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Determination of Nutrient Accumulation Pattern of New Aromatic Rice (*Oryza sativa* L.) as Influenced by Different Applied Fertilizers and Plant Spacing

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Abstract

Field and laboratory experiments were conducted at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, during boro season of 2015-2016 to determine the response of rice crop (BU Dhan 2) to different plant densities under different fertilizer levels. The variety was grown with three fertilizer levels viz. recommended (57-10-8-7-0.9 kg NPKSZn ha^{-1}), 50% higher (114-20-16-14-1.8 kg NPKSZn ha^{-1}) and 50% lower (28.5-5-4-3.5-0.45 kg NPKSZn ha^{-1}) than recommended level and three plant spacing (20 cm x 25 cm, 20 cm x 20 cm and 20 cm x 15 cm) representing wider, standard and closer plant densities. Nutrient uptake of the variety was higher at higher level of fertilizer and closer plant spacing. The highest grain yield 5.18 t ha^{-1} of the variety was associated with the highest nutrient uptake under higher dose of fertilizer at closer plant spacing. This treatment combination also showed the highest nitrogen (86.53 kg ha^{-1}), phosphorus (9.85 kg ha^{-1}), potassium (103.9 kg ha^{-1}), sulphur (12.27 kg ha^{-1}) and zinc uptake (265.76 g ha^{-1}) of the variety, although nutrient use efficiency was higher at lower fertilizer level under wider plant density.

Keywords: New aromatic rice, plant spacing, fertilizer level

1. Introduction

Rice is the main cereal crop, which ranks first position in Bangladesh. It occupies nearly 75% of total cropped area of the country (BBS, 2015). More than 99% of the people of the country consume rice as their main food at the rate of 416 g per person per day (HEIS, 2010). It is main source of energy, which supplies about 75% of calories intake daily diet (Bhuiyan *et al.*, 2004). It also provides vitamin and other nutrients to the common people consuming rice as a staple food. Rice production in the country is increasing but emphasis was given mostly on yield improvement. Currently, people are becoming more conscious about the quality of rice they consume. Therefore, it is desirable to increase yield as well as quality of rice. The new rice variety (BUdhan 2) developed by Department of Genetics and Plant Breeding, BSMRAU is high grain quality with aromatic characteristics. This variety needs optimum plant nutrients as many soils of the country is inherently poor in nutrient content (Ahmed, 1992). The most common limiting nutrients in rice are nitrogen, phosphorus, potassium, sulphur, zinc and boron (Suriya-arunroj *et al.*, 2000).

Nitrogen is one of the essential macronutrients for rice growth and one of the main factors to be considered for developing a high yielding rice cultivar. The demand of the plant for other macronutrients mainly depends on the nitrogen supply (Dobermann *et al.,* 1996). Rice plant normally responds to nitrogen fertilizers and in addition, some cases of responses to phosphorous, potassium, sulphur and zinc have been described (Ragland and Bunpukdee, 1987). Adequate supply of nitrogen is beneficial for nitrogen, carbohydrates and protein metabolism, promoting cell divisions and enlargement.

Similarly, good supply of phosphorus is usually associated with increased exploration and supply of nutrients and water to the growing plant parts, resulting in increased growth and yield traits, thereby ensuring more seed and dry matter yield (Matti and Jana, 1985). Potassium nutrition in rice promotes panicle development, spikelet fertility, leaf area and leaves longevity, stem strength and plant tolerance to diseases and pests. Sulphur plays an important role in the biochemistry and physiology of the rice plant, mainly in chlorophyll synthesis. Zinc is critical for many physiological functions including the maintenance of structural and functional integrity of biological membranes and the facilitation of protein synthesis (Singh et al., 2012).

Understanding the dynamics of these nutrients in terms of their uptake, translocation and distribution in rice plant is an important aspect of its nutrition that will improve its production and reduce the cost of fertilization. Besides nutrition, plant density is one of the most significant agronomic practices contributing towards grain yield as well as other important attributes of the crop. Rautaray (2007) reported that 15 ×15 cm plant spacing resulted in highest grain yield of 4.51 t ha^{-1} during wet season and 5.27 t h^{-1} during dry season. Many studies have been conducted to elucidate the factors controlling nitrogen, phosphorus, potassium, sulphur and zinc uptake efficiencies and nutrient content in plants (Tillman *et al.,*1991) but there is scarce information on nutrient efficiency of new rice variety involving several plant densities. A study was, therefore, conducted to determine the response of rice crop (BUdhan 2) to different plant densities under different fertilizer levels.

2. Materials and Methods

Field and laboratory experiments were conducted at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, during boro season of 2015-2016. The planting material was an aromatic rice variety (BUdhan2). The experiment having two factors (fertilizer level and plant spacing) was set up in a randomized complete block design with four replications. Fertilizer levels are 50% higher 114-20-16-14-1.8 kg NPKSZn ha^{-1}) than recommended dose (F_1), recommended (57-10-8-7-0.9 kg NPKSZn ha^{-1}) dose (F_2) and 50% lower (28.5-5-4-3.5-0.45 kg NPKSZn ha^{-1}) than recommended dose (F_3) and three plant spacing such as wider, 20 cm × 25 cm (S_1), standard, 20 cm × 20 cm (S_2) and closer 20 cm × 15 cm, (S_3) plant densities. Compared treatments are F_1 S_1: Higher dose of fertilizer application with wider spacing. F_1 S_2: Higher dose of fertilizer application with standard spacing, F_1 S_3: Higher dose of fertilizer application with closer spacing, F_2 S_1: Recommended dose of fertilizer application with wider spacing, F_2 S_2: Recommended dose of fertilizer application with standard spacing, F_2 S_3: Recommended dose of fertilizer application with closer spacing, F_3 S_1: Lower dose of fertilizer application with wider spacing, F_3 S_2: Lower dose of fertilizer application with standard spacing, F_3 S_3: Lower dose of fertilizer application with closer spacing.

2.1 Plant analysis

Rice plant of five hills from each plot were sampled at 10 days interval from 30 DAT and continued till 90 DAT. Nitrogen, P, K, S and Zn were determined from the collected plant samples. The leaf sample was dried at 70^0C for 72 hrs and ground by Wiley Mill. The ground sample was digested in concentrated H_2PO_4 and total N concentration was determined by micro

Kjeldahl method (Yoshida *et al*., 1976). The concentration of P, K, S and Zn was analyzed digesting a 0.2 g leaf sample with 6 ml of 5:2 HNO_3: $HClO_4$ (Yoshida *et al*., 1976). Grain and straw samples from each plot (200 mg) were taken and separately oven dried at 65^0 C over night to grind in a grinding machine. Total N content was determined by Micro-kjeldahl distillation. Total N uptake was determined by the following formulae:

$$\text{Nitrogen uptake by grain (kg ha}^{-1}) = \frac{\text{\% N in grain x Grain yield (kg ha}^{-1})}{100}$$

$$\text{Nitrogen uptake by straw (kg ha}^{-1}) = \frac{\text{\% N in straw x straw yield (kg ha}^{-1})}{100}$$

Nutrient use efficiencies were calculated using the following formula (Fageria *et al*., 1997):

$$\text{Nutrient use efficiency} = \frac{(G_f - G_u)}{N_a}$$

where, G_f is the grain yield of the fertilized plot (kg), G_u is the grain yield of the unfertilized plot (kg) and N_a is the quantity of nutrient applied (kg).

2.2 Statistical analysis

The data of different parameters were analyzed statistically by a statistical procedure of analysis of variance (ANOVA). Microsoft Excel and software program were used whenever appropriate to perform statistical analysis. Duncan's Multiple Range (DMRT) Test was used to compare means at 0.05 level of significance.

3. Results and Discussion

3.1 Nitrogen content, uptake and use efficiency

Nitrogen concentration was maximum (0.83%) in rice plants under the application of higher dose of fertilizer at closer plant spacing (Table 1). Similar result was observed by Khanam *et al.* (2000) who reported that nitrogen content in rice plant increased with the increase of fertilizer dose and at closer plant spacing. But Shehu *et al.* (2010) reported that nitrogen content in rice plant increased under higher dose of fertilizer with wider plant spacing. On the other hand, minimum (0.78%) was found with the application of the lower dose of fertilizer at wider plant spacing. Higher amount of nitrogen concentration in rice plants at higher dose of fertilizer indicated that the new rice variety required higher amount of nitrogen to sustain maximum growth rate. Havlin *et al.* (2006) observed that when a nutrient is deficient, increasing nutrient availability at higher fertilizer dose will increase plant nutrient contents. Further, application of other nutrients also increases plant nitrogen content as Mugwira *et al.* (1997) reported that application phosphorus increased shoot nitrogen content of plant. Because phosphorus plays a role in uptake and utilization of nitrogen by developing extensive roots through which nitrogen can be absorbed and distributed to other parts of the plant.

Nitrogen uptake by rice plant under higher dose of applied fertilizer with closer spacing was the highest (86.53 kg ha^{-1}) and the lowest nitrogen uptake (50.54 kg ha^{-1}) was observed in lower dose of applied fertilizer with wider spacing. This confirms the findings of Mahato *et al.* (2007) who explained that higher level of fertilizer dose and plant spacing increased dry matter yield per unit area and ultimately increased nitrogen uptake over lower fertilizer dose and wider plant spacing.

Application of lower dose fertilizer with wider plant spacing showed the highest (65.49 kg grain per kg N uptake) nitrogen use efficiency. On the other hand, the lowest nitrogen use efficiency (59.87 kg grain per kg N uptake) was recorded at high level of fertilizer dose with closer planting spacing. Liu *et al*. (2016) also observed decrease of nitrogen use efficiency due to use of high level of N fertilizer and inappropriate fertilization management in rice cultivation. In this context, Jiang *et al.* (2013) explained that, narrow spacing of rice plant decreases nitrogen use efficiency, because of excessive absorption of nitrogen under higher fertilizer level. In closer spacing most of the nitrogen was accumulated in the vegetative organs and few were translocated to the grains, which decreases nitrogen use efficiency in rice (Mae *et al.*, 2006).

Table 1. Nitrogen content, uptake and use efficiency of new aromatic rice variety BUdhan 2 as influenced by different level of fertilizer dose and plant spacing

Fertilizer level (N P K S Zn kg ha^{-1})	Spacing (cm)	Nitrogen content (%)	Nitrogen uptake (kg ha^{-1})	Nitrogen use efficiency (kg grain per kg N uptake)
Higher dose (114 - 20 - 16- 14 -1.8)	Wide (20×25)	0.81 a	62.46 de	61.54 ab
	Standard (20×20)	0.82 a	67.27 cd	60.84 ab
	Closer (20×15)	0.83 a	86.53 a	59.87 b
Mean of higher doses of different plant spacing		0.82 a	72.08 a	60.75 b
Recommended dose (57 - 10 - 8- 7 – 0.9)	Wide (20×25)	0.80 a	54.70 f	63.08 ab
	Standard (20×20)	0.80 a	64.12 de	62.85 ab
	Closer (20×15)	0.81 a	77.53 b	61.01 ab
Mean of recommended doses of different plant spacing		0.80 a	65.45 b	61.32 ab
Lower dose (28.5 - 5 - 4- 3.5 -0.45)	Wide (20×25)	0.78 a	50.54 f	65.49 a
	Standard (20×20)	0.79 a	61.22 e	63.06 ab
	Closer (20×15)	0.79 a	70.66 c	62.69 ab
Mean of lower doses of different plant spacing		0.79 a	60.81c	63.75 a
CV (%)		6.78	5.77	5.22
LSD (0.05%)		0.0794	5.5676	4.7467

Means in a column followed by same letter (s) did not differ significantly by DMRT at 0.05 level

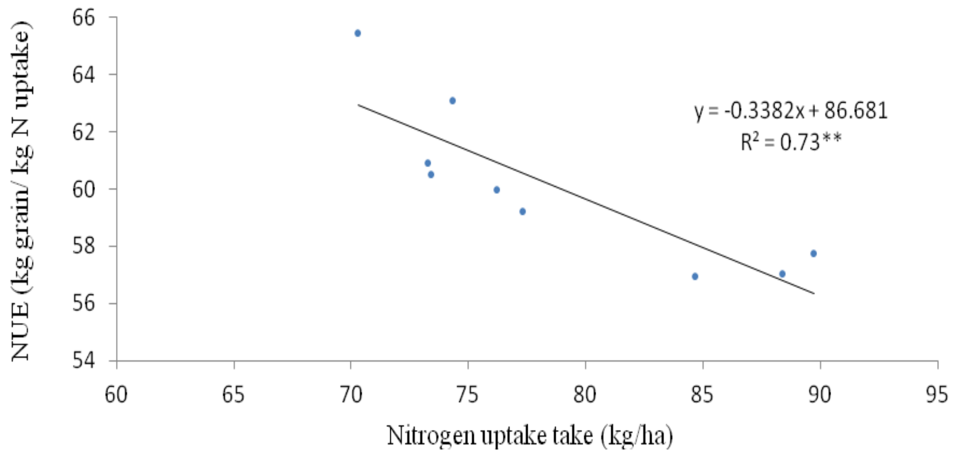

Figure 1. Functional relationship between N uptake and N use efficiency of new aromatic rice variety BUdhan 2 as influenced by variable fertilizer dose and plant spacing.

* indicates significant at 5% level of probability

The result confirms with the functional relationship (Fig. 1) between nitrogen uptake and nitrogen use efficiency that nitrogen use efficiency decreases with the increase of nitrogen uptake by the rice plant.

3.2 Phosphorus content, uptake and use efficiency

Application of higher amount of fertilizer increased phosphorus content in rice plant. The maximum phosphorus concentration (0.089%), in rice plants was found with the application of the higher dose of fertilizer and it was profoundly influenced by plant density. The minimum (0.083%,) was obtained at lower dose of fertilizer in wider plant spacing, which indicated that phosphorus availability was not sufficient for rice plant at lower fertilizer dose. Low availability of phosphorus in soil showed down phosphorus absorption which reduces phosphorus concentration in rice plant (Tandon, 1995).

As phosphorus content increases at higher fertilizer dose, the highest phosphorus uptake (9.85 kg ha^{-1}) was found under higher dose of fertilizer with closer plant spacing (Table 2). The lowest phosphorus uptake (6.0 kg ha^{-1}) was observed in rice plants grown under lower dose of fertilizer with wider plant spacing. In present study, phosphorus uptake further influenced by application of higher amount of other element especially from increase in nitrogen rate. Sieling *et al.* (2006) reported that nitrogen promote phosphorus uptake by increasing tap root growth, plant metabolism, phosphorus solubility and availability of phosphorus by decreasing the soil pH through NH_4^+ absorption.

Table 2. Phosphorus content, uptake and use efficiency of new aromatic rice variety BUdhan 2 as influenced by different level of fertilizer dose and plant spacing

Fertilizer level (N P K S Zn kg ha^{-1})	Spacing (cm)	Phosphorus content (%)	Phosphorus uptake (kg ha^{-1})	Phosphorus use efficiency (kg grain per kg P uptake)
Higher dose (114 - 20 - 16- 14 – 1.8)	Wide (20×25)	0.085 a	6.94 e	547.44 a
	Standard (20×20)	0.084 a	7.75 cd	534.22 a
	Closer (20×15)	0.089 a	9.85 a	521.58 a
Mean of higher doses of different plant spacing		0.086 a	8.18 a	549.00 a
Recommended dose (57 - 10 - 8- 7 – 0.9)	Wide (20×25)	0.084 a	6.27 f	550.55 a
	Standard (20×20)	0.089 a	7.4 de	544.39 a
	Closer (20×15)	0.08 a	9.07 b	521.76 a
Mean of recommended doses of different plant spacing		0.084 a	7.58 b	538.90 a
Lower dose (28.5 - 5 - 4- 3.5 –0.45)	Wide (20×25)	0.083 a	6 f	551.82 a
	Standard (20×20)	0.084 a	7.03 e	549.29 a
	Closer (20×15)	0.085 a	8.12 c	545.89 a
Mean of lower doses of different plant spacing		0.084 a	7.05 c	534 41a
CV (%)		8.29	5.80	8.84
LSD (0.05%)		0.0102	0.6437	69.800

Means in a column followed by same letter (s) did not differ significantly by DMRT at 0.05 level

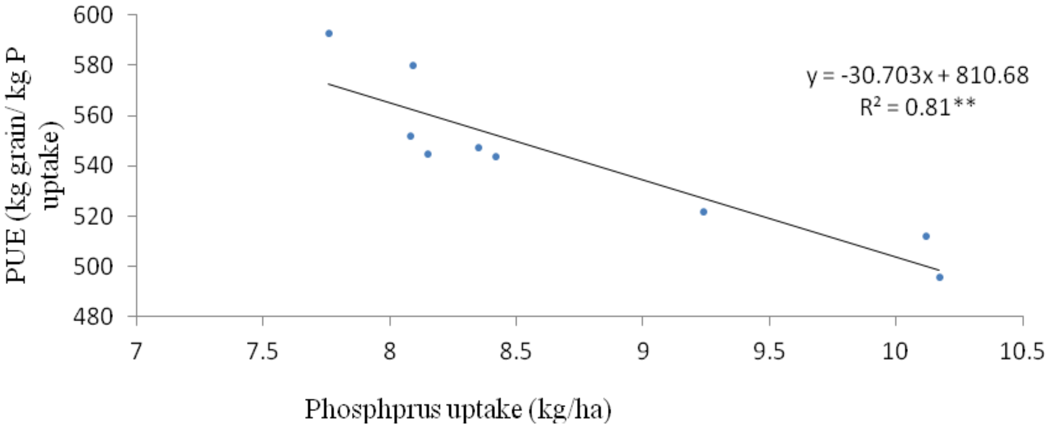

Figure 2. Functional relationship between P uptake and P use efficiency of new aromatic rice variety BUdhan2 as influenced by applied fertilizer rate and plant spacing.
** indicates significant at 1% level of probability.

Table 3. Potassium content, uptake and use efficiency of new aromatic rice variety BUdhan 2 as influenced by different level of fertilizer dose and plant spacing.

Fertilizer level (N P K S Zn kg ha^{-1})	Spacing (cm)	Potassium Content (%)	Potassium uptake (kg ha^{-1})	Potassium use efficiency (kg grain per kg K uptake)
Higher dose (114 - 20 - 16- 14 – 1.8)	Wide (20×25)	0.17 a	72.06 de	52.74 a
	Standard (20×20)	0.17 a	80.51 c	51.42 a
	Closer (20×15)	0.18 a	103.9 a	49.86 a
Mean of higher doses of different plant spacing		0.17 a	0.85.48 a	51.57 a
Recommended dose (57 - 10 - 8- 7 – 0.9)	Wide (20×25)	0.17 a	65.14 ef	52.96 a
	Standard (20×20)	0.16 a	77.74 cd	51.84 a
	Closer (20×15)	0.16 a	92.91 b	50.91 a
Mean of recommended doses of different plant spacing		0.16 a	78.60 b	51.90 a
Lower dose (28.5 - 5 - 4- 3.5 –0.45)	Wide (20×25)	0.15 a	61.1f	54.18 a
	Standard (20×20)	0.16 a	71.57de	53.93 a
	Closer (20×15)	0.16 a	84.23c	52.59 a
Mean of lower doses of different plant spacing		0.16 a	72.30 c	53.57 a
CV (%)		8.46	5.10	9.66
LSD (0.05%)		0.0203	5.8645	7.3705

Means in a column followed by same letter (s) did not differ significantly by DMRT at 0.05 level.

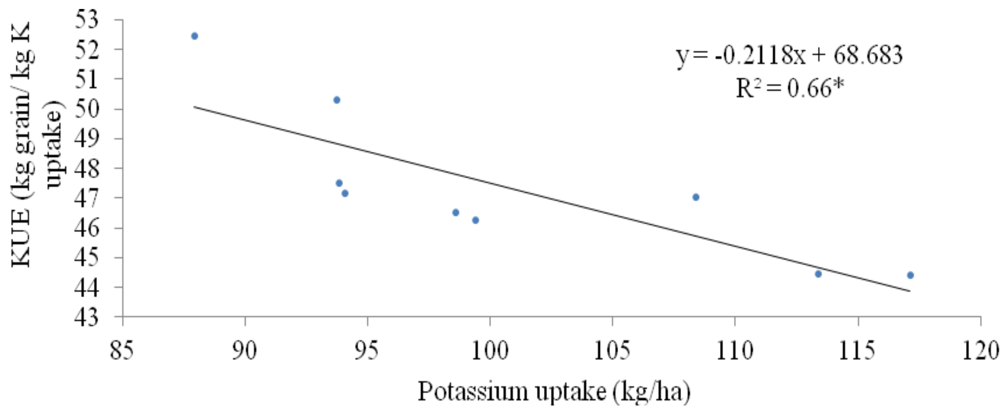

Figure 3. Functional relationship between K uptake and K use efficiency of new aromatic rice variety BUdhan 2 as influenced by applied fertilizer rate and plant spacing. * indicates significant at 5% level of probability.

Phosphorus use efficiency also decreased with the increase of the level of fertilizer dose and decrease of plant spacing. Phosphorus use efficiency was the lowest (521.58 kg grain per kg P uptake) under high fertilizer dose with closer plant spacing and the highest phosphorus use efficiency (551.82 kg grain per kg P uptake) was recorded under low level of fertilizer dose with wider plant spacing. Venugopalan and Blaise (2001) also reported that phosphorus uptake greatly influences on phosphorus use efficiency and there is negative relationship (Fig. 2) between phosphorus uptake and phosphorus use efficiency in rice plants in present study.

3.3 Potassium content, uptake and use efficiency

Application of higher dose of fertilizer did not increase plant potassium content significantly but it tended to increase to some extent (Table 3). However, potassium uptake increased at higher fertilizer dose and closer plant spacing. Maximum amount (103.9 kg ha^{-1}) of potassium uptake was recorded at higher fertilizer with closer spacing. The application of potassium through higher fertilizer rate promoted greater availability of potassium in the soil, and consequently, the contact between potassium and the rice roots (Filho *et al.*, 2017). Potassium use efficiency was the highest (54.18 kg grain per kg K uptake) at lower fertilizer dose in wider plant spacing and the lowest (49.86 kg grain per kg K uptake) at higher fertilizer dose with closer plant spacing. Similar result was found by Filho (2017) who observed the highest potassium use efficiency with the application of lower dose of potassium fertilizer. However, much decrease in potassium use efficiency is not consistent as it is not a part of structural organs of the plant. Decrease in potassium use efficiency (Fig.3) with increasing potassium uptake in rice also illustrated in present study.

3.4 Sulphur content, uptake and use efficiency

Sulphur content in rice plants increased under higher fertilizer dose (Table 4) as higher fertilizer dose contains higher amount of other elements including sulphur. This increase in sulphur content may be due to its stimulation of root and shoot growth. Sanju *et al.* (2005) reported that plants with well-developed root systems have the ability to exploit a greater soil volume which is fundamental for increasing the contact between roots and nutrients resulting in an improvement in sulphur content and sulphur uptake. Sulphur uptake further enhanced by plant density where closer spacing increased sulphur uptake in rice. Thus maximum content (0.066%) and uptake (12.27 kg ha^{-1}) of sulphur was recorded at higher fertilizer level with closer plant spacing. Sulphur use efficiency however decreased with the increase of fertilizer dose and plant spacing as there is negative relationship (Fig. 4) between sulphur uptake and sulphur use efficiency in rice.

Table 4. Sulphur content, uptake and use efficiency of new aromatic rice variety BUdhan 2 as influenced by variable fertilizer dose and plant spacing

Fertilizer level (N P K S Zn kg ha^{-1})	Spacing (cm)	Sulphur content (%)	Sulphur uptake (kg ha^{-1})	Sulphur use efficiency (kg grain per kg S uptake)
Higher dose (114 - 20 - 16- 14 – 1.8)	Wide (20×25)	0.063a	8.28 cd	458.98 b
	Standard (20×20)	0.064a	9.62 bc	430.43 c
	Closer (20×15)	0.066a	12.27 a	422.28 c
Mean of higher doses of different plant spacing		0.064 a	10.06 a	437.22 b
Recommended dose (57 - 10 - 8- 7 – 0.9)	Wide (20×25)	0.063a	7.29 de	473 b
	Standard (20×20)	0.063a	8.64 bcd	66.32 b
	Closer (20×15)	0.066a	10.22 b	462.85 b
Mean of recommended doses of different plant spacing		0.064 a	8.72 b	467.39 ab
Lower dose (28.5 - 5 - 4- 3.5 –0.45)	Wide (20×25)	0.061a	6.54 e	505.86 a
	Standard (20×20)	0.062a	8.05 cde	479.23 b
	Closer (20×15)	0.063a	9.35 bc	473.62 b
Mean of lower doses of different plant spacing		0.062 a	7.98 c	486.23 a
CV (%)		7.71	4.90	9.08
LSD (0.05%)		7.132	0.6381	61.422

Means in a column followed by same letter (s) did not differ significantly by DMRT at 0.05 level.

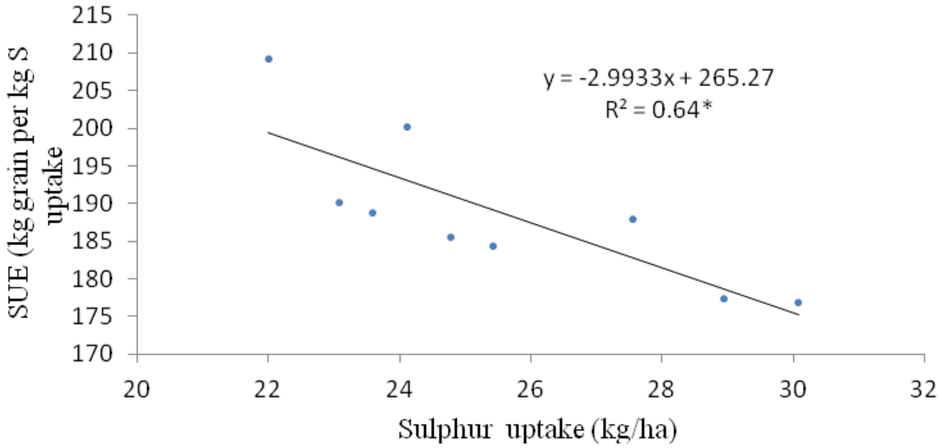

Figure 4. Functional relationship between S uptake and S use efficiency of new aromatic rice variety BUdhan 2 as influenced by applied fertilizer dose and plant spacing.* indicates significant at 5% level of probability.

Table 5. Zinc content, uptake and use efficiency of new aromatic rice variety BUdhan 2 as influenced variable fertilizer dose and plant spacing

Fertilizer level (N P K S Zn kg ha^{-1})	Spacing (cm)	Zinc content (µ g g^{-1})	Zn uptake (g ha^{-1})	Zn use efficiency (kg grain per g Zn uptake)
Higher dose (114 - 20 - 16- 14 – 1.8)	Wide (20×25)	81.74a	180.9 bcde	21.00 f
	Standard (20×20)	82.40a	206.37 bc	20.06 g
	Closer (20×15)	83.99a	265.76 a	19.49 h
Mean of higher doses of different plant spacing		82.71 a	217.67 a	20.18 b
Recommended dose (57 - 10 - 8- 7 – 0.9)	Wide (20×25)	80.91a	158.99 de	21.69 d
	Standard (20×20)	81.89a	186 bcd	21.66 d
	Closer (20×15)	82.98a	220.7 b	21.43 e
Mean of recommended doses of different plant spacing		81.93 a	188.56 b	21.60 ab
Lower dose (28.5 - 5 - 4- 3.5 –0.45)	Wide (20×25)	81.74 a	144.16 e	22.96 a
	Standard (20×20)	82.40 a	173.10 cde	22.29 b
	Closer (20×15)	83.99a	203.42 bc	21.77 c
Mean of lower doses of different plant spacing		82.71 a	173.56 c	22.34 a
CV (%)		7.90	5.79	9.36
LSD (0.05%)		9.5001	16.340	2.9180

Means in a column followed by same letter (s) did not differ significantly by DMRT at 0.05 level

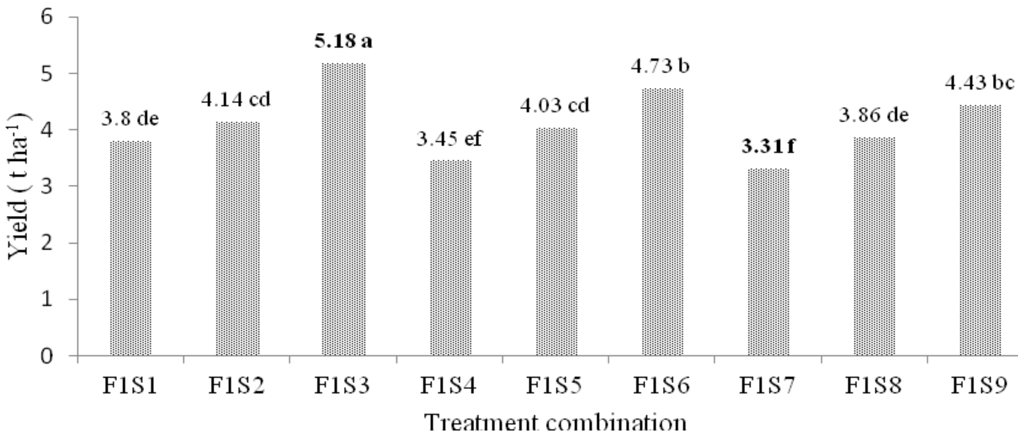

Figure 5. Grain yield of new aromatic rice variety BUdhan 2 as influenced by variable fertilizer dose and plant spacing

3.5 Zinc content, uptake and use efficiency

Zinc concentration in rice plants did not vary significantly due to levels of fertilizer and plant spacing (Table 5). However, higher zinc concentration in rice plant was observed under higher fertilizer level over the plant spacing. Zinc accumulation pattern in plant is genetic characteristics that control the variability of specific carrier involved in ion uptake through the plasmatic membrane of root cell. The specificity and selectivity of this carrier are directly related to mineral uptake and fertilizer use efficiency (Fageria, 2011). Although zinc uptake by rice plant was higher (265.76 g ha^{-1}) in higher fertilizer level and closer plant spacing but zinc use efficiency (22.96 kg grain per g Zn uptake) was the highest under lower fertilizer level with wider plant spacing. This result agreed well with the findings of Zand *et al.* (2014) in sorghum and Ghoneim (2016) in rice.

4. Conclusions

The highest uptake of nitrogen (86.53 kg ha^{-1}), phosphorus (9.85 kg ha^{-1}), potassium (103.9 kg ha^{-1}), sulphur (12.27 kg ha^{-1}) and zinc (265.76 g ha^{-1}) was found under higher dose of applied fertilizer with closer spacing was the maximum. On the other hand, the minimum uptake of nitrogen (50.54 kg ha^{-1}), phosphorus (6.0 kg ha^{-1}), potassium (61.1 kg ha^{-1}), sulphur (6.54 kg ha^{-1}) and zinc (144.16 g ha^{-1}) was observed under lower dose of applied fertilizer with wider spacing. Comparing the nutrient use efficiency among all nine treatments, lower dose of applied fertilizer with closer plant spacing showed the highest nutrient use efficiency of nitrogen (65.49 kg grain per kg N uptake), phosphorus (551.82 kg grain per kg P uptake), potassium (54.18 kg grain per kg K uptake), sulphur (505.86 kg grain per kg S uptake) and zinc (22. 96 kg grain per g Zn uptake).

5. Recommendations

To accelerate the nutrient uptake (kg ha^{-1}) of the variety BUdhan 2 for the yield of more than 5 t ha^{-1}, higher fertilizer dose of 114-20-16-14-1.8 kg NPKSZn ha^{-1} at plant spacing of 20 cm x 15 cm is recommended.

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