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Original Research Article

Response of Integrated Nutrient Management on Nutrient Uptake of Aromatic Rice and Its Residual Effect on Lentil Yield Cropping System under Terai Region of West Bengal

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A B S T R A C T

Keywords

Integrated nutrient management, Nutrient uptake, Aromatic rice, Lentil

To study the nutritional uptake of aromatic rice and its residual effect of lentil cropping system under Terai zone of West Bengal investigation was conducted at the instructional farm of Uttar Banga Krishi Viswavidyalaya located at Pundibari, Cooch Behar, West Bengal during 2014-15 and 2015-16. The experiment was laid out in split plot design with 2 aromatic rice varieties (Gobindabhog and Kalonunia) in main plots and 12 treatments of nitrogen management in sub-plot. Results reveal that variety 'Gobindabhog' with treatment 50% RDN through fertilizer + 50% RDN through VC recorded higher growth parameter, yield attribute and yield of aromatic rice. The nutrient uptake (N, P and K) also observed highest in the plot of 'Gobindabhog' variety treated with 50% RDN with fertilizer + 50% RDN through VC. Uptake of nutrients (N, P and K) in aromatic rice greatly varied with treatments. The maximum grain yield of residual effect of succeeding lentil crop was observed in plots of Kalonunia with treatment 50% RDN through fertilizer + 50% RDN through FYM.

Introduction

Rice is being grown in 117 countries and is a staple food for more than 70 per cent of global population. At global level, rice is grown on an area of about 163.2 million hectare with a production of 719.7 million tonnes. Among the rice growing countries, India is having the largest share in area for rice in the world and in case of production it ranks second in the world, only after China. India produces about 120.32 million tonnes from 42.62 million hectare with an average productivity of 2.82 tonnes per hectare (FAO stat, 2014). Among the rice varieties, aromatic or scented (fragrant) rice occupies a prime position on account of its excellent quality characters and thereby having great export potentiality. Among the agricultural commodities exported, aromatic rice holds a major share. Aromatic rice is very popular and highly priced due to its inherent aroma and cooking characteristics. It emits specific aroma in fields at the time of flowering, at harvesting, in storage even during milling, cooking and eating (Gibson, 1976; Efferson, 1985).

Many unique varieties of non-basmati aromatic rice like Gobindabhog, Tulaipanji, Kalonunia, Tulsibhog, Kataribhog, Radhunipagal, Radhatilak, Badshabhog, Kalojeera, Harinakhuri, etc. are cultivated in India especially in the state of West Bengal. All these traditional rice varieties are tall with weak stem, prone to lodging, photosensitive and having moderate to very strong aroma. These varieties have long duration and are low yielding. They are susceptible to many diseases and pests and their cultivation is restricted to certain areas only.

The issue of lower productivity of local aromatic rice is mainly due to inadequate as well as imbalanced use of nutrients which can be addressed through proper agronomic management in which selection of appropriate variety with balanced nutrient management may hold the key role. Declining soil health and increase in cost of inorganic fertilizers focus on the feasibility and use of organic sources to partially supplement the need of nitrogen to the crop as low priced organic manures. Farm yard manure or vermicompost when integrated with reduced doses of inorganic fertilizers result in improved soil fertility, growth and yield of plant (Subbian, and Palaniappan, 1992. Nutrient supply plays an important role in the crop production but under intensive cultivation use of chemical fertilizers alone for long period could result in deterioration of soil fertility and quality of produce. Chemical fertilizers have deleterious effect on soil fertility leading to unsustainable yields; while integration of chemical fertilizers with organic manures would be able to maintain soil fertility and sustain crop productivity (Jeyabal *et al.,* 2000). The use of organic manure in combination with inorganic fertilizers has been recommended for balancing soil fertility by several workers. Therefore, present was conducted to investigate the response of Integrated nutrient management practices on nutrient uptake of the rice crop and the beneficial residual effect on succeeding crop lentil.

Materials and Methods

The experiment was laid out in split plot design in sandy loam soil of West Bengal at Instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar with 2 aromatic rice varieties (Gobindabhog' and 'Kalonunia') in main plots and 12 treatments of nitrogen management in sub-plot (T_1-Control, T_2-100% RDN (40 kg N ha^{-1}) through fertilizer, T_3-25% RDN through fertilizer + 75% RDN through vermicompost, T_4 -25% RDN through fertilizer + 75% RDN through FYM, T_5-25% RDN through fertilizer + 37.5% RDN through vermicompost + 37.5% N through FYM, T_6 -50% RDN through fertilizer + 50% RDN through vermicompost, T_7-50% RDN through fertilizer + 50% RDN through FYM, T_8-50% RDN through fertilizer + 25% RDN through vermicompost + 25% N through FYM, T_9-75% RDN through fertilizer + 25% RDN through vermicompost, T_{10}-75% RDN through fertilizer + 25% RDN through FYM, T_{11}-75% RDN through fertilizer + 12.5% RDN through vermicompost + 12.5% N through FYM, T_{12}-50% RDN through vermicompost + 50% RDN through FYM). As per the treatments specification, Nitrogen fertilizers were applied in the form of urea at different doses. However in case of 100% of recommended dose of N fertilizer, 50%N was applied before transplanting through respective sources and rest 50% was applied as top dressing through prilled urea in two equal splits coinciding maximum tillering and panicle initiation stage. A uniform dose of 20 kg P_2O_5 ha^{-1} and 20 kg K_2O_5 ha^{-1} was applied to rice in the form of single super phosphate and murate of potash. All the plots were treated with FYM or vermicompost accordingly except T_1 (Control) and T_2 (100% RDN through fertilizer). In *kharif*, rice was transplanted on 16th June (2014) and 15th June (2015) in the spacing of 20 x 15 cm and harvested on 28th October (2014) and 26th October (2015). After rice, in *rabi* lentil as a succeeding crop were sown on 7th November (2014) and 5th November (2015) with spacing of 25 cm and harvested on 4th April (2014) and 1st April (2015). For both the respective years 2014-2015 and 2015-2016, pooled mean was calculated for each an every parameter recorded. Yield attributing characters and Yield parameter was calculated.

In the succeeding lentil crop no fertilizer was applied and lentil variety moitree was raised on residual fertility following data such as growth parameters (plant height, number of nodules per plant), yield attributes (number of pods per plant, 1000 grain weight) and yield (grain and stover) was collected and calculated. For nutrient uptake analysis, plant samples from each plot was taken at 30 days interval and kept the sample in an oven at 600C. When it was fully dry, then it was grind in a mixture and then analysed using the required equipment.

The effect of the experiment was recorded according to the varieties, nitrogen management and interaction between the varieties and nitrogen management for every parameter. Statistical analysis of all the collected data from the experiment was computed on analysis of variance method as suggested by Gomez and Gomez (1984) at 5% level of probability.

Results and Discussion

Effect of varieties and nitrogen management on nutrient uptake (N, P and K) by aromatic rice root, rice grain and its total uptake

Data presented in Table 1, revealed that nutrient uptake (N, P, K) of rice straw (74.41 N Kg ha^{-1}, 23.18 P_2O_5 Kg ha^{-1}, 62.06 K_2O Kg ha^{-1}), rice grain (53.49 N Kg ha^{-1}, 23.66 P_2O_5 Kg ha^{-1}, 45.14 K_2O Kg ha^{-1}) and total uptake (89.53 N Kg ha^{-1}, 32.79 P_2O_5 Kg ha^{-1}, 75.04 K_2O Kg ha^{-1}) was recorded to be highest with Gobindobog variety and lower in Kalonunia variety i.e. rice straw (65.37 N Kg ha^{-1}, 21.01 P_2O_5 Kg ha^{-1}, 56.61 K_2O Kg ha^{-1}), rice grain (48.62 N Kg ha^{-1}, 21.56 P_2O_5 Kg ha^{-1}, 40.88 K_2O Kg ha^{-1}) and total uptake (79.79 N Kg ha^{-1}, 29.80 P_2O_5 Kg ha^{-1}, 68.24 K_2O Kg ha^{-1}), respectively.

There was a significant variation in nutrient uptake (N, P, K) by rice straw and grain due to different nitrogen treatments. Higher nutrients uptake (N, P, K) of rice straw and rice grain was obtained with 50% RDN through fertilizer + 50% RDN through vermicompost i.e. Rice straw (77.11 N Kg ha^{-1}, 26.60 P_2O_5 Kg ha^{-1}, 68.56 K_2O Kg ha^{-1}) and Rice grain (55.60 N Kg ha^{-1}, 25.30 P_2O_5 Kg ha^{-1}, 47.86 K_2O Kg ha^{-1}) which was at par with treatment 75% RDN through fertilizer + 25% RDN through vermicompost for nitrogen uptake of rice straw and rice grain and Potassium uptake of rice straw and the treatment 50% RDN through fertilizer + 25% RDN through vermicompost + 25% N through FYM for phosphorus uptake of rice straw and rice grain and also for Potassium uptake of rice grain. The total nutrient uptake (N, P, K) was also found to be highest with 50% RDN through fertilizer + 50% RDN through vermicompost treatment (93.09 N Kg ha^{-1}, 36.33 P_2O_5 Kg ha^{-1}, 81.92 K_2O Kg ha^{-1}) which was at par with 75% RDN through fertilizer + 25% RDN through vermicompost for nitrogen and potassium uptake and the treatment 50% RDN through fertilizer + 25% RDN through vermicompost + 25% N through FYM for phosphorus uptake. Increase in N, P and K uptake with application of organic manures was also reported by many workers (Virdia and Mehta, 2009; Sathish *et al.,* 2011)

The pooled data of the interaction effect between the varieties and nitrogen management was found to be significant for nitrogen uptake by rice straw and its total uptake whereas for rice grain observed to be non-signicant.

Effect of varieties and nitrogen management on yield attributes and yields of aromatic rice

Results (Table 2) indicated that the yield attributes (number of tillers m^{-2}, number of panicles m^{-2}, panicle length, number of filled grains $panicle^{-1}$ and test weight) and yield varied appreciably due to the effect of varieties and was found to be statistically significant. Among the varieties, Gobindobog varieties had highest number of tillers m^{-2} (371), number of panicles m^{-2} (287), number of filled grains $panicle^{-1}$ (155) and test weight (21.2) as well as the yield of aromatic rice i.e. grain yield (2.32 t ha^{-1}), straw yield (5.85 t ha^{-1}) and harvest index (29.33%) whereas maximum panicle length was observed in Kalonunia variety (27.95).

There was a significant variation in the number of tillers m^{-2}, number of panicles m^{-2}, panicle length, number of filled grains $panicle^{-1}$, test weight, straw yield, grain yield and harvest index of aromatic rice due to various treatments during both the years. Incorporation of 50% RDN through fertilizer + 50% RDN through VC (T_6) brought about significant improvement in the number of tillers m^{-2} (395), number of panicles m^{-2} (317), number of filled grains $panicle^{-1}$ (156) and test weight (20.8) which was closely followed by T_8 (50% RDN through fertilizer + 25% RDN through VC + 25% RDN through FYM) and T_9 (75% RDN through fertilizer + 25% RDN through VC) in all the parameters recorded. Result of the experiment also reveal that application of 50% RDN through fertilizer + 50% RDN through VC showed appreciable response in the grain yield (2.41 t ha^{-1}) and straw yield (5.84 t ha^{-1}) of aromatic rice as compared with plots receiving 25% RDN through organic manure, plots receiving 25% RDN through fertilizer and plots receiving 100% RDN through fertilizer. Combined use of inorganic fertilizer and organic manure enhanced all the yield attributes of aromatic rice might be due to higher availability and efficient use of nutrients throughout the growing period as a result of plant nutrients from organic manures by greater microbial activities. The increase in yield attributes in turn helped the grain yield of aromatic rice. These results were in agreement with the finding Kumar *et al.,* (2014) and Yadav Lalji and Meena (2014). But the treatment 75% RDN through fertilizer + 25% RDN through VC found to have increase in panicle length (27.66 cm). Jayaraman and Purushothaman (1988) also obtained similar results.

Harvest index remain unaffected by different nitrogen treatments which remained at par with each other in respect of grain yield. In case of the interaction effect between the varieties and nitrogen management, all the yield components was found to be insignificant.

Effect of varieties and nitrogen management on the growth parameter, yield attributes and yields of lentil

From the pooled data (Table 3), Kalonunia transplanted plot obtain maximum residual effect of succeeding lentil crop in plant height (3.35 cm), number of nodules/plant (20.33), number of pods/plant (47.65) and 1000 grain weight (17.82) as well as the grain yield of lentil (1.13 t ha^{-1}) and stover yield (9.12 t ha^{-1}).

Table.1 Effect of varieties and nitrogen management on nutrient uptake (N, P and K) by aromatic rice root, rice grain and its total uptake

Treatment	Straw N uptake (kg ha^{-1})	Grain N uptake (kg ha^{-1})	Total N uptake (kg ha^{-1})	Straw P uptake (kg ha^{-1})	Grain P uptake (kg ha^{-1})	Total P uptake (kg ha^{-1})	Straw K uptake (kg ha^{-1})	Grain K uptake (kg ha^{-1})	Total K uptake (kg ha^{-1})
MAIN PLOT	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**
Kalonunia	65.37	48.62	79.79	21.01	21.56	29.8	56.61	40.88	68.24
Gobindobog	74.41	53.49	89.53	23.18	23.66	32.79	62.06	45.14	75.04
SEm±	0.33	0.34	0.14	**0.35**	**0.29**	**0.42**	**0.72**	**0.11**	**0.49**
CD(P=0.05)	1.98	2.07	0.84	**2.13**	**1.77**	**2.56**	**4.40**	**0.66**	**3.01**
Sub plot treatment									
T1	51.68	44.26	67.16	13.9	18.48	22.67	38.82	35.65	52.13
T2	69.48	49.19	81.81	20.39	21.91	29.89	56.12	41.29	67.73
T3	71.55	51.08	86.63	22.81	23.31	32.52	61.37	43.86	73.34
T4	64	46.26	76.59	16.98	19.26	25.37	48.05	37.64	59.98
T5	71.45	52.61	86.71	23.55	23.22	32.5	62.8	43.87	74.98
T6	77.11	55.6	93.09	26.6	25.3	36.33	68.56	47.86	81.92
T7	73.41	52.08	87.84	23.67	23.25	32.84	63.34	44.32	75.36
T8	76.1	54.28	91.26	26.46	25.11	36.1	67.13	47.38	79.76
T9	77.03	54.82	92.1	25.88	24.92	35.56	68.36	47.27	80.91
T10	67.69	50.99	83.68	21.56	21.98	30.2	58.49	41.19	70.24
T11	73.95	53.26	89.05	24.56	23.84	33.88	65.06	45.7	77.53
T12	65.21	48.24	80	18.8	20.71	27.66	53.94	40.07	65.81
SEm±	**0.76**	**1.14**	**0.9**	**0.67**	**0.81**	**0.68**	**1.84**	**0.96**	**1.36**
CD(P=0.05)	**2.17**	**3.26**	**2.56**	**1.92**	**2.32**	**1.94**	**5.24**	**2.72**	**3.86**
Interaction effect (AB)									
SEm±	**1.08**	**1.62**	**1.27**	**0.95**	**1.15**	**0.96**	**2.60**	**1.35**	**1.92**
CD(P=0.05)	**3.06**	**N.S.**	**3.62**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**

Table.2 Effect of varieties and nitrogen management on yield attributes, yields and quality of aromatic rice

Treatment	No. of effective tillers m^{-2}	No. of panicles m^{-2}	Panicle length (cm)	No. of filled grains $panicle^{-1}$	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Milling (%)	Hulling (%)	Head Rice Recovery (%)	Carbohydrate Rice	Protein Rice
MAIN PLOT	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**
Kalonunia	305	228	27.95	**134**	**19.4**	2.18	5.34	28.97	63.42	73.55	50.92	11714	50.1
Gobindobog	371	287	24.92	**155**	**21.2**	2.32	5.59	29.33	65.96	74.96	52.29	12985	53.64
SEm±	**6.10**	**4.59**	**0.29**	**0.83**	**0.10**	**0.004**	**0.0159**	**0.034**	**0.27**	**0.09**	**0.26**	**898.6**	**0.27**
CD(P=0.05)	**37.14**	**27.94**	**1.75**	**5.02**	**0.30**	**0.025**	**0.0965**	**0.208**	**1.63**	**0.56**	**1.55**	**5468**	**1.63**
Sub plot treatment													
T1	254	206	24.64	126	19.6	2.08	4.98	29.47	60.80	71.80	44.80	8421	37.66
T2	329	237	26.23	142	20.4	2.23	5.52	28.75	63.50	73.80	51.30	12898	47.72
T3	330	249	26.25	141	20.0	2.23	5.49	28.98	63.80	74.00	52.80	11793	51.26
T4	293	221	25.75	135	19.8	2.16	5.19	29.39	62.30	72.50	46.80	10760	41.35
T5	356	270	26.76	148	20.1	2.28	5.57	29.03	65.30	74.30	53.30	12324	54.97
T6	395	317	27.57	156	20.8	2.41	5.84	29.19	68.70	76.50	56.30	14097	60.98
T7	352	257	26.22	147	20.7	2.29	5.56	29.08	65.00	74.80	51.30	13298	54.77
T8	379	303	27.15	154	20.8	2.34	5.69	29.23	68.00	76.00	55.80	14557	58.85
T9	390	300	27.66	153	20.8	2.36	5.62	29.55	68.00	76.50	56.00	14155	60.52
T10	328	246	26.21	143	20.6	2.23	5.34	29.54	63.00	73.50	49.00	12963	52.17
T11	367	250	27.08	151	20.2	2.3	5.67	28.82	65.80	75.30	54.50	12984	56.16
T12	285	232	25.72	134	19.7	2.16	5.23	29.38	69.00	76.70	57.70	9948	46.03
SEm±	**17.27**	**23.44**	**0.42**	**5.91**	**0.10**	**0.019**	**0.0584**	**0.284**	**0.91**	**0.82**	**0.93**	**1846**	**0.91**
CD(P=0.05)	**49.22**	**66.8**	**1.21**	**16.85**	**0.30**	**0.054**	**0.1664**	**0.808**	**2.58**	**2.33**	**2.63**	**5261**	**2.6**
Interaction effect (AB)													
SEm±	**24.42**	**33.14**	**0.60**	**8.36**	**0.20**	**0.027**	**0.0826**	**0.401**	**1.28**	**1.16**	**1.31**	**2610**	**1.29**
CD(P=0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**

Table.3 Effect of varieties and nitrogen management on succeeding lentil crop

Treatment	Plant Height (cm)	No. of nodule/plant	No. of pods/plant	1000 grain weight (g)	Grain yield of lentil (t ha^{-1})	Stover yield (t ha^{-1})
MAIN PLOT	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**
Kalonunia	34.35	20.33	47.65	17.82	1.13	9.12
Gobindobog	31.41	19.32	46.06	17.29	1.12	8.95
SEm±	**0.084**	**0.189**	**0.11**	**0.08**	**0.0041**	**0.0133**
CD(P=0.05)	**0.513**	**1.15**	**0.68**	**0.48**	**0.0247**	**0.0809**
Sub plot treatment						
T1	31.31	17.39	35.92	16.7	1.00	7.58
T2	33.89	19.62	49.37	17.55	1.12	9.55
T3	32.69	19.75	47.04	17.46	1.11	9.22
T4	33.46	20.35	45.73	17.55	1.12	8.79
T5	32.09	18.91	45.13	17.6	1.12	8.56
T6	33.29	19.21	48.57	17.67	1.15	9.32
T7	33.89	21.19	50.87	17.93	1.20	9.71
T8	32.41	20.63	50.15	17.88	1.20	9.45
T9	32.63	19.78	46.21	17.74	1.15	8.95
T10	33.52	20.59	49.69	17.64	1.13	9.59
T11	31.46	18.56	43.4	17.05	1.07	8.01
T12	33.94	21.12	50.23	17.85	1.17	9.66
SEm±	**0.387**	**0.662**	**0.59**	**0.13**	**0.0088**	**0.0866**
CD(P=0.05)	**1.104**	**1.886**	**1.68**	**0.36**	**0.0250**	**0.2469**
Interaction effect (AB)						
SEm±	**0.548**	**0.936**	**0.83**	**0.18**	**0.0124**	**0.1225**
CD(P=0.05)	**N.S.**	**N.S**	**2.38**	**0.51**	**N.S.**	**N.S.**

Residual effect of various nitrogen treatments (organic or inorganic) applied to preceding rice influenced significantly the plant height, number of nodules per plant, number of pods/plant, 1000-grain weight, grain and stover yield of succeeding lentil crop. In general, the plot receiving 50% RDN through organic manure (vermicompost or FYM or vermicompost + FYM) showed significant residual response in terms of plant height, number of nodules/plant and yield attributes of lentil as compared to plots receiving 25% RDN or 75% RDN or 100% RDN through organic manure except the plot receiving 75% RDN through fertilizer + 25% RDN through vermicompost and plot receiving 100% RDN through inorganic fertilizer.

Nitrogen applied at the rate of 50% of the recommended dose through combination of inorganic fertilizer and organic FYM had more pronounced residual effect on number of nodules/plant (21.19), number of pods per plant (50.87), 1000-grain weight (17.93), grain yield (1.20 t/ha) and stover yield (9.71 t/ha). However, no marked differences was observed in grain yield of the plot incorporated with 50% RDN through fertilizer + 25% RDN through VC + 25% RDN through FYM.

The higher grain yield of lentil recorded due to residual effect of organic and inorganic nutrient together may be accounted for enhanced availability and gradual release of plant nutrient through organic sources. Similar results have also been reported by many workers (Maskina, 1989, Singh *et al.*, 2002 and Singh *et al.,* 2004). The interaction effect of succeeding lentil crop between varieties and nitrogen management was found to be significant in the number of pods/plant and 1000-grain weight (g).

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