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Effect of Nutrient management on growth, yield and quality parameters of Black Rice

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ABSTRACT

Black rice is getting more popular recently and is consumed as functional food due to health consciousness. Black rice contains higher levels of proteins, essential amino acids like lysine, tryptophan, vitamins such as vitamin B_1, B_2, folic acid and minerals including iron, zinc, calcium, phosphorus and selenium. Estimating crop nutrient requirements is essential for informing decisions of optimal nutrient management by maintaining quality. However, the nutrient requirements often vary depending on climates and soil conditions. Nitrogen, phosphorus, and potassium are important macronutrients for plant growth and development. In this context a field experiment was conducted at Agricultural Research Station, ANGRAU, Bapatla. This experiment was conducted in randomized block design with 10 treatments which were replicated thrice. The treatments were; different levels of nitrogen, phosphorus and potassium *i.e.,* 80:60:40 kg NPKha^{-1}, 120:60:40 kg NPKha^{-1}, 120:40:40 kg NPKha^{-1}, 120:40:30 kg NPKha^{-1}, 160:60:40 kg NPKha^{-1}, 160:40:40 kg NPKha^{-1}, 160:40:30 kg NPKha^{-1}, 200:60:40 kg NPKha^{-1}, 200:40:40 kg NPKha^{-1}and 200:40:30 kg NPKha^{-1}. The results revealed that the application 160:60:40 kg NPK per ha treatment recorded significantly higher yield attributes like no. of productive tillers per plant, panicle length, filled grains per panicle, highest grain yield (4967 kg ha^{-1}) and straw yield (5590 kg ha^{-1}) when compared to 80:60:40 kg NPKha^{-1}. The quality parameters, total phenols and antioxidants contents was recorded highest in 160:60:40 kg NPKha^{-1} treatment.

***Key words**: Black rice, Nitrogen, Antioxidants, Phenols, Yield attributes, Yield*

Introduction

Rice as a staple food consumed by more than half of the word population to meet their dietary requirement. Black rice is one its coloured rice that is getting more popular in recent times and is consumed as a functional food due to its health benefits. Black rice is also known as purple rice, forbidden rice, heaven rice, imperial rice, king's rice and prized rice. The cyanidin-3-glucoside and peonidin 3-glucosidase which is an anthocyanin because of which the colour of the rice turns in to black color (Abdel-aal *et al*., 2006; Yang *et al*., 2008; Escribano-Bailón *et al*., 2004; Lee, 2010). Black rice contains higher levels of vitamins (Qui *et al*., 1993; Du, 2011), antioxidants (Das *et al*., 2014; Gani *et al*., 2012), essential amino

([1]Senior Scientist, [2]Senior Scientist, [3]Associate Professor, [4]Teaching Associate) acids (Qui *et al*., 1993; Jin, 2016; Ma *et al*., 2018), anthocyanin (Wang *et al*., 2017; Ma *et al*., 2018), phenolic acids (Ma *et al*., 2018), variety of trace elements (Qui *et al*., 1993; Gou and Jiang, 1997), fiber (Xie *et al*., 2003; Gani *et al*., 2012) and good source of plant-based protein (Gani *et al*., 2012; Xie*et al*., 2003). Both brown rice and black rice contain vitamins, minerals, and dietary fiber. However, black rice is superior when compared with brown rice because it contains more protein and fiber (Ha *et al*., 1999; Sutharut and Sudarat, 2012).

Several researchers concluded that application of Fertilizers in the form of organic and inorganic sources increases yield in black rice (Yuniarti *et al*., 2019; Tigangam and George, 2017; Marwanto *et al*., 2018). In view of the nutritional importance much of the research was carried on integrated nutrient management and use of organic and inorganic form of NPK fertilizers. Due to its bulk in nature, availability and cost factor restricting the farmers and encouraging them to sow the pulses as second crop to improve the soil fertility. The role of balanced NPK is unknown on phenols and antioxidants. In view of the above, the current experiment was formulated to study the effect of different dosages of NPK fertilizers on growth, yield attributes, yield, antioxidants and phenols of black rice.

Materials and Methods

A field experiment was carried out during the *kharif* season in 2020 at Agricultural Research Station, Bapatla. The soil was clay loam in texture, neutral (pH 7.49) in reaction and low electrical conductivity (0.24 dS m^{-1}). The soil is medium in organic carbon content, low in available nitrogen, medium in available phosphorus and high in potash. The experiment was laid out in a randomized block design with 10 treatments which were replicated thrice. The treatments were; different levels of nitrogen, phosphorus and potassium *i.e.,* T_1-80:60:40 kg NPK per ha, T_2-120:60:40 kg ha^{-1}, T_3-120:40:40 kg ha^{-1}, T_4-120:40:30 kg ha^{-1}, T_5-160:60:40 kg ha^{-1}, T_6-160:40:40 kg ha^{-1}, T_7-160:40:30 kg ha^{-1}, T_8-200:60:40 kg ha^{-1}, T_9-200:40:40 kg $ha^{-1}$and T_{10}- 200:40:30 kg ha^{-1}. Rice variety BPT 2841 was sown separately in the nursery and 25 days old seedlings were transplanted at 20 cm x 15 cm spacing @ two seedlings per hill. Nitrogen was applied in the form of urea as per treatments in three equal splits. Phosphorus and potassium were supplied through single super phosphate and muriate of potash. Recommended package and practices were imposed to maintain healthy crop. The plant height was measured from ground level to the apex of the last fully opened leaf during the vegetative period and upto the tip of the panicle after flowering. The panicle length of ten randomly selected panicles from each plot was measured from the neck node to the tip of the panicle, then averaged and expressed in cm. The number of grains of 10 randomly selected panicles from each plot was counted and then averaged as grains $panicle^{-1}$. Samples of grain collected separately at the time of threshing from each plot were dried and 1000grains 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 attain 14 per cent moisture level. The grain from the net plot area was thoroughly sun dried, threshed, and cleaned and the weight of grains was recorded and converted in to yield per hectare. The data were analyzed statistically following the method given by Panse and Sukhatme (1978) at a 5 per cent level of significance.

Results and Discussion

Nutrient management in different dosages showed significant differences on the growth parameters of paddy. At maturity, significantly the maximum plant height (123.9 cm) was recorded with the application of NPK @ 200:60:40 $kgha^{-1}$ which was significantly superior to 80:60:40 kg NPK ha^{-1}application treatment (Table 1) and it was on par with all other treatments. An increase in levels of nutrient application might have increased nutrient availability to the crop which might have enhanced cell division, photosynthesis metabolism, assimilated production and cell elongation resulting in taller plants. Such a favourable effect of nutrients like NPK on an increase in plant height of rice has been reported by many researchers (Prasad Rao *et al.,* 2011 Contreras *et al.,* 2017).

A significantly greater number of tillers (14.1) was observed with the application of 200:60:40 kg NPK ha^{-1} treatment followed by all other treatments except the T_1 treatment. The lowest number of tillers was recorded with the application of 80:60:40 kg NPK ha^{-1} treatment. Increased levels of nitrogen favour greater absorption of nutrients resulting in the rapid expansion of foliage, better accumulation of photosynthates and eventually resulting in increased growth structure. Similar results were also reported by Mamata Meena *et al.* (2013). The P element is part of the cell core. Therefore, it is essential in cell division and the development of meristem networks to stimulate crop root growth, especially lateral roots and hair roots, to absorb a higher amount of nutrients. Hence, it results in higher rice tillers.

The N element supports the wider leaf growth, then the photosynthesis process. The more leaves of the plant, followed by increasing chlorophyll content, support the photosynthesis process. The optimum leaf area produces maximum carbohydrates. The N element application sufficiently caused by the increase of shoot growth hence endorses the development of tillers number, stem, and leaf to the maximum. This optimal growth of rice will automatically produce higher shoot dry weight.

Yield parameters were significantly influenced by different doses of nitrogen, phosphorus and potassium application. During the study, it was revealed that, significantly longer panicle length (24.7 cm) was observed in 160:60:40 kg NPKha^{-1} application treatments followed by all other treatments. A significantly shorted panicle length (21.7 cm) was recorded with the 80:60:40 kg NPK ha^{-1} treatment. Panicle length increased significantly with increased levels of nitrogen. An adequate supply of nitrogen probably favoured the proper cellular activities during panicle formation and development, which led to an increase in the development of yield-attributing characteristics reported by Sorour *et al.* (2016). The increase in panicle length with N fertilization was reported by Yosef Tabar (2013)

The numbers of filled grains were significantly influenced by different doses of nitrogen, phosphorus and potassium. A maximum number of filled grains (195) was produced with 160:60:40 kg NPKha^{-1} application treatment, which was significant to T1 treatment. The increased number of panicles was produced with the higher number of filled grains with a greatertest weight under adequate N content in rice plants. The effect of major nutrients particularly N on yield attributes is primarily a function of assimilates accumulation and in turn facilitating higher N assimilation with an adequate supply of photosynthates to grain (Kumar, 1986). The increase in the number of filled grains with an increase in N rates indicates that N fertilization is important for both source and sink development (Yesuf and Balcha, 2014). The lowest number of filled grains (132) per panicle^{-1} was observed in 80:60:40 kg NPK ha^{-1} application treatment.

There is the significant difference was observed in test weight. Significantly the highest test weight of 14.9 g was observed with the application of 160:60:40 kg NPK ha^{-1} treatment and the lowest test weight were observed in treatment (13.0 g) received with 80:60:40 kg NPKha^{-1} treatment. Such an increase in 1000-grain weight with the application of nitrogen was also noticed elsewhere (Zaidi *et al.*, 2007 Narendra Pandey *et al.*, 2008).

Among different doses of nitrogen, phosphorus and potassium application 160:60:40 kg NPKha^{-1} treatment recorded significantly higher grain yield (4967 kg ha^{-1}) and straw yield (5590 kg ha^{-1}) when

Table 1. Effect of nitrogen, phosphorus and potassium doses on growth and yield attributes of black rice

Treatments	Plant height (cm)	No of tillers/plant	Panicle length (cm)	Filled grains/ Panicle	Test weight (g)
T1-80:60:40 kg NPK/ha	100.3	11.3	19.2	126	11.0
T2-120:60:40 kg NPK/ha	112.3	13.7	21.6	162	12.8
T3-120:40:40 kg NPK/ha	112.3	13.7	21.5	158	12.6
T4-120:40:30 kg NPK/ha	112.2	13.6	21.4	153	12.5
T5-160:60:40kg NPK/ha	122.8	14.8	24.7	198	14.9
T6-160:40:40kg NPK/ha	122.7	14.8	24.6	197	14.7
T7-: 160:40:30kgNPK/ha	122.6	14.7	24.3	194	14.6
T8-200:60:40kg NPK/ha	123.9	14.8	24.7	195	14.5
T9-200:40:40kg NPK/ha	123.5	14.7	24.6	193	14.3
T10-200:40:30kg NPK/ha	123.2	14.6	24.3	190	14.1
Sem+	3.5	0.3	0.7	10.1	0.2
CD (0.05)	10.3	1.0	2.1	30.6	0.7
CV (%)	7.1	8.0	8.6	7.3	5.3

compared to all other treatments (Table 2). Increased grain yield associated with added fertilizer levels might be due to the cumulative effect of increased translocation of photosynthates to sink resulting in an enhanced level of yield components. The results confirm the findings of Rao *et al*. (2004) and Sunita Gaind and Lata Nain (2012). The lowest grain yield (4083 kg ha^{-1}) and straw yield (4327 $kgha^{-1}$) were recorded in the application of 80:60:40 kg NPK ha^{-1} 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, drymatter accumulation and tillering. These results conform to Yogeshwar Singh *et al.* (2006) and Zayed *et al.* (2011). There is no significant difference in harvest index among different doses of nitrogen, phosphorus and potassium application. The highest harvest index was observed in application 200:60:40 kg NPK ha^{-1} treatment. The increase in harvest index with increasing levels of nitrogen might be due to better translocation of assimilates from source to sink as was observed with a number of filled grains per panicle and 1000 grain weight reported by a few other researchers (Zayed *et al.*, 2011 and Sunita Gaind and Lata Nain, 2012). The Harvest index is dependent on the ability of variety or treatment to produce more grain yield than the straw accumulation. As such, higher grain yields than straw would account for a higher harvest index stated by Yumnam *et al*. (2021).

Rice containing pigments is one of the good sources of antioxidant compounds, including anthocyanin. As far as an antioxidant and their activity are concerned, it was found that coloured rice contains more anthocyanin and antioxidant activity than non-coloured rice. Quality parameters were significantly influenced by different doses of nitrogen, phosphorus and potassium. Significantly the highest antioxidant content was observed with 160, 60 and 40 kg $NPKha^{-1}$ treatment and the lowest antioxidant content was observed with 80,60 and 40 kg $NPKha^{-1}$ treatment. The lowest value of antioxidant activity was observed in parboiled rice. It may be due to a reduction in polyphenol content as the concentration of the total soluble phenolic contents was related to the lower antioxidant activity

Significantly the highest total phenols content was observed with 160: 60:40 kg $NPKha^{-1}$treatment

Table 3. Effect of nitrogen, phosphorus and potassium doses on Antioxidants and Total phenols content of black rice

Treatments	Antioxidants (mg/100g)	Total phenols (mg/100g)
T1-80:60:40 kg NPK/ha	60.4	67.7
T2-120:60:40 kg NPK/ha	71.7	78.3
T3-120:40:40 kg NPK/ha	70.4	76.3
T4-120:40:30 kg NPK/ha	69.8	75.7
T5-160:60:40kg NPK/ha	83.2	86.8
T6-160:40:40kg NPK/ha	82.2	85.7
T7-160:40:30kg NPK/ha	81.0	84.7
T8-200:60:40kg NPK/ha	82.5	86.3
T9-200:40:40kg NPK/ha	81.8	85.7
T10-200:40:30kg NPK/ha	81.2	84.3
Sem±	3.1	2.7
CD (0.05)	9.2	8.1
CV (%)	6.9	7.6

Table 2. Effect of nitrogen, phosphorus and potassium doses on grain yield, straw yield and harvest index of black rice

Treatments	Grain yield (kg/ha)	Straw Yield (kg/ha)	Harvest index (%)
T1-80:60:40 kg NPK/ha	3183	4127	48.5
T2-120:60:40 kg NPK/ha	3967	4983	46.5
T3-120:40:40 kg NPK/ha	3898	4890	48.4
T4-120:40:30 kg NPK/ha	3846	4823	48.0
T5-160:60:40kg NPK/ha	4967	6390	47.0
T6-160:40:40kg NPK/ha	4750	6200	47.3
T7-: 160:40:30kgNPK/ha	4517	6080	46.6
T8-200:60:40kg NPK/ha	4817	5947	48.8
T9-200:40:40kg NPK/ha	4650	5717	48.6
T10-200:40:30kg NPK/ha	4590	5693	48.4
Sem+	206.5	231.7	1.47
CD (0.05)	622.3	698.4	NS
CV (%)	7.9	8.2	5.3

and it was on par with all other treatments except 80:60:40, 120:60:40, 120:40:40 kg ha^{-1} and 120:40:30 kg ha^{-1} treatments. The phenolic constituents of rice are mainly distributed in rice pericarp (Paiva *et al*., 2014), their content may be related to grain size, colour and weight and controlled by genetic factors. These may be the reason for the higher phenolic contents in black rice than the white rice.

Conclusion

Based on the experimental results, it can be concluded that the application of 160 kg nitrogen 60 kg phosphorus and 40 kg potassium recorded a significant effect on yield parameters and yield of black rice. It was found that 160, 60 and 40 kg $NPKha^{-1}$ produced the maximum grain yield, antioxidant and phenol content and minimum grain yield, antioxidant and phenol content was achieved at 80, 60 and 40 kg $NPKha^{-1}$ treatment. Application of 160 kg N with 60 kg P and 40 kg K ha^{-1} was the suitable combination for getting maximum grain yield and quality performance of black rice.

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