Short communication

Evaluation of black rice under different fertilizer doses in western Terai, Nepal

Ram Bahadur Khadka
Regional Agriculture Research station, Khajura, Nepalganj
Email: vijayautsarga@gmail.com

Abstract
The black rice varieties are considered to have multiplier benefits in human health due to the presence of different antioxidants. An experiment was conducted at RARS, Khajura during rainy season of 2014 to evaluate the response of black rice with different doses of fertilizers and to document the basic phonological characters. It was found to be of short duration, low productive and non-responsive towards the fertilizer doses. Due to health benefiting qualities, the market price could easily compensate the low productivity and be of high commercial value in farming communities. However, more detail studies required on agronomy, protection, quality and breeding aspects before going to commercialization.
Key words*:* antioxidant, anthocyanin, black pigmentation, grain yield

Introduction

Rice is most important food grain of Nepal in terms of area, production, and consumption. According to ABPSD (2012) the area production and yield of rice in Nepal is 1496476 ha, 460278 mt and 2.981 mt per ha respectively. High diversity in rice determines the consumer preference on demand and price. The aromatic fine grain rice varieties have generally high price than coarse and nonaromatic rice. The rice gene pool contains some special rice landraces which have high medicinal value. Black rice (*Oryza sativa L. indica*), a special cultivar of rice which contains a much higher content of anthocyanins in the aleurone layer than white rice, has been regarded as a food and widely consumed as a health-promoting food in China and other Eastern Asian countries for thousands of years (Qing *et al.* 2007). The purple pigment (anthocyanin: cyaniding-3-glucoside) in the husk (hull) and pericarp and gamma oryzanol from rice bran oil are advantageous antioxidants (Xu *et al*., 2001; Juliano *et al.,* 2005; Vorarat *et al.,* 2010; Pitija *et al.,* 2013). Black rice contained two to three times the amount of anthocyanin and gamma oryzanol higher than did white rice (Ryu *et al.,* 1998; Boonsit *et al.,* 2010). For gamma oryzanol, it is a mixture of phytosterylferulate esters in the rice bran oil (Bergman and Xu, 2003; Boonsit *et al;* 2010) with properties that are beneficial to health including improving the plasma lipid profile, reducing total plasma cholesterol, increasing high-density lipoprotein (HDL) cholesterol levels and inhibiting platelet aggregation (Cicero and Gaddi, 2001).It is believed that the supplementation of black rice pigment fraction markedly reduced oxidative stress and inflammation, improved plasma lipid level and alleviates atherosclerotic lesions (Xia *et.al.* 2003, Ling et. al. 2002 and Ling et. al, 2001). Black rice

pigment fraction can reduce some cardiovascular risk factors in patients. Similarly black rice anthocyanin have both antioxidant and anti-inflammatory properties in human (Qing *et al;* 2007).

In Thailand, black glutinous rice has been increasingly attractive as a high value-added crop and it has become a key driving force in economic development. It is grown under rainfed condition in both upland and lowland environments. The farmers mostly grow local genotypes of black glutinous rice with low yield (Saenjum *et al*., 2012; Somsana *et al.*, 2013).In context of Nepal it is new. No report of previous study on agronomy, breeding, quality and health aspect has been documented in black rice in Nepal. The samples received from the District Agricultural Development officer, Rukum (Unknown Source, Personnel Communication, KB Adhikari, DADO, Rukum) was multiplied and put under the agronomy trials to understand basic features including crop duration, productivity and response with different fertilizer doses at RARS, Khajura.

Material and methods

The experiment was conducted at RARS, Khajura in rainy season of 2014. RARS, Khajura is located at at 81^0 37" east longitudes and 28^0 06" north latitude and an altitude of 181 meters above mean sea level. Average annual rainfall of the station is 1000-1500 mm. The soil of the experimental plot was sandy to silty loam, poor in organic carbon and available nitrogen but medium in available phosphorus and potassium pH varies from 7.2-7.5. The average monthly temperature ranged from 25 to 31^0 C, relative humidity 29 to 76 % and total monthly rainfall from 87 to 549 mm (Fig.1) of the experimental site during the experimental period.

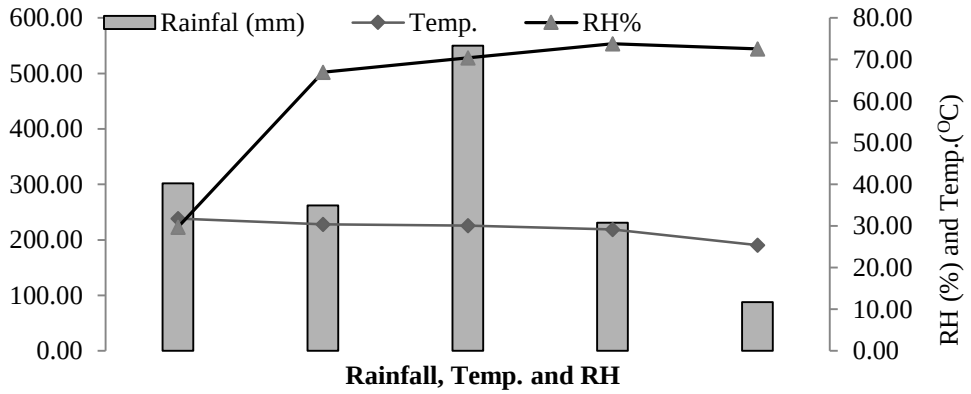

Fig.1. Average temperature, average relative humidity (RH%) and total rainfall over the crop period at RARS, Khajura

The experiment was laid out in a RCB design with six replications planting 21 days old seedlings at a spacing of 20 x 15 cm with 2-3 seedlings per hill. There were three different

doses of fertilizer (Table 1). Water was maintained at a depth of 2 cm up to panicle initiation and 5 cm thereafter up to one week before harvest. Weeds were controlled by two-hand weeding at 20 and 40 days after transplanting. The field was drained before application of fertilizers and one week before harvest. Nitrogen was applied in three doses; 50% of total Nitrogen was applied as basal doses before final land preparation, remaining nitrogen was divided in two equal parts, one was applied at 20 days after transplanting and another half doses was applied at 45 days after transplanting. The experiment received uniform plant protection and cultural management practices throughout the period of crop growth. The three doses of fertilizers were considered as a treatments and classified as low, medium and high doses as per the usual practices generally followed by the local growers.

Table 1. The fertilizer doses was applied as per the following

Doses	Application (Kg NPK per ha.)
High doses	120:80:40
Medium doses	100:60:30
Low doses	50:30:15

Data on tillers m-2 were collected from ten randomly marked hills at active tillering stage. The number of ear bearing tillers were counted from tagged plants, averaged to compute productive tillers hill-1 and expressed as panicles m-2. Panicle length was recorded following standard procedures from 10 randomly marked hills. Grain from the net plot was thoroughly sun dried to 14 per cent moisture content, weighed and expressed in mt/ha. Data analysis was done with Microsoft Excel (2007) and R-program. Data were subjected to analysis of variance (ANOVA) tests. When significant differences were found, means were separated and assessed using Duncan's Multiple Range Test (DMRT).

Results and discussion

The plant height under three different doses of fertilizer was found not significant. It ranged from 50.33 – 52.073 cm. It means the black rice varieties grown were dwarf type as compared to the prevailed varieties.

Similarly, the length of panicle was also not significant among the tested doses of fertilizer. The panicle length ranged from 18.17 to 19.533 cm. Number of grain per panicle was also insignificant among the tested doses of fertilizers. The number of grain per panicle was ranged from 59.46 to 71.80.

Table 1. Effect of differ doses of fertilizer on plant height, panicle length, number of grain per panicle

Doses of fertilizer	Plant height (cm)	Panicle length(cm)	No of grain per panicle	Number of unfilled grain
High	50.33 a	19.53 a	67.80 a	13.40 a
Medium	51.20 a	18.17 a	59.46 a	17.53 a
Low	52.07 a	19.41 a	71.80 a	8.33 a
CV (%)	4.21	4.40	20.83	55.44
F-test	0.65	0.20	0.58	0.39
LSD	4.88	1.90	31.33	16.45

The thousand grain weight ranged from 23.71 to 25.08 gm. The seed was found to be bold sized. However the thousand grain weight did not showed significant change over the different doses of fertilizers.

The black rice variety tested was found to be high tillering. The average tiller recorded per square meter was ranged from 431.67 to 516.00 while it was not found to be significantly different among the tested doses of fertilizers.

Table 2. Effect of differ doses of fertilizer on yield, test weight, tiller per square meter and total grain panicle

Doses of fertilizer	Yield (mt/ha)	Test weight (gm)	Tiller per m^2	Total grain per panicle
High	2.58 a	25.08 a	415.67 a	81.20 a
Medium	2.10 a	24.52 a	516.00 a	77.00 a
Low	2.28 a	23.72 a	431.67 a	80.13 a
CV (%)	13.86	3.60	18.59	11.01
F-test	0.29	0.27	0.38	0.84
LSD	0.73	1.99	190.77	19.82

The yield is considered to be one of the most important factors for accepting the variety as a commercial; allied with quality. The tested black rice variety was not found to be high yielding. The yield ranged from 2.1 - 2.5 mt/ha which is far lower than the prevailed rice varieties. But due to the many health benefiting qualities the variety could be considered for commercial productions. The result of this study is similar to the results obtained by Banterng & Joralee (2015). Their study revealed that the mean number of panicle per hill was 5.90–9.27, filled grains per panicle, 77.00–130.60 and test weight, 21.79–29.26 g for 1000-grain weight. In addition, grain yield was reported to be between 1274.50–2155.27

kg ha^{-1}at Thailand. It showed that the requirement of high yielding and fertilizer responsive variety is necessary. The farmers mostly grow local genotypes of black glutinous rice with low yield (Saenjum *et al.,* 2012; Somsana *et al*., 2013). In order to improve the productivity, growing the suitable genotypes is an alternative option for sustainable farming systems. Therefore, growing the recommended rice genotypes with good adaptation practices is pivotal for commercial cultivation; high yield could be important stimuli to farmers. The government should focus introductions of wide range of black rice genotypes for enhancing the breeding program.

Conclusion

The black rice varieties are considered to have multiplier benefits in human health due to the presence of different antioxidants. It was found to be of short duration, photo insensitive, non-responsive and low productive towards the fertilizer doses. Due to health benefiting qualities the market price would be good enough to compensate the low productivity and could fetch good commercial value in farming communities. However, more detail study is required on agronomy, protection, quality and breeding aspects before going to commercialization.

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References

ABPSD. 2012**.** *Statistical information on Nepalese agriculture***.**Government of Nepal.Ministry of Agriculture and Co-operatives.

Bergman, CJ and Z Xu. 2003. Genotype and environment effects on tocopherol, tocotrienol, and oryzanol contents of southern U.S. rice. *Cereal Chemistry*. 80(4): 446–449.

Boonsit, P; P Pongpiachan; S Julsrigival; and DKarladee. 2010. Gamma oryzanol content in glutinous purple rice landrace varieties. C.M.U. *Journal of Natural Science*. 9(1): 151–157.

Cicero, AFG and A Gaddi. 2001. Rice bran oil and γ-oryzanol in the treatment of hyperlipoproteinemias and other conditions. *Phototherapy Research*. 15: 277–289.

Juliano, C; M Cossu; M CAlamanni; and L Piu. 2005. Antioxidant activity of gamma-oryzanol: Mechanism of action and its effect on oxidative stability of pharmaceutical oils. *International Journal of Pharmacy*. 299: 146–154.

Ling, WH; Cheng QX; Ma J; and T Wang. 2001. Red and black rice decrease atherosclerotic plaque formation and increase antioxidant status in rabbits. *Journal ofNutrition*; 131:1421-1426.

Ling, WH; LLWang; and J Ma. 2002.Supplementation of the black rice outer layer fraction to rabbits decreases atherosclerotic plaque formation and increases antioxidant status. *Journal of Nutrition* 132: 20-26.

Pitija, K; M Nakornriab; T Sriseadka; A Vanavichit; and SWongpornchai. 2013. Anthocyanin content and antioxidant capacity in bran extracts of some Thai black rice varieties. *International Journal of Food science and Technology*. 48: 300–308.

Ryu, SN; SZ Park; and CT Ho. 1998. High performance liquid chromatographic determination of anthocyanin pigments in some varieties of black rice. *Journal of Food Drug Anal.* 6: 729–736.

Saenjum, C; C Chaiyasut; S Chansakaow; M Suttajit; and BSirithunyalug. 2012. Antioxidant and anti-inflammatory activities of gamma-oryzanol rich extracts from Thai purple rice bran. *Journal of medicinal plants Research* 6(6): 1070–1077.

Somsana, P; P Wattana; B Suriharn; and J Sanitchon. 2013. Stability and genotype by environment interactions for grain anthocyanin content of Thai black glutinous upland rice (Oryza sativa). *SABRAO Journal of Breeding and Genetics* 45 (3): 523–532.

Vorarat, S; CManagit; L Iamthanakul; W Soparat; and N Kamkaen. 2010. Examination of antioxidant activity and development of rice bran oil and gamma-oryzanolmicroemulsion. *Journal of Health Research*. 24(2): 67–72.

Wang, Q; P Han; M Zhang; M Xia; H Zhu; J Ma; M Hou; Z Tang; and W Ling. 2007.Supplementation of black rice pigment fraction improves antioxidant and anti-inflammatory status in patients with coronary heart disease. *Asia Pacific Journal of ClinicalNutrtion. 2007;16 :295-301.*

Xia M; WH Ling; J Ma; DD Kitts; and J Zawistowski. 2003. Supplementation of diets with the black rice pigment fraction attenuates atherosclerotic plaque formation in apolipoproteine deficient mice. *Journal of Nutrition*133: 744-751.

Xu, Z; N Hua; and JS Godber. 2001. Antioxidant activity of tocopherol, tocotrienols, and gamma-oryzanol components from rice bran against cholesterol oxidation accelerated by 2,2'-azobis (2-methylpropionamidine) dihydrochloride. *Journal of Agriculture and Food Chemistry*. 49: 2077–2081.