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Evaluation of Pre-Released Rice Cultures at Different Nitrogen Levels

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Abstract

A field experiment was conducted to evaluate the pre-released rice cultures at different nitrogen levels during *kharif,* 2020-21 at Agricultural Research Station, Bapatla. The experiment was laid-out in split plot design with three replications. The four rice varieties *viz*, BPT 2776, BPT 2766, BPT 2824 and BPT 2846 were considered as main treatments and four nitrogen levels *viz,* 80 kg ha^{-1}, 120 kg ha^{-1}, 160 kg ha^{-1} and 200 kg ha^{-1}were considered as sub treatments. The results revealed that BPT 2846 recorded the highest plant height, productive tillers, panicle length, grain yield (5417 kg ha^{-1}) and straw yield (7073 kg ha^{-1}). The highest nitrogen uptake both in grain and straw also recorded highest values with BPT 2846 pre-released culture. Among the nitrogen levels 200 kg N ha^{-1} recorded the highest growth, yield attributes, yield and nutrient uptake of pre-released cultures. The data pertaining to economics 160 kg N ha^{-1} recorded the highest gross returns, net returns and B:C ratio.

Keywords: Pre-released culture, yield, nutrient uptake.

Introduction

Rice (*Oryza sativa* L.) is a primary source of nutrition for over 50% of the world's population, catering to their daily dietary needs. Asia accounts for approximately 92% of the overall global rice production and 90% of the worldwide rice consumption. India is recognised as the second largest global contributor to rice production, constituting approximately 20% of the total global output. Rice cultivation in India encompasses a vast expanse of approximately 46.3 million ha^{-1}, yielding an annual production of approximately 129.5 million tonnes, with a productivity rate of approximately 2,798 kg ha^{-1}. Rice cultivation in Andhra Pradesh spans an area of 22.9 lakh ha^{-1}, resulting in an annual production of 77.6 lakh tonnes and a productivity of 3,392 kg ha^{-1} (Ministry of Agriculture and Farmer Welfare, GOI, 2022).

In comparison to other essential nutrients, the rice crop necessitates a substantial quantity of nitrogen. Biradar (2005) revealed that in rice production Nitrogen (N) is the most limiting nutrient. 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 puddled soils depend on the rate of N fertilizer application. The application of nitrogen fertilisation is a significant agronomic practise that has a notable impact on both the yield and quality of rice crops (Venkatanna *et al*., 2022).

Annually, farmers worldwide utilise approximately 112.36 million tonnes of nitrogen for agricultural purposes (IFA, 2021). Approximately 35% (equivalent to 39.32 million tonnes) of nitrogen is utilised by the crop, while the remaining 82 million tonnes are discharged into rivers, lakes and natural ecosystems. The over utilization of nitrogen fertiliser has resulted in diverse forms of nitrogen losses, which can have detrimental consequences on the environment. The emission of nitrous oxide (N_2O) gas into the atmosphere from agricultural fields has a significant impact on the warming of the Earth's atmosphere (Vijayakumar *et al*., 2022). In fact, the warming potential of 1 pound of N_2O is approximately 265 times greater than that of 1 pound of carbon dioxide. The process of nitrate leaching into rivers and lakes can give rise to eutrophication, a phenomenon characterised by the proliferation of aquatic weeds and algae. The decline in fish population and the subsequent reduction in the recreational value of water were observed. Furthermore, this phenomenon has resulted in the contamination of groundwater with nitrate-N (NO_3-N), a substance that can pose a health hazard to both humans and livestock when its concentration exceeds 10 mg L^{-1} in drinking water (Cameron *et al*., 2013 and Sainju *et al*., 2020).

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 up to 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 depends on the ability to incorporate 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). The rice varieties differ from one variety to another in response to different levels of nitrogen. Fixing optimum dose of N fertilizer for each pre- released cultures is important to avoid excess application of fertilizers. Keeping the above points in view, the present investigation was conducted at Agricultural Research station, Bapatla during 2020-21 to optimize the nitrogen level for the pre-release rice cultures and observe the influence of nitrogen fertilizer on grain yield.

Materials and Methods

A field experiment was conducted during *kharif,* 2020-21 at Agricultural Research Station, Bapatla. The soil is clay loam in texture. The soil is neutral (pH 7.5) in reaction with low electrical conductivity (0.32 dS m^{-1}). The soil is medium in organic carbon content, low in available nitrogen, medium in available phosphorus and potash. The experiment was laid out in split plot design with 4 main plots treatments and 4 sub-plot treatments replicated thrice. Main treatments were pre-released cultures *viz,* V_1-BPT 2776, V_2-BPT 2766, V_3-BPT 2824 and V_4-BPT 2846; sub-treatments were four nitrogen levels *viz,* N_1- 80 kg ha^{-1}, N_2-120 kg ha^{-1}, N_3-160 kg ha^{-1} and N_4-200 kg ha^{-1}. Rice pre-released cultures were sown separately in nursery and 25 days old seedlings were transplanted at 20 cm x 15 cm spacing @ two seedlings per hill in three years. Nitrogen (Urea) was applied as per treatments in three equal splits (1/3 as basal, 1/3 at maximum tillering and 1/3 at panicle initiation stage). Phosphorus and potassium were applied through single super phosphate and muriate of potash. Irrigation and weed management were done time to time. The plant height was measured from ground level to the apex of last fully opened leaf during vegetative period and up to the tip of the panicle after flowering. Panicle length of ten randomly selected panicles from each plot was measured from neck node to the tip of panicle and then averaged and expressed in cm. Number of grains of 10 randomly selected panicles from each plot were counted and then averaged as grains $panicle^{-1}$. Samples of grain collected separately at the time of threshing from each plot were dried properly. 1000-grains from each of these samples were taken and their weights were recorded and expressed in grams. The border rows were harvested first and then, the net plot area was harvested and the produce was threshed by beating on a threshing bench, cleaned and sun dried to 14 per cent moisture level. Grain from net plot area was thoroughly sun dried, threshed, cleaned and weight of grains was recorded and expressed in yield per hectare. The data were analyzed statistically following the method given by Panse and Sukhatme (1978) and wherever the results were calculated at 5 per cent level of significance.

Results and Discussion

Plant height was significantly affected by nitrogen levels in all rice pre-released cultures. The highest plant height of 129.7 cm was observed with BPT 2776 pre-released culture which was significantly superior to BPT 2846 whereas, the lowest plant height of 118.4 cm was observed with BPT 2846 variety. Among the nitrogen levels, application of 200 kg N ha^{-1} recorded significantly the highest plant height (125.4 cm) followed by 160 N kg ha^{-1} treatment. There is significant interaction affect among nitrogen levels and different rice varieties in the case of plant height. Increase in the level of nitrogen application might have increased nitrogen availability to the crop which might have enhanced cell division, photosynthesis, metabolism, assimilate production and cell elongation resulting in taller plants. Such a favourable effect of nitrogen on increase in plant height of rice has been reported by many researchers (Prasad Rao *et al.,* 2011 and Contreras *et al.,* 2017).

There is significant difference among the nitrogen levels and varieties in tiller number. Significantly more number of tillers was observed in BPT 2846 variety (13.8) and lowest number of tillers (13) was recorded with BPT 2766 variety. In different nitrogen levels applied to rice varieties 200 kg N ha^{-1} treatment recorded maximum number of tillers (13.9) followed by 160 kg N/ha applied treatment. Nitrogen

Table 1: Effect of nitrogen levels on growth and yield attributes of different pre-released rice cultures

	Plant height (cm)	No. of productive tillers/plant	Panicle length (cm)	No of filled grains/ panicle	Test weight (g)
Varieties					
V_1-BPT 2776	129.7	13.1	26.3	232.3	14.7
V_2-BPT 2766	124.1	13.0	27.0	252.7	15.6
V_3-BPT 2824	121.0	13.7	25.8	245.6	15.2
V_4-BPT 2846	118.4	13.8	27.2	250.8	16.1
SEm±	2.2	0.2	0.4	5.3	0.3
CD (P=0.05)	6.6	0.6	1.2	15.9	1.0
CV (%)	9.2	8.5	10.0	9.3	6.2
Nitrogen doses					
N_1-80 kg ha^{-1}	110.3	12.1	24.6	217.3	13.6
N_2-120 kg ha^{-1}	117.0	12.9	25.7	235.0	14.7
N_3-160 kg ha^{-1}	125.1	13.7	26.8	253.6	15.8
N_4-200 kg ha^{-1}	125.4	13.9	26.9	263.8	16.0
SEm±	1.8	0.2	0.3	4.5	0.3
CD (P=0.05)	5.3	0.6	0.9	13.2	0.9
CV (%)	8.1	10.1	9.3	12.9	6.6
Interaction					
SEm±	3.2	0.4	0.5	7.8	0.5
CD (P=0.05)	9.2	NS	1.5	NS	NS
SEm±	3.3	0.4	0.6	8.2	0.5
CD (P=0.05)	9.5	NS	2.5	NS	NS

fertilization plays a vital role in cell division and might have supported the increase in number of tillers m^{-2}. Similar results were also reported by Mamata Meena *et al.,* (2013). The data indicated that the nitrogen levels and rice varieties significantly influenced the panicle length. The highest panicle length was recorded with BPT 2846 (27.2 cm) and the lowest was recorded with BPT 2824 (25.8 cm) variety (**Table 1**). There was significant difference in case of panicle length at different nitrogen levels. Application of 200 kg N ha^{-1} treatment recorded significantly longer panicle (26.9cm) and the shortest panicle was observed at 80 kg N ha^{-1} applied treatment (24.7cm). The increase in panicle length with N fertilization was also reported by Tabar (2013) and Gewaily *et al.,* (2018).

Yield attributes were significantly affected by nitrogen levels in different pre-released rice cultures. More number of filled grains per panicle was recorded with BPT 2766 variety (252.7) which was significantly superior to BPT 2776 variety (232.3). Significantly highest number of filled grains $panicle^{-1}$ was recorded with 200 kg N ha^{-1} treatment (263.8) followed by 160 kg N ha^{-1} treatments. Lowest number of filled grains $panicle^{-1}$ was recorded with 80 kg N ha^{-1} treatment (217.3). There is no significant interaction among rice varieties and nitrogen levels in number of grains/ panicle. The increase in the number of filled grains with increase in N rates indicates that N fertilization is important for both source and sinks development (Yesuf and Balcha, 2014).

Significant difference in test weight was observed in rice varieties at different nitrogen levels. Among the rice varieties BPT 2846 recorded highest test weight (16.1 g) followed by BPT 2766 and the lowest test weight was observed in BPT 2776 variety (14.7 g). Among nitrogen levels 200 kg N ha^{-1} recorded significantly highest test weight (16.0 g) followed by 160 kg N ha^{-1} which compared to 120 & 80 kg N ha^{-1}. Such an increase in 1000 grain weight with the application of nitrogen was also noticed earlier (Zaidi *et al.,* 2007 and Pandey *et al.,* 2008).

The data pertaining to the grain yield revealed significant influence of the nitrogen levels on rice varieties. Among the four rice varieties, BPT 2846 produced significantly the highest grain yield (5417 kg ha^{-1}) and the lowest grain yield (5039 kg ha^{-1}) was recorded with BPT 2776 variety. There was no significant difference in interaction in case of grain yield. Data revealed that the maximum grain yield (5515 kg ha^{-1}) was recorded with 200 kg N ha^{-1}followed by 160 kg N ha^{-1}. The linear response was observed in grain yield is also supported by the similar trend noticed with all growth and yield attributing characters studied. The increase in grain yield might be due to nitrogen application enhancing the dry matter production and improved growth rate. These results are in confirmation with the findings of Singh *et al.,* (2012), Gaind and Nain (2012) and Mrudhula *et al*., (2021).

The data pertaining to straw yield was significantly affected by different nitrogen levels and rice varieties. Significantly highest straw yield (7570 kg ha^{-1}) was recorded with BPT 2776 variety followed by BPT 2766 variety whereas, the lowest straw yield (6880 kg ha^{-1}) was recorded with BPT 2824 variety. Among the nitrogen levels applied to different rice varieties 200kg N ha^{-1} recorded significantly the highest straw yield (7657 kg ha^{-1}) followed by 160 kg N $ha^{-1}$and lowest straw yield (6186 kg ha^{-1}) was recorded in 80 kg N ha^{-1} applied treatment. Overall, the increase in straw yield with these treatments might be due to better growth reflected in these treatments in terms of plant height, dry matter accumulation and tillering. These results are in conformity with Singh *et al.,* (2006) and Zayed *et al.,* (2011). There was no significant difference in rice varieties, nitrogen levels and interaction in case of harvest index (**Table 2**).

Table 2: Effect of nitrogen levels on grain yield, straw yield and harvest index of different pre-released rice cultures

	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Varieties			
V_1-BPT 2776	5039	7570	43.9
V_2-BPT 2766	5146	7291	43.9
V_3-BPT 2824	5246	6880	43.8
V_4-BPT 2846	5417	7073	44.7
SEm±	87.8	188.2	0.5
CD (P=0.05)	303.9	651.4	NS
CV (%)	9.8	11.1	4.1
Nitrogen doses			
N_1-80 kg ha ha^{-1}	4536	6186	42.3
N_2-120 kg ha^{-1}	4921	6896	43.3
N_3-160 kg ha^{-1}	5406	7595	44.1
N_4-200 kg ha^{-1}	5515	7657	44.3
SEm±	97.8	240	0.6
CD (P=0.05)	285.3	665	NS
CV (%)	12.5	15.7	4.4
Interaction			
SEm±	169.3	203.2	1.1
CD (P=0.05)	494.2	593.2	NS
SEm±	165.2	239.9	0.9
CD (P=0.05)	457.8	665	NS

The data pertaining to nitrogen content in rice grain, there was significant difference was observed among the pre-released cultures of rice varieties. Among the rice varieties BPT 2846 recorded significantly highest grain nitrogen content (1.78%) followed by BPT 2776 and BPT 2824. The lowest grain nitrogen content (1.52%) was observed in BPT 2766 variety. Significant difference was observed at different nitrogen levels. The highest nitrogen content (1.7%) was observed with 200 kg N ha^{-1} followed by 160 kg Nha^{-1} (1.66%). No significant difference was observed in interaction among rice varieties and nitrogen levels. Maximum nitrogen uptake in rice grain was recorded with BPT 2846 variety (95.9 kg ha^{-1}) and the lowest nitrogen uptake was recorded with BPT 2776 variety (88.1 kg ha^{-1}). Significantly high nitrogen uptake was recorded with 200 kg N ha^{-1} treatment (93.7 kg ha^{-1}) followed by 160 kg N ha^{-1} treatment (89.7 kg N ha^{-1}) **(Table 3)**.

Table 3: Effect of nitrogen levels on grain and straw nitrogen content and uptakes of different pre-released rice cultures

	Nitrogen content in grain (%)	Nitrogen uptake in grain (kg ha^{-1})	Nitrogen content in straw (%)	Nitrogen uptake in straw(kg ha^{-1})
Varieties				
V_1-BPT 2776	1.76	88.1	1.17	82.4
V_2-BPT 2766	1.52	78.3	1.21	88.6
V_3-BPT 2824	1.65	86.6	1.28	86.9
V_4-BPT 2846	1.78	95.9	1.37	96.8
SEm±	0.05	2.9	0.03	2.6
CD (P=0.05)	0.16	10.3	0.12	9.0
CV (%)	9.9	11.9	9.36	10.0
Nitrogen doses				
N_1-80 kg ha^{-1}	1.54	69.8	1.02	63.1
N_2-120 kg ha^{-1}	1.60	78.7	1.14	78.6
N_3-160 kg ha^{-1}	1.66	89.7	1.26	95.7
N_4-200 kg ha^{-1}	1.70	93.7	1.27	97.2
SEm±	0.06	2.6	0.04	1.4
CD (P=0.05)	NS	7.5	0.11	4.1
CV (%)	12.5	10.4	10.6	13.3
Interaction				
SEm±	0.1	4.5	0.07	2.4
CD (P=0.05)	NS	13.0	NS	7.0
SEm±	0.1	4.6	0.06	3.1
CD (P=0.05)	NS	NS	0.19	8.8

Significant difference was noticed among the pre-released cultures and nitrogen levels in nitrogen content of rice straw. Data revealed significantly high nitrogen content (1.37%) and uptake (96.8 kg ha^{-1}) in BPT 2846 followed by BPT 2766 (1.21% and 88.6 kg ha^{-1}) in case of paddy straw. Among the nitrogen doses 200 kg/ha nitrogen application treatment recorded significantly highest nitrogen content (1.27%) and uptake (97.2 kg ha^{-1}) and the lowest nitrogen content (1.02%) and uptake (63.1 kg ha^{-1}) were recorded with 80 kg N ha^{-1} treatment in rice straw.

Gross returns, net returns and benefit cost ratio was affected by nitrogen levels and all pre-released rice cultures. The highest gross returns, net returns and benefit cost ratio of Rs. 85,615, Rs.16,534/- and 1.24 was observed with BPT 2846 pre-released culture which was superior to BPT 2776 whereas, the lowest gross and net returns was Rs. 80,641/- and Rs. 11,057/- with BPT 2776 pre-released rice culture (**Table 4**). Application of 200 kg N ha^{-1} recorded the maximum gross returns (Rs.84225/-), net returns (Rs.14759/-) and benefit cost ratio (1.21). These results are in agreement with the findings of Singh *et al*., (1998) and Mishra *et al.,* (2015).

Table 4: Effect of nitrogen levels on economics of different pre-released rice cultures

	Gross Returns (Rs.ha^{-1})	Net Returns (Rs.ha^{-1})	B:C Ratio
Varieties			
V_1-BPT 2776	80641	11057	1.17
V_2-BPT 2766	81906	12822	1.19
V_3-BPT 2824	82845	13761	1.20
V_4-BPT 2846	85615	16534	1.24
Nitrogen doses			
N_1-80 kg ha^{-1}	81084	12855	0.19
N_2-120 kg ha^{-1}	82266	13568	0.20
N_3-160 kg ha^{-1}	84225	14759	1.21
N_4-200 kg ha^{-1}	83432	13494	1.19

Conclusion

The experimental results revealed that grain yield was significantly affected by the application of nitrogen at different levels in rice cultivars. BPT 2846 pre-released rice culture recorded significantly the highest grain yield, yield attributes and nitrogen uptake. Incremental doses of nitrogen influenced the grain yield significantly. Application of 200 kg N ha^{-1} recorded significantly the highest grain yield of BPT 2846 pre-released rice culture when compared to all other pre-released rice cultures and nitrogen levels.

References

Ahmed S, Humphreys E, Salim M and Chauhan BS. 2016. Growth, yield and nitrogen use efficiency of dry-seeded rice as influenced by nitrogen and seed rates in Bangladesh. *Field Crops Research,* 186: 18-31.

Biradar DP, Shivakumar N and Basavanneppa MA. 2005. Productivity of irrigated rice as influenced by leaf color chart based N management in the Tungabhadra Project (TBP) area in Karnataka, India. *International Rice Research Notes*, 30(2): 40-42.

Cameron KC, Di HJ and Moir JL. 2013. Nitrogen losses from the soil/plant system. *Annals of Applied Biology*, 162(2): 145-173.

Contreras HAS, Barzan RR, Contreras MS and Brito OR. 2017. Growth, yield and agronomic efficiency of rice (*Oryza sativa* L.) cv. IAPAR 117 affected by nitrogen rates and sources. *Acta Agronomica*, 66(4): 558-565.

Mishra D, Sharma JD, Pandey AK Mishra RK, Shukla UN and Kumar, J. 2015. Effect of nitrogen levels on yield and quality and economics of rice (*Oryza sativa* L.) varieties. *International Journal of Agricultural Statistical Science,* 11(1): 1-5.

Gewaily EE, Ghoneim AM and Osman MM. 2018. Effects of nitrogen levels on growth, yield and nitrogen use efficiency of some newly released Egyptian rice genotypes. *Open Agriculture*, 3(1): 310-318.

IFA. 2021. IFA Medium-Term Fertilizer Outlook. Paris. https://www.ifastat.org/market-outlooks.

Mae T. 1997. Physiological nitrogen efficiency in rice: nitrogen utilization, photosynthesis and yield potential. *Plant and Soil,* 196(2): 201-210.

Mahajan G and Timsina J. 2011. Effect of nitrogen rates and weed control methods on weeds abundance and yield of direct-seeded rice. *Archives of Agronomy and Soil Science*, 57(3): 239-250.

Mamata Meena, Patel MV, Poonia TC, Meena MD and Tania Das. 2013. Effects of organic manures and nitrogen fertilizer on growth and yield of paddy grown in system of rice intensification technique under middle Gujarat conditions. *Annals of Agri Bio Research,* 18(2): 141-145.

Mikkelsen MP, Mikkelsen SP and Karlen JD. 1995. Molluscan biodiversity in the Indian river lagoon, Florid. *Bulletin of Marine Science*, 57(1): 94-127.

Ministry of Agriculture, Government of India, 2022. *https://www.statista.com*

Mrudhula KA, Suneetha Y and Veni BK. 2021. Effect of nitrogen levels on growth, yield, nitrogen uptake and economics of rice variety BPT 2782-Bhavathi. *International Journal of Chemical Studies,* 9(1): 2496-2499.

Pandey N, Verma AK and Tripathi RS. 2008. Effect of planting dates and N levels on N concentration in the leaf, grain yield and N uptake by hybrid rice. *Oryza*, 45(1): 18-22.

Singh O and Awanish SK. 2012. Productivity and profitability of rice (*Oryza sativa*) as influenced by high fertility levels and the residual effect on wheat (*Triticum aestivum*). *Indian Journal of Agronomy*, 57(2): 143-147.

Panse VG and Sukhatme PV. 1978. Statistical methods for Agricultural workers. ICAR, New Delhi, 199-211.

Prasad Rao V, Subbaiah G, Chandrasekhar K and Prasuna Rani P. 2011. Validation of nitrogen recommendations for popular rice (*Oryza sativa* L.) varieties of costal Andhra Pradesh. *The Andhra Agricultural Journal*, 58(1): 1-4.

Sainju UM, Ghimire R, Mishra U and Jagadamma S. 2020. Reducing nitrous oxide emissions and optimizing nitrogen-use efficiency in dryland crop rotations with different nitrogen rates. *Nutrient Cycling in Agroecosystems*, 116: 381-395.

Singh U, Ladha JK, Castillo EG., Punjalan G, Padre AT. and Duqueza M. 1998. Genotypic variation in nitrogen use efficiency in medium and long duration rice. *Field Crops Research*, 58(1): 35-53.

Gaind S and Nain. L. 2012. Soil carban dynamics in response to compos and poultry manure under rice (*Oryza sativa* L.) wheat (*Triticum aestivum* L.) crop rotation. *Indian Journal of Agricultural Sciences*, 82(5): 410-415.

Venkatanna B, Latha PC, Srinivas D and Kumar RM. 2022. Comparative analysis of different nitrogen treatments on yield and its attributes in SRI and conventional cultivation. *Journal of Rice Research,* 15(2): 138-146, https://doi.org/10.58297/SNZZ6760.

Vijayakumar S, Lokesh Goud D, Hareesh Reddy Ch, Mahender Kumar R and Sundaram RM. 2022. Efficient nitrogen management technologies for sustainable rice production. *Journal of Rice Research,* 15(2): 1-19, https://doi.org/10.58297/VZZH6068.

World fertilizer trends and outlook to 2020. Summary Report. Food and Agriculture Organization of United Nations - Rome, 2017.

Xing GX and Zhu ZL. 2000. An assessment of N loss from agricultural fields to the environment in China. *Nutrient Cycling in Agro-ecosystems*, 57: 67-73.

Yesuf E and Balcha A. 2014. Effect of nitrogen application on grain yield and nitrogen efficiency of rice (*Oryza sativa* L.). *Asian Journal of Crop Science*, 6(3): 273-280.

Yogeshwar Singh, Singh CS, Singh TK and Singh TP. 2006. Effect of fortified and unfortified rice-straw compost with NPK fertilizers on productivity, nutrient uptake and economics of rice (*Oryza sativa* L.). *Indian Journal of Agronomy*, 51(4): 297-300.

Yoseftabar S. 2013. Effect nitrogen management on panicle structure and yield in rice (*Oryza sativa* L.). *International Journal of Agriculture and Crop Sciences,* 5(11): 1224-1227.

Zaidi SF and Tripathi HP. 2007. Effect of nitrogen on yield, N uptake and nitrogen use efficiency of hybrid rice. *Oryza,* 44(2): 181-183.

Zayed BA, Salem AKM and Elsharkwy HM. 2011. Effect of different micronutrient treatments on rice (*Oryza sativa* L.) growth and yield under saline soil condition. *World Journal of Agricultural Sciences,* 7(2): 179-184.