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Research Paper

Standardization of planting time, spacing and nutrient management for traditional red-husked scented rice (*Oryza sativa*) in West Bengal

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ABSTRACT

The effect of planting time (10 July, 25 July and 10 August), spacing (15 cm × 15 cm and 20 cm × 15 cm), and nutrient management [100% recommended dose (RD) of organic, 100% RD inorganic, and 50% RD organic + 50% RD inorganic] of small-grained red-husked scented “Lal Badshabhog” rice was studied during the wet season of 2014 and 2015 in a split split-plot design at Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India. Early-planted crop (10 July) produced tallest plants at maturity (160.2 cm) and leaf-area index (LAI) at 84 days after transplanting (DAT) (4.88), but late planting (10 August) resulted in better tiller production at 56 DAT (285.4/ m^2). Mean light extinction co-efficient (k) of the variety was 0.40 and 0.37 at 56 and 84 DAT, respectively. ‘Lal Badshabhog’ rice planted on 10 August recorded the highest grain yield (2.72 t/ha), which was 3.77 and 12.76% higher over 25 July and 10 July planting, respectively. Close planting (15 cm × 15 cm or 44 hills/m^2) could improve the grain yield of ‘Lal Badshabhog’ rice by 3.95% (2.63 vs. 2.53 t/ha) over wider spacing (20 cm × 15 cm or 33 hills/m^2), and application of 100% RD (N 50, P_2O_5 25, K_2O 25 kg/ha) through chemical fertilizers resulted in higher grain yield (2.64 t/ha), net returns (₹ 32,900/ha) and benefit : cost ratio (2.02) compared to organic or integrated nutrient management. Mean N, P and K uptake by “Lal Badshabhog” rice at maturity was 41.2, 15.8 and 30.3 kg/ha, respectively, and the crop grown under integrated nutrient management (50% RD organic + 50% RD chemical fertilizer) left the field with better residual status (+5.9% N, +28.3% P_2O_5 and +1.7% K_2O) over initial values after 2-year study in Gangetic alluvium soil.

Key words: Aromatic rice, Economics, Growth attributes, Nutrient management, Planting time, Spacing, Yield

“Lal Badshabhog” is a small-grained, non-Basmati aromatic rice of West Bengal (Deb, 2005), which is traditionally grown in *rahr* (red-laterite) region of South Bengal, covering the districts of Purulia, Bankura, Paschim Medinipur etc. Important characteristic features of the variety are: plant height 140–150 cm, duration (130–135 days), grain yield 2.3–2.6 t/ha, brownish-red coloured grain, short-bold-type kernel, amylose 18.1%, alkali spreading value 3.3 and medium aroma (Ghosh *et al*., 2019). Farmers in native areas cultivate “Lal Badshabhog” rice in small portion of their agricultural lands following traditional methods intermixed with a few locally-adaptable modern technologies in recent times. Moreover, the sowing and/or planting of the variety is often delayed under rainfed cultivation due to late onset or poor monsoon in early rainy season in the region. The nutrition of “Lal Badshabhog” rice is provided by the farmers following untested nutrient schedule including home-made cowdung manure and/or low dose of chemical fertilizers, which needs to be refined.

Among various cultivation practices, optimum sowing or planting time, appropriate planting geometry and location-specific nutrient management are key factors to enhance the productivity of rice up to a sustained level as well as for restoration of soil fertility. Sowing or planting period is an important non-monetary practice considering the weather- dependent correlations with yield and quality parameters of aromatic rice (Mahata, 2014). Spacing determines the plant population in unit area, thereby influencing the input-use efficiency and yield of the crop. At farmers’ fields, manures are usually given with some application

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rates, but the nutrient supply from organic manure may be excessive or insufficient for rice growth and unsynchronized with crop N demands (Moe *et al*., 2019). Although organic manures, viz. *Dhaincha* [*Sesbania bispinosa* (Jacq.) W. Wight], sunnhemp (*Crotalaria juncea* L.) and FYM could improve the soil-fertility status like organic carbon, available N, P and K content in soil at post-harvest stage (Hemlatha *et al*., 2000); but integrated nutrient management (INM) might be imperative for quality aromatic rice production in a sustainable way. Since testing the performance of 'Lal Badshabhog' rice under varied sowing time, planting geometry and nutrient management is of great necessity to find out economically-sustainable production technology, present study was carried out.

MATERIALS AND METHODS

A field experiment was conducted during wet (*kharif*) seasons of 2014 and 2015 at 'C' Block Farm (22°58' N, 88° 26' E, 15.9 m altitude) of the Bidhan Chandra Krishi Viswavidyalaya (BCKV), Kalyani, Nadia, West Bengal. The soil was sandy-loam (Order Entisol), neutral in reaction (pH 6.9), medium in organic C (0.58%), available N (235.2 kg/ha), P (32.3 kg/ha) and K (180.6 kg/ha). Month-wise maximum and minimum temperature during the cropping period was found to vary between 15.9 and 35.4°C during 2014, and 18.8 and 34.6°C during 2015, and the rainfall received for the growing seasons were 1307.0 mm and 1273.4 mm, respectively. The variation in monthly average maximum relative humidity was 79.7 and 95.8% during the first year, and 90.3 and 97.8% during the second year. The bright sunshine hour was lower in high rainfall months mainly due to cloud-cast days and that ranged between 4.6 (August) and 7.5 hours (November) during 2014, and between 2.5 (October) and 7.3 hours (November) during 2015.

The experiment was laid out in a split split-plot design, replicated thrice, comprising 3 planting dates (10 July, 25 July and 10 August) in main plots, 2 spacings [20 cm × 15 cm and 15 cm × 15 cm] in subplots, and 3 nutrient-management practices [100% recommended dose (RD) organic, i.e. (25% RD FYM + 75% RD mustard [*Brassica juncea* (L.) Czernj.] cake, 100% RD inorganic (N 50, $P_2O_5$25, K_2O 25 kg/ha), and 50% RD organic (25% RD FYM + 25% RD Indian mustard cake + 50% RD inorganic (N 25, P_2O_5 12.5, K_2O 12.5 kg/ha) in sub-subplots. Mean N, P and K content of FYM and Indian mustard cake were 0.48, 0.23 and 0.53%, and 4.65, 1.47 and 1.15% respectively. Urea, single superphosphate (SSP) and muriate of potash (MoP) were used to supply nitrogen, phosphorus and potassium, respectively, to the crop.

Seeds of "Lal Badshabhog" rice, collected from RKVY Project on "Bengal Aromatic Rice" of BCKV were sown @ 18–20 kg/ha in wet nursery. Seedlings of 24–25 days age @ 2–3/hill were transplanted as per planting time and spacing schedule at a shallow depth (3–4 cm) in puddled field. Manual weeding was done 3 and 6 weeks after transplanting (WAT), and other crop-management practices were adopted as per the standard recommendations. Growth attributes like tiller production, leaf-area index (Watson, 1958), light transmission ratio (LTR) and light extinction coefficient (Saeki, 1963) were recorded at different stages, while lodging (IRRI, 1996) at dough stage, and yield at maturity. Total and available N, P, K in soil and plant were determined by standard methods (Jackson, 1973), and nutrient uptake was estimated by multiplying the dry-matter yield of grain and straw by their respective nutrient percentages. The cost of cultivation, gross returns, net income and benefit: cost ratio were calculated, based on the market prices of inputs and produces along with the related wages during the years of investigation. The data were analysed using the Analysis of Variance technique as per the procedure described by Gomez and Gomez (1984) and the treatment means were compared at 5% level of significance.

RESULTS AND DISCUSSION

Growth attributes

"Lal Badshabhog" rice planted on 10 July showed the highest plant height at harvesting (160.2 cm) compared to late plantings on 25 July (153.0 cm) and 10 August (152.6 cm) in the study (Table 1). Close planting (15 cm × 15 cm) resulted in greater number of tillers per m^2 area at 56 days after transplanting (DAT) due to accommodation of more hills (44 hills vs 33 hills) over wider spacing (20 cm × 15 cm). But the field-based observation showed that, number of tillers/hill in wider and closer spaced plants were 7.02 and 6.46 at 56 DAT, which indicated that widely spaced plants or hills had more tillers due to less inter-space competition than the closer planted ones. Similar reduction in tiller production was recorded by Marzia *et al*. (2016) for triple row arrangement (25-10-10-25 cm) compared to single row (25 cm) and double row (25-10-25 cm) for aromatic fine rice (cv. BRRI Dhan 34) at Mymensingh, Bangladesh. The application of 100% RD inorganic @ 50 : 25 : 25 kg/ha and integrated nutrient management (50% RD organic + 50% RD inorganic) usually resulted in similar production of tillers at 56 DAT (278.7 and 277.0/ m^2), which were significantly greater than 100% RD organic sources in "Lal Badshabhog" rice field at Kalyani, West Bengal.

Leaf growth, light interception and extinction coefficient

"Lal Badshabhog" rice plants produced long, narrow and green leaves with split-type ligule and sickle-shaped

Table 1. Effect of planting time, spacing and nutrient management on growth attributes of scented 'Lal Badshabhog' rice (pooled data of 2 years)

Treatment	Plant height at harvesting (cm)	Tillers/ m^2 at 56 DAT	Leaf-area index		Light transmission ratio		Extinction coefficient (k)		CGR (g/m^2 /day) 56-84 DAT
			56 DAT	84 DAT	56 DAT	84 DAT	56 DAT	84 DAT	
Planting time									
10 July	160.2	255.2	3.36	4.88	25.8	19.6	0.41	0.34	5.73
25 July	153.0	272.5	3.64	4.44	24.1	19.9	0.40	0.37	5.61
10 August	152.6	285.4	3.47	3.99	25.2	20.8	0.40	0.40	5.51
SEm±	1.14	4.46	0.03	0.05	0.54	0.37	0.01	0.01	0.09
CD (P=0.05)	3.71	14.55	0.11	0.17	NS	NS	NS	0.02	NS
Spacing									
20 cm × 15 cm	156.1	258.0	3.31	4.30	24.7	20.0	0.43	0.38	5.49
15 cm × 15 cm	154.4	284.1	3.67	4.57	25.3	20.2	0.38	0.35	5.75
SEm±	0.89	2.73	0.04	0.04	0.34	0.31	0.01	0.01	0.07
CD (P=0.05)	NS	8.41	0.13	0.13	NS	NS	0.02	0.02	0.22
Nutrient management									
100% RD organic	153.1	257.3	3.36	4.27	26.7	21.3	0.40	0.37	5.83
100% RD inorganic	156.9	277.0	3.60	4.55	23.4	18.7	0.41	0.38	5.24
50% RD organic + 50% RD inorganic	155.8	278.7	3.51	4.49	25.0	20.3	0.40	0.36	5.79
SEm±	1.33	2.65	0.04	0.04	0.60	0.52	0.01	0.01	0.10
CD (P=0.05)	NS	7.54	0.11	0.12	1.70	1.47	NS	NS	0.29

CGR, Crop-growth rate; RD, recommended dose

auricles at the leaf base. The attitude of flag leaf was semi-erect at flowering and near-maturity stage. The foliage growth of rice in terms of leaf-area index (LAI) was increased consistently up to 84 DAT (i.e., post-anthesis stage) and declined thereafter due to drying and withering of lower leaves during the ripening phase. The crop planted on 25 July had the highest LAI (3.64) at 56 DAT, but early planted crop (10 July) exhibited maximum LAI (4.88) at 84 DAT in the experiment (Table 1). The planting geometry had significant effect on foliage growth of "Lal Badshabhog" rice in later phase of life-cycle, i.e., at 56 and 84 DAT during the rainy (*kharif*) season; where closely spaced crop recorded greater foliage in terms of LAI due to more number of hills in unit area. However, Singh *et al.* (2012) reported that, wider spacing (30 cm × 30 cm) favoured the production of more leaves with greater size leading to higher LAI values of 3 aromatic rice varieties "Pusa Basmati 1", "Pusa Sugandh 5" and "Pusa Sugandh 3" at 30 and 60 DAT compared to closer spacing (25 cm × 25 cm) at New Delhi. Sole application of chemical fertilizers (N 50, P_2O_5 25, K_2O 25 kg/ha) usually resulted in the highest LAI at both 56 DAT (3.60) and 84 DAT (4.55), being mostly at par with integrated nutrient dose (50% RD inorganic + 50% RD organic) in Gangetic alluvial soil of West Bengal. On the other hand, 100% organic sources of nutrients (FYM + Indian mustard cake) had slow and less effect towards the foliage growth of "Lal Badshabhog" rice in the investigation.

Mean light intensity at crop canopy and ground level, averaged over treatments and years were: 74,992 and 15,450 lux (56 DAT) and 94,869 and 19,069 lux (84 DAT). Mean light interception by the canopy of "Lal Badshabhog" rice were 25.0 and 20.1% at 56 and 84 DAT, respectively, which indicated a declining trend probably due to panicle exertion at pre-flowering stage. The light transmission ratio (LTR) values, in general, showed inverse relationship with their respective LAI values because of the influence of foliage toward penetration of light at the ground. The curvilinear relationships between LAI and LTR values for three different planting times were noted as: $y = 1.8149\ x^2 – 16.514\ x + 57.04$ for 10 July-planted crops, $y = 2.6105\ x^2 – 21.198\ x + 63.235$ for 25 July-planted crops and $y = 3.278\ x^2 – 22.892\ x + 61.302$ for 10 August-planted crops in the study (Fig. 1).

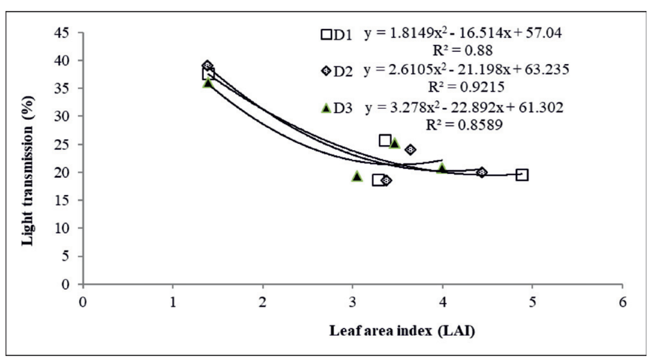

Fig. 1. Effect of planting time on relationship between light transmission ratio and leaf-area index of "Lal Badshabhog" rice during rainy season (pooled data of 2 years)

Mean light extinction coefficient (k), averaged over either of planting time or spacing or nutrient management, was 0.40 and 0.37 at 56 and 84 DAT; which indicated that the leaves of "Lal Badshabhog" rice plants were erect during panicle initiation to 50% flowering stage (56–84 DAT). Widely spaced crop (20 cm × 15 cm) recorded greater k values (0.43 and 0.38) at 56 and 84 DAT compared to closely planted one (15 cm × 15 cm) in the study.

Yield and lodging

"Lal Badshabhog" rice planted on 10 August gave the highest grain yield (2.72 t/ha), which was 3.77 and 12.76% greater over 25 July and 10 July plantings, respectively (Table 2). The optimum planting time (25 July) of another small-grained scented "Gobindabhog" rice was found different for better yield and quality at the same location (Mahata, 2014). The finding indicated the scope of planting of "Lal Badshabhog" rice during the first fortnight of August after harvesting of jute in early August under jute - *kharif* rice sequence in Gangetic West Bengal. Square-planting method (15 cm × 15 cm or 44 hills/m^2) resulted in greater grain yield (2.63 t/ha) over wide spacing (20 cm × 15 cm or 33 hills/m^2) in the experiment. But Islam *et al*. (2014) recorded the highest grain yield (2.38 t/ha) of black-husked aromatic rice (cv. Kalizira) with 25 cm × 15 cm, significantly greater over wider (25 cm × 20 cm) and closer (25 cm × 10 cm) at Dinajpur, Bangladesh. The application of 100% RD through chemical fertilizers (N 50, P_2O_5 25, K_2O 25 kg/ha) resulted in the highest grain (2.64 t/ha) and straw yield (6.51 t/ha) of "Lal Badshabhog" rice, being at par with integrated dose (50% RD organic + 50% RD chemical fertilizer), which were significantly greater over 100% RD organic (2.50 t/ha and 6.21 t/ha) in the investigation. Similarly, Bhowmick *et al*. (2011) found that application of 50% RFD + 50% FYM and 100% RFD were equally effective in production of grain yield of aromatic rice varieties (2.92 t/ha and 2.86 t/ha) in West Bengal. The interaction effect showed that, "Lal Badshabhog" rice planted on 10 August at 15 cm × 15 cm spacing with 100% RD through chemical fertilizers (N 50, P_2O_5 25, K_2O 25 kg/ha) gave the highest grain yield (2.84 t/ha) in the study (Table 3).

The field-based observation indicated that, most (>50%) of "Lal Badshabhog" plants had a general tendency to lodge down slightly (score more or less 3.00) at hard dough stage. The lodging score was decreased with the delay in planting from 10 July (3.39) to 10 August (2.17), which might be due to successive reduction in plant height in later planted crop compared to 2 earlier planted ones. However, spacing and nutrient management caused non-significant variation in lodging tendency of "Lal Badhabhog" rice in the experiment.

Nutrient uptake and residual fertility status

The N, P and K uptake by "Lal Badshabhog" rice crop varied significantly among 3 planting times and 3 nutrient-management practices adopted in the experiment (Table 2). The range of variation in uptake of nutrients among nutri-

Table 2. Effect of planting time, spacing and nutrient management on yield, nutrient uptake and economics of "Lal Badshabhog" rice (pooled data of 2 years)

Treatment	Grain yield (t/ha)			Straw yield (t/ha)	Lodging (score)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Cost of cultivation (×10³ ₹/ha)	Gross returns (×10³ ₹/ha)	Net income (×10³ ₹/ha)	Benefit: cost ratio
	2014	2015	Pooled									
Planting time												
10 July	2.29	2.53	2.41	6.76	3.4	40.6	15.6	30.9	39.7	61.1	21.5	1.59
25 July	2.57	2.66	2.62	6.46	2.8	41.2	15.7	30.4	39.7	64.6	25.0	1.68
10 August	2.68	2.75	2.72	5.97	2.2	41.6	16.1	29.7	39.7	65.6	25.9	1.70
SEm±	0.02	0.01	0.01	0.05	0.2	0.38	0.20	0.34		0.42	0.31	0.01
CD (P=0.05)	0.09	0.05	0.04	0.17	0.7	NS	NS	NS		1.37	1.22	0.03
Spacing												
20 cm × 15 cm	2.47	2.59	2.53	6.32	2.9	40.6	15.8	29.6	39.7	62.6	22.9	1.62
15 cm × 15 cm	2.56	2.71	2.63	6.47	2.7	41.7	15.8	31.0	39.7	65.0	25.3	1.69
SEm±	0.03	0.03	0.02	0.04	0.1	0.36	0.19	0.31		0.48	0.48	0.01
CD (P=0.05)	NS	0.10	0.06	0.13	NS	NS	NS	0.94		1.65	1.65	0.05
Nutrient management												
100% RD organic	2.45	2.55	2.50	6.21	2.2	40.4	15.2	28.4	48.0	61.8	13.8	1.29
100% RD inorganic	2.55	2.73	2.64	6.51	3.3	41.7	16.1	31.6	32.3	65.2	32.9	2.02
50% RD organic + 50% RD inorganic	2.54	2.68	2.61	6.46	2.8	41.4	16.1	31.0	38.7	64.4	25.7	1.66
SEm±	0.04	0.03	0.02	0.05	0.1	0.36	0.18	0.42		0.55	0.55	0.01
CD (P=0.05)	NS	0.08	0.07	0.15	0.5	1.03	0.52	1.18		1.60	1.60	0.04

Selling price of grain, ₹19,500/t (2014); and ₹20,000/t (2015); selling price of straw, ₹2,000/t (2014 and 2015)

Table 3. Interaction effect of planting time, spacing and nutrient management on grain yield and net income of scented "Lal Badshabhog" rice (pooled data of 2 years)

Nutrient management	10 July		25 July		10 August	
	20 cm × 15 cm	15 cm × 15 cm	20 cm × 15 cm	15 cm × 15 cm	20 cm × 15 cm	15 cm × 15 cm
Grain yield (t/ha)						
100% RD organic	2.29	2.33	2.48	2.62	2.56	2.71
100% RD inorganic	2.41	2.55	2.53	2.76	2.75	2.84
50% RD organic + 50% RD Inorganic	2.40	2.49	2.64	2.68	2.70	2.73
Net income (×10^3 ₹/ha)						
100% RD organic	10.1	11.4	13.7	16.3	14.1	17.2
100% RD inorganic	28.6	32.4	30.6	35.3	34.0	36.2
50% RD organic + 50% RD inorganic	21.9	24.4	26.7	27.2	26.5	27.6

RD, Recommended dose

tion-based treatments was noted as: 40.4–41.7 kg N/ha, 15.2–16.1 kg P/ha and 28.4–31.6 kg K/ha. Besides, N uptake by grain was usually more than double (26.9–27.6 kg/ha) compared to the uptake by straw (13.5–14.2 kg/ha) of "Lal Badshabhog" rice during *kharif* season (data not shown). The greater replacement of chemical fertilizers by organic manures (50% RD organic + 50% inorganic or 100% organic) resulted in lower uptake of N, P and K by "Lal Badshabhog" rice in the present study.

Perusal of data on changes in residual fertility status shown in Fig. 2 indicated that, there was positive build-up of N and P, but negative balance of K in soil after 2-year study on "Lal Badshabhog" paddy in Gangetic alluvium soil at Kalyani, West Bengal. However, Kumari *et al.* (2010) reported loss in soil N irrespective of organic treatments in scented rice (cv. Birsamati) at Ranchi, Jharkhand. "Lal Badhsabhog" crop grown under integrated nutrient management (50% RD organic + 50% RD chemical fertilizer) left the field with better residual status (+5.9% N, +28.3% P_2O_5 and +1.7% K_2O) after 2-year study in Gangetic alluvium soil.

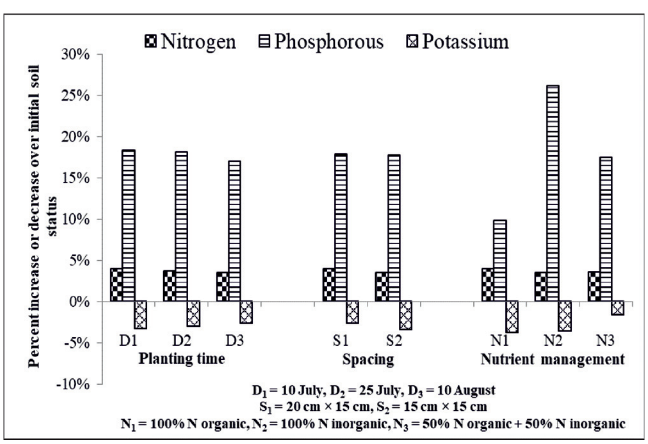

Fig. 2. Effect of planting time, spacing and nutrient-management on residual soil fertility status of "Lal Badshabhog" rice during rainy season (pooled data of 2 years)

Economics

The common cost of cultivation included the cost of inputs and income wages for transplanting, weeding, harvesting, threshing etc., excluding the cost of chemical fertilizers and organic manures used in the treatment schedule. The variation in treatment cost for the nutrient management led to differences in total cost of cultivation between ₹ 32,300 (100% RD inorganic) and ₹ 48,000/ha (100% RD organic) (Table 2). Gross returns included the values of grain and straw of 'Lal Badshabhog' rice, where the income ratio from grain and straw was 3.5–4.5 : 1 in our experiment. With delay in planting from 10 July to 10 August, the gross returns was increased by ₹ 4,500/ha (₹ 65,600 vs. ₹ 61,100/ha) during rainy (*kharif*) season at Kalyani, West Bengal. The net income and benefit : (B : C) cost ratio obtained from chemical fertilizer-based nutrient management was the highest (₹ 32,900/ha and 2.02), which was ₹ 7,100 and ₹ 19,100/ha greater over integrated and organic nutrient management. Thus, 100% RD inorganic appeared as profitable nutrient-management system in "Lal Badshabhog" rice field during *kharif* season. Planting of Lal Badshabhog rice on 10 July with wider spacing (20 cm × 15 cm) and 100% RD organic nutrient management resulted in the lowest net returns of ₹ 10,100/ha, which could be improved up to ₹ 36,200/ha under 10 August planting along with 15 cm × 15 cm spacing and nutrient dose of 100% RD inorganic in the investigation (Table 3).

It can be concluded that planting of "Lal Badshabhog" rice on 10 August at a spacing of 15 cm × 15 cm with 100% RD (N 50, P_2O_5 25, K_2O 25 kg/ha) through chemical fertilizers could be recommended for higher yield and income.

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