444, higher number of panicles (535/m^2), panicle length (23.81 cm), panicle weight (4.56 g), 1000 grain weight (25.3 g) was obtained compared to DRR Dhan-44 (493/m^2, 22.81 cm, 4.17 g and 23.5 g respectively). The increase in hundred grain weight was significantly more by 7.65% in PA-6444 over DRR Dhan-44 (Table 2).

Among the nutrient management practices, significantly higher number of panicles/m^2 (532), panicle length (25.6 cm), panicle weight (5.07 g) and 1000 grain weight (25.2 g) was recorded in N_2-125 per cent RDF + Biofertilizers and was comparable with N_1-125 per cent RDF and N_4-100 per cent RDF + Biofertilizers. More yield attributes can be attributed to increased nutrient supply at distinct physiological phase, which might have supported better assimilation of photosynthates and translocation to the sink, resulting in the production of more number of panicles/m^2 at higher nutrient level. The lowest number of panicles/m^2 (489) and panicle length (21.74 cm) was noticed in N_5-75 per cent RDF. The increase in yield attributes can be attributed to the more availability of macronutrients during panicle differentiation stage which increased the yield attributes.

The interaction effect between the cultivars and treatments was found significant in case of panicle length. This was mainly due to increase in dry matter production and enhanced uptake of nutrients.

3.3 Yield

PA-6444 produced significantly higher grain (3.40 t/ha) and straw yield (4.53 t/ ha) over DRR Dhan-44 (2.75 t/ha and 3.56 t/ha, respectively). Increase in the grain yield of PA-6444 is mainly due to its superiority in production of higher number of productive tillers/m^2, dry matter production and more number of panicles/m^2. PA-6444 produced over 23.71% and 27.33% more grain and straw yield compared to DRR Dhan-44. The results are in agreement with the findings of earlier researcher [10] (Table 2).

With respect to nutrient levels, 125 per cent RDF + Biofertilizers (N_2) recorded significantly higher grain yield (3.55 t/ha), straw yield (4.62 t/ha) and was comparable with 125 per cent RDF and 100 per cent RDF + Biofertilizers. The lowest grain and straw yield was recorded in N_5-75 per cent RDF (2.69 t/ha and 3.43 t/ha). Combined inoculation of *Azosprillium* + Phosphorus Solubilising Bacteria with 100 per cent RDF gave markedly higher yield over 75 per cent RDF alone [11]. The interaction between cultivars and treatments was found significant in case of grain yield.

Table 1. Effect of cultivars and graded nutrient levels on growth parameters of aerobic rice

Treatments	Growth attributes			
	Crop dry matter (g/m^2)	Root dry matter (g/m^2)	Tillers/m^2	LAI
Main factors: Cultivars (V)				
V_1- PA-6444	2582	910	566	4.54
V_2- DRR Dhan-44	2413	679	523	3.65
LSD(P= 0.05)	1.89	65.13	0.38	0.06
Sub factors: Nutrient levels (N)				
N_1- 125% RDF	2900.71	1026	560	5.1
N_2- 125%RDF+Biofertilizers*	2901.6	1028	561	5.2
N_3- 100% RDF	2332.5	713.4	541	4.2
N_4- 100%RDF+Biofertilizers*	2901.04	1025	560	5.07
N_5- 75% RDF	1916.56	461.9	521	2.03
N_6- 75%RDF+Biofertilizers*	2035	512.2	524	3.0
LSD(P= 0.05)	2.1	69.15	0.75	0.21
Interaction: (V x N)				
LSD(P= 0.05)	4.62	NS	1.44	NS

Table 2. Effect of cultivars and graded nutrient levels on yield attributes, yield and economics at harvest of aerobic rice

Treatments	No. of panicles/m^2	Panicle length (cm)	Panicle weight (g)	Test weight (g)	Grain yield (t/ ha)	Straw yield (t/ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
Main factors: Cultivars (V)									
V_1- PA-6444	535	23.81	4.56	25.3	3.40	4.53	60426	41698	2.23
V_2- DRR Dhan-44	493	22.81	4.17	23.5	2.75	3.56	46348	28149	1.55
LSD(P= 0.05)	19.11	1.92	3.96	0.03	0.96	1.26	-	-	-
Sub factors: Nutrient levels (N)									
N_1- 125% RDF	529	25.36	4.83	25.1	3.46	4.38	58927	35548	1.52
N_2- 125%RDF+Biofertilizers*	532	25.6	5.07	25.2	3.55	4.62	60881	37202	1.57
N_3- 100% RDF	510	21.56	3.95	24.0	2.93	3.87	50245	27849	1.24
N_4- 100%RDF+Biofertilizers*	529	25.29	4.74	25.1	3.33	4.34	57118	34421	1.51
N_5- 75% RDF	489	21.74	3.66	23.4	2.69	3.43	45145	23732	1.11
N_6- 75%RDF+Biofertilizers*	494	23.52	3.96	23.8	2.76	3.63	47368	25654	1.18
LSD(P= 0.05)	61.71	0.39	0.36	0.10	0.27	3.52	-	-	-
Interaction: (V x N)									
LSD(P= 0.05)	NS	1.05	NS	NS	2.37	NS	-	-	-

**Biofertilizers (Azospirillum + Phosphorus Solubilising Bacteria + Potassium Solubilizer)*

Table 3. Effect of cultivars and graded level of nutrients on nutrient uptake by grain and straw of aerobic rice

Treatments	**Nutrient Uptake by grain (kg/ha)**			**Nutrient uptake by straw (kg/ha)**		
	N	**P**	**K**	**N**	**P**	**K**
Main factors: Cultivars (V)						
V_1- PA- 6444	53.06	11.61	14.94	15.77	4.0	51.32
V_2- DRR Dhan- 44	45.32	7.44	13.42	11.05	3.16	39.63
LSD(P= 0.05)	0.51	0.48	0.27	0.69	0.18	0.18
Sub factors: Nutrient levels (N)						
N_1- 125% RDF	52.91	11.25	15.55	16.44	3.88	47.75
N_2- 125%RDF+Biofertilizers*	53.46	11.44	15.82	17.03	4.11	48.24
N_3- 100% RDF	48.96	8.42	14.15	12.42	3.7	44.86
N_4- 100%RDF+Biofertilizers*	52.36	11.23	15.48	16.4	3.77	47.26
N_5- 75% RDF	44.86	6.82	11.04	10.07	2.85	42.53
N_6- 75%RDF+Biofertilizers*	46.01	7.99	13.02	12.39	3.18	43.64
LSD(P= 0.05)	0.57	0.45	0.45	0.72	0.42	0.51
Interaction: (V x N)						
LSD (P=0.05)	1.26	1.2	0.63	1.71	0.45	0.48

3.4 Nutrient Uptake by Crop

The maximum nitrogen uptake by grain (53.06 kg/ha) and straw (15.77 kg/ha) was recorded in PA-6444 over DRR Dhan 44 (45.32 kg/ha and 11.05 kg/ha, respectively). With respect to phosphorus uptake, significantly higher phosphorus uptake in grain (11.61 kg/ha) and straw (4 kg/ha) was noted in PA 6444 over DRR Dhan 44 (7.44 kg/ha and 3.16 kg/ha, respectively). The maximum potassium uptake by grain (14.94 kg/ha) and straw (51.32 kg/ ha) was noted in PA-6444 over DRR Dhan 44 (13.42 kg/ha and 39.63 kg/ha, respectively), which was similar to trend observed in nitrogen and phosphorus uptake in grain and straw (Table 3). The higher nutrient uptake in PA 6444 can be attributed to higher root development and dry matter production.

Among the varied nutrient levels, N_2- 125 per cent RDF + Biofertilizers recorded the higher nitrogen uptake by grain (53.46 kg/ha) and straw (17.03 kg/ha) and was comparable with N_1-125 per cent RDF and N_4-100 per cent RDF + Biofertilizers. Similarly, application of 125 per cent RDF + Biofertilizers recorded higher phosphorus and potassium uptake by grain (11.41 and 15.82 kg/ha) and straw (4.11 and 48.24 kg/ha) and was on par with N_1-125 per cent RDF and N_4-100 per cent RDF + Biofertilizers. The lowest nutrient uptake by both grain and straw was recorded in N_5- 75 per cent RDF. Inoculation of Biofertilizers enhanced the N, P and K uptake in grain and straw of rice and similar result has been reported by Islam et al. [12]. This might be due to the reason that Biofertilizers like PSB solubilized the fixed P and made it available to the plant according to Panhwar et al. [13]. PSB also solubilized NPK and increased the availability of nutrients for plant growth according to Yaduvanshi and Sharma [14].

The interaction between cultivars and treatments for N, P and K uptake was found to be significant which might be due to adequate supply of nitrogen through conjunctive use of inorganic nutrients and Biofertilizers combine with less nutrient loss due to presence of moisture at field capacity and is supported by the findings of Sreedevi et al. [15], Raki [16].

3.5 Economics

The total gross returns was recorded highest in PA-6444 (Rs. 60,427/ha) over DRR Dhan 44 (Rs. 46,348/ha) due to higher grain yield. Similar trend was observed for net returns, where PA-6444 yielded higher net returns (Rs. 41,698/ha) over DRR Dhan 44 (Rs. 28,149/ ha). These results are in concurrence with the findings of Ramanjaneyulu et al. [17].

Among the nutrient management practices, higher gross returns was recorded in N_2-125% RDF + Biofertilizers (Rs. 60,881/ha) followed by N_1- 125% RDF (Rs. 58,927/ha). The interaction effect between cultivars and nutrient management was found to be significant for gross returns, net returns and B:C ratio.

4. CONCLUSION

PA-6444 with nutrient management of 125% RDF + Biofertilizers was found to be an effective combination for enhancing the yield attributes, yield as well as profitability to the farmers. NPK uptake by grain as well as straw was found to be higher with PA 6444 with 125% RDF + Biofertilizers as compared to rest of the treatments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Singh RP, Singh CM, Singh AK. Effect of crop establishment methods, split application of nitrogen and weed management on growth analysis of rice (*Oryza sativa* L.). Oryza. 2004;41(3&4): 120-124.
2. Wang H, Bouman BAM, Dhule, Zhao WC, Moya PF. Aerobic rice in Northern China: Opportunities and challenges. In: Water Wise Rice Production, IRRI, Phillipnes and PRI, Netherlands. 2002;143-154.
3. Castaneda AR, Bouman BAM, Peng S, Visperas RM. The potential of aerobic rice to reduce water use in water scarce irrigated lowlands in the tropics. In: Water Wise Rice Production. Proceeding of International Workshop on Water Wise Rice Production. International Rice Research Institute, Los Banos, Philippines, 8-11, April. 2002;165-176.
4. Kant S, Bi YM, Rothstein SJ. Understanding plant response to nitrogen limitation for the improvement of crop nitrogen use efficiency. J. Exp. Bot. 2011;62:1490–1509.
5. Rawat A, Agrawal SB. Effect of soil enrichment in conjunction with bio-organics

and chemical fertilizers on yield and quality of rice. Res. J. Agric. Sci. 2010;35(4):190-192.

6. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd Edition, An International Rice Research Institute Book. Wiley-Inter-Science Publication. New York: John Wiley & Sons; 1984.
7. Dinesh GR, Jayadeva HM, Gowda TH. Evaluation of rice genotypes for dry matter accumulation, tillering pattern and grain yield in drum-seeded rice. Mysore J Agril Sci. 2005;39(4):437-442.
8. Afzal A, Bano A. Rhizobium and phosphate soulbilizing bacteria improve the yield and phosphorus uptake in wheat (*Triticum aestivum* L.). International Journal of Agriculture and Biology. 2008;10(1):85-88.
9. Babu RBT, Reddy VC. Effect of nutrient sources on growth and yield of direct seeded rice (*Oryza sativa* L.). Crop Research. 2000;25:189-193.
10. Venkatesh MM, Krishnamurthy N, Tuppad GB, Venkatesh KT. Effect of INM practices on yield, dry matter production and nutrient uptake in aerobic rice cultivars. Trends in Biosciences. 2014;7(18):2806-2812.
11. Sreedevi B. Suitable agronomic management practices for improving the productivity of aerobic rice. DRR Annual Report. 2013;30-31.
12. Islam MZ, Sattar MA, Ashrafuzzaman M, Mohd SH, Uddin MK. Improvement of yield potential of rice through combined application of biofertilizer and chemical nitrogen. African Journal of Microbiology Research. 2012;6(4):745-750.
13. Panhwar QA, Radziah OA, Zararah R, Sariah R, Razi MI. Role of phosphate solubilising bacteria on rock phosphate solubility and growth of aerobic rice. J Environmental Biology. 2014;32:607-612.
14. Yaduvanshi NPS, Sharma DR. Effect of organic sources with and without chemical fertilizers on productivity of rice (*Oryza sativa* L.) and wheat (*Triticum aestivum*) sequence and plant nutrients balance in a reclaimed sodic soil. Indian Journal of Agricultural Sciences. 2010;80(6):482-486.
15. Sreedevi B, Latha PC, Senguttuvel P, Ram T, Viraktamath BC. Aerobic rice- An alternative cultivation method for water constrained rice environments. 2nd International Conference on Agriculture and Horticultural Sciences. 2014;2:4.
16. Raki. Influence of biofertilizers in combination with chemical fertilizers in aerobic rice. M.Sc. (Ag) Theis. Indira Gandhi Krishi Vishwavidyalay, Raipur (C.G.), India; 2015.
17. Ramanjaneyulu AV, Madhavi A, Neelima TL, basha AS, Singh TVK, Reddy M, Shashibhushan D, Shankar G, Jagadeeshwar R. Differential yield, nutrient uptake and water productivity of rice cultivars under aerobic conditions on alfisols of a semi-arid environment. International Journal of Bio-resource and Stress Management. 2014;5(4):513-521.

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