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Influence of Field Deep Fertilisers on Nitrogen, Phosphorous, Potassium and Sulfur Uptake and Yield Performance of Green Super Rice

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Authors' contributions

This work was carried out in collaboration between all authors. Author RK designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors MZK and MSA reviewed the study design and all drafts of the manuscript. Authors MZK and RK undertook the statistical analysis of the data collected and managed the literature searches and reference-citations. Finally, all the authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted to investigate the Influence of field deep fertilisers on nitrogen, phosphorous, potassium and sulfur uptake and yield performance of green super rice during the period of 15th January to 16th May 2015. Soil samples were collected at a depth of 0-15 cm from the sara soil series at Jessore District in Bangladesh. The experiment was laid to fit a completely randomised design (CRD) with five treatments (constituted with organic, inorganic and mixed fertiliser along with different levels of field deep urea) each having three replications. Results indicate that the highest amount of macronutrient uptake was found in inorganic treatment (T_2) with field deep urea. But mixed fertiliser (T_4) with field deep urea showed nearer results with a specific advance period of yield performance of green super rice than other treatments. So, deep placement of urea is better than traditional placement. Macronutrient uptake was significantly (P <

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0.05) influenced by various treatments and application procedure of urea. Yield performance in the sara soil series of Jessore District will require field deep urea with mixed fertiliser (T_4) to get advance production of rice with less damage to soil health than inorganic fertiliser (T_2). In addition, inorganic fertilizer can give quite higher production than mixed (T_4) or organic fertilizer (T_3). In case of T_4 the grain formation and harvesting period occurred 8-10 days before the other treatments which can be used in future if it is essential to get advance production.

Keywords: Organic; inorganic and mixed fertiliser; field deep fertilizer; N; P; K and S uptake; yield performance.

1. INTRODUCTION

Production of rice, the most important food staples in the world, affects cost and environment depending on its growth pattern and use of materials. In the past 10 years, the growth of rice yield has dropped below 1% per year worldwide, but a rice yield increases of more than 1.2% per year will be required to meet the growing demand for food that will result from population growth and economic development in the next decade [1]. Sharing alone 70-75% of the total fertiliser use of urea, Triple superphosphate (TSP) and Muriate of potash (MP) country has increased over time due to the expansion of irrigation facilities and depletion of soil fertility induced by higher cropping intensity and cultivation of high yielding crop varieties.

Fertilisation is essential to get higher yields from rice. It is a major input for crop production. Depending on applying procedure, soil quality, plant quality and the amount of nutrient uptake (particularly macronutrient uptake) can vary which affects yield performance. Those nutrients help to grow rice through various stages of life and finally ready to harvest. There is no substitute for nutrients for high production [2]. It is observed that the high yielding varieties are responding to higher levels of nitrogen, phosphorus and potassium than what is recommended today [3]. The rate of nutrient uptake and the growth and development varies from treatment to treatment which can be organic or inorganic. It is reported that the response of rice to nutrient supply by organic and inorganic fertiliser is universal but may vary with locations, soil and fertiliser types [4]. Similarly, crops have been reported to respond differently to different composts under similar soil fertility condition. Fertiliser use efficiency is a measure of maximum returns per unit of fertiliser applied [5]. Imbalanced use of fertiliser is a serious problem for the management of soil fertility in the country as a whole. Rice yield is low in many areas of Bangladesh, primarily due to low fertility status of soils and unbalanced use of fertilisers [6].

So, with increasing demand for fertiliser application should be such an amount that ensure higher yield. But soil health should also be a major concern as it is related to soil fertility and productivity. Urea is very much volatile which is applied the higher amount to supply sufficient nitrogen. By deep placement of urea, the waste of urea can be reduced which can reduce the cost of production. So, it is clear that to ensure higher yield for present demand without endangering soil health to supply macronutrients the type of fertiliser, its placement procedure is also important as it is also related to the availability to the plants. Therefore, the research was done to find the best treatment of fertiliser with application procedure of fertiliser either it is traditional of the field deep to increase N, P, K, S uptake and yield performance of Green Super Rice.

2. MATERIALS AND METHODS

The research was conducted on agricultural soils of Jamtola of Jessore. The physiography was Ganges meander floodplain. The parent materials of studied areas were Ganges alluvium. General information's of sampling sites are given in Table 1.

The climatic condition of the experimental area is sub-tropical which has the high temperature, high humidity and heavy precipitation with occasional winds in Kharif season (April - September) and scantly rainfall associated with moderately low temperature during Rabi season (October-March).

2.1 Crop and Varieties

Green Super, a high yielding and popular variety of rice, was used as the test crop in this experiment.

Table 1. General information of sampling site

Morphology	Characteristics
Location	Norendrapur Union, Rupdia, Jessore
GPS reading	23°07'18" N and 89°17'24" E
Topography	Moderately high land
Soil series	Sara
Agro-ecological zone	High Ganges river floodplain
Flood level	Above flood level
Drainage	Moderately well drained

2.2 Soil Sample and Land Preparation

Soil samples were collected at a depth of 0-15 cm from the experimental plots before ploughing. The samples were drawn from the whole experimental plot and mixed to make a composite sample. Collected soil samples were spread on polythene sheet and then plant roots, leaves, dried grass, etc. were picked up and removed carefully. After making, soils were made free from the plant roots and unnecessary materials and dried under the sunlight. The soils were mixed up thoroughly and 500 g soil was taken for initial physical and chemical analysis. The land was prepared by ploughing and cross ploughing with a power tiller. Then the land was made saturated with irrigation water and prepared by successive ploughing, cross ploughing and laddering. All kinds of weeds, stubbles and crop residues were removed from the field before final ploughing and levelling.

2.3 Treatments

Different types of chemical fertilisers-urea, triple superphosphate, muriate of potash, gypsum and organic fertilizer-compost were used in the study following Randomized Complete Block Design (RCBD) including five treatments with three replications. The treatment combinations are given in Table 2.

2.4 Experimental Design

The unit plot size was 4 m x 2.5 m. Block to block and plot to plot distance was maintained as 1.0 m and 0.5 m, respectively. There were 0.5 m drains between the blocks. Plant spacing was 20 cm x 20 cm. The treatments were randomly distributed to each block. The layout of the experiment is shown in Appendix 1.

2.4.1 Fertilizer application and intercultural operations

Triple superphosphate, muriate of potash, gypsum was applied as basal doses in all the plots at the time of final land preparation while Urea was applied in three equal splits considering 20 days interval. Organic fertiliser, as well as compost, was added six plots as per treatment at 7 days before transplanting of the rice seedlings. The seedlings of 30 day-olds were transplanted in the plots on 24th January 2015. The number of rows and hills per plot was equal in all plots. Intercultural operations were performed for ensuring and maintaining the normal growth of the crop. The detailed intercultural operations were recorded in Appendix 1.

After transplanting, 5 to 6 cm water was maintained in each plot throughout the growing period. Electrical conductivity (EC) of irrigation water were maintained at an optimum level. Excess water was drained out from the plots and from panicle initiation to hard dough stage. At ripening stage, water was not allowed to stay on the field. Weeding and pest control were done properly. The crops were harvested plot-wise at maturity (10th May 2015). After harvesting, crop of each plot was bundled separately and brought to the threshing floor. The harvested crops were threshed, cleaned and processed. Then each of them was preserved separately to analyse for collecting data.

Table 2. Treatment combinations of field site

Treatment	Nitrogen (kg/ha) (Urea)	Phosphorous (kg/ha) (TSP)	Potassium (kg/ha) (MP)	Sulfur (kg/ha) (Zypsum)	Organic fertiliser
T_0	-	-	-	-	-
T_1	120	50	40	20	-
T_2	120 (Field Deep)	50	40	20	-
T_3	-	-	-	-	800
T_4	120 (Field Deep)	-	-	-	400

2.5 Data Collection and Recording

The following parameters were recorded during harvesting:

Plant height (cm), number of total tillers hill^{-1}, panicle length (cm), number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, the weight of 1000-grain (g), grain yield (t ha^{-1}) and straw yield (t ha^{-1}).

2.6 Analysis of Physical Chemical Parameters of Soil

The particle size analysis of the soils was done by the combination of sieving and hydrometer method as described by Bouyoucos [7]. Textural classes were determined using Marshall's Triangular Coordinate systems. Soil pH was determined electrochemically with the help of glass electrode pH meter using soil to water ratio of 1:2.5 as suggested by Jackson [8]. The EC of the soil was measured at a soil: water ratio of 1:5 with the help of EC meter and then converted into 1:1 ratio as USDA [9]. The CEC of the soils were determined by extracting the soil with 1N KCl (pH 7.0) followed by the replacing the potassium in the exchange complex by 1 N NH_4OAc. The displaced potassium was determined by a flame analyser at 589 nm [10]. Soil organic carbon was determined by Walkley and Black's wet oxidation method as outlined by Jackson [8]. Soil organic matter was calculated by multiplying the percent value of organic carbon by the conversion factor 1.724. Available Phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ [11] at pH 8.5 and ascorbic acid blue colour method was employed for determination [12]. Exchangeable K in soil with by extracting soils with 1 N NH_4OAC (pH 7.0) and then the K was measured by using flame photometer [13]. Available S in soil was determined by extracting soil samples with 0.15% $CaCl_2$ solution [14]. The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by Spectrophotometer at 420 nm wavelengths.

2.7 Methods of Plant Analysis

Plant samples collected from the field experiment were analysed for N, P, K and S contents. Grain and straw samples were dried in an oven at about 65°C for 48 hours and then ground in a grinding mill to pass through a 2 mm sieve. The ground plant materials (grain and straw) were stored in small paper bags and placed in a desiccator. Plant extract was prepared by digesting dried samples first with concentrated sulfuric acid and then perchloric acid for the determination of N. An amount of 0.5 g oven-dry, ground samples was taken in a 150 ml Kjeldahl flask. 5 ml concentrated H_2SO_4 acid was added into the flask and the flask was allowed to stand for over-night. Then 2.5 ml perchloric acid was added into the flask. After leaving for a while, the flasks were heated and the temperature was raised slowly to 200°C. Heating was continued until the digest was clear and colourless. After cooling, the content was transferred into a 100 ml volumetric flask, and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. This digestion was performed particularly for N determination. The N in the digest was determined by distillation with 35% NaOH followed by titration of the distillate trapped in H_2BO_3 with 0.01 N H_2SO_4 [15].

A subsample weighing 0.5 g was transferred into a dry clean digestion vessel. 10 ml of di-acid (HNO_3: $HClO_4$ in the ratio 5: 1) added to the vessel. After leaving for a while, the vessels were heated at a temperature slowly raised to 185^0 C. Heating was stopped when the dense white fumes of $HClO_4$ occurred. The contents of the vessel were boiled until they became clear and colourless. After cooling, the contents were taken into a 50 ml volumetric flask and the volume was made with distilled water. This digest was used for estimating P, K and S.

The Compost was analysed for the determination of N, P, K and S contents following the method used for grain and straw samples. The percent material (PM) contained %N, %P, %K and %S 1.14, 1.09, 0.79 and 0.32, respectively.

2.8 Nutrient Uptake

After a chemical analysis of straw and grain samples, the nutrient uptake was calculated from the nutrient content and yield of rice crop by the following formula:

Nutrient uptake = Nutrient content (%) × yield (kg ha^{-1}) /100

2.9 Statistical Analysis

Data were analysed statistically by ANOVA to examine whether treatment effects were significant [16]. Mean values were compared by Duncan's Multiple Range Test (DMRT).

2.10 Economic Analysis

For economic analysis, variable costs have only been considered and fixed costs were ignored. Variable costs included variable money costs and variable opportunity costs. Net return was calculated by subtracting the control total variable cost from the other total variable cost. Variable money cost was the purchasing price of, and variable opportunity cost included the amount of money paid for carrying and broadcasting the fertilisers.

3. RESULTS AND DISCUSSION

It presents the effect of different rates of organic, inorganic and mixed fertiliser with applying procedure on N, P, K, S uptake as well as growth and yield of Green Super Rice including soil physical and chemical properties. The soil physical and chemical properties are shown in Table 3.

3.1 Yield Components

The yield components include the plant height, panicle length, number of tillers hill^{-1}, grains panicle^{-1} and 1000-grain weight.

Plant height of Green Super Rice was significantly influenced due to the application of inorganic and organic fertiliser alone or in combination along with the application procedure of urea (Fig. 1). Plant height varied from 67.9 cm (T_0) to 91.2 cm (T_2). The plant height was significantly affected due to the application of organic and inorganic fertiliser alone or in combination which was statistically similar to the findings of Islam [17].

There found a significant *(P* <0.05*)* change in treatment T_0, T_1, T_2, T_3 and T_4. Here small letters denote the level of significance where common letter(s) do not differ significantly at 5% levels of significance.

Panicle length of Green Super Rice was significantly influenced by the different treatments (Fig. 2). Panicle length due to different treatments varied from 19.9 cm in T_0 to 22.7 cm in T_2. It was found that with the application of the higher amount of available nutrients through fertiliser panicle length differ significantly which was statistically similar to Islam [17].

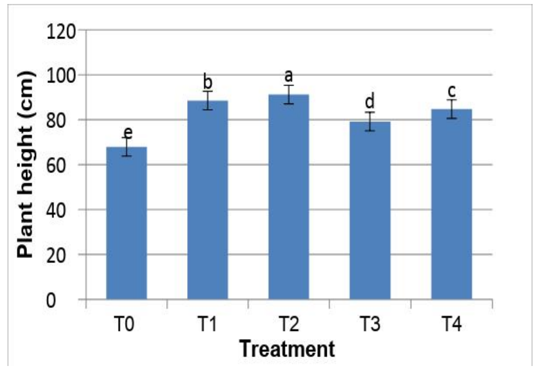

Fig. 1. Plant height with different treatments

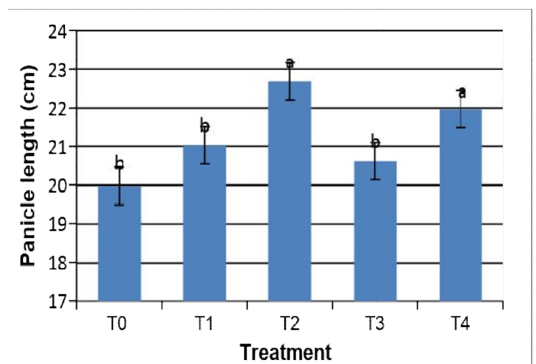

Fig. 2. Panicle length with different treatments

Table 3. Physical and chemical properties of studied soils

Characteristics	Value
pH (soil: water = 1:2.5)	7.8
Organic Matter (%)	1.41
Total N	0.10
Available phosphorous (ppm)	16.18
Available sulfur (ppm)	10.81
Water-soluble + Exchangeable K (Cmol(+)/kg soil)	0.19
Cation exchange capacity (Cmol(+)/kg soil)	12.03
Texture	Silt Loam

There found a significant *(P <0.05)* change in treatment T_0, T_2 and T_4. Here small letters denote the level of significance where common letter(s) do not differ significantly at 5% levels of significance.

There was a significant effect of different fertiliser treatments on the production of effective tillers hill^{-1} of rice plants (Fig. 3). The number of tillers hill^{-1} due to different treatments varied from 8.5 to 11.5. The treatments may be ranked in the order T_1>T_2>T_4>T3>T_0. The maximum number effective tiller hill^{-1} found in T_1 which was identical to Das [18] who found that effective tillers hill^{-1} increased significantly with the increasing level of fertiliser.

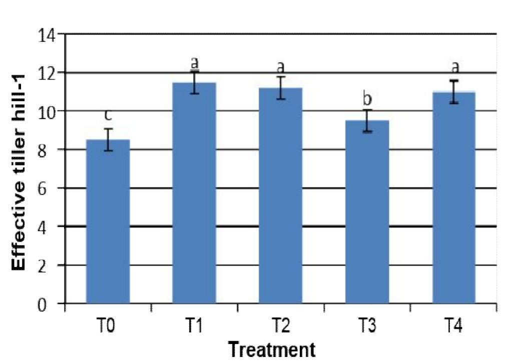

Fig. 3. Effective tiller hill^{-1} (no) with different treatments

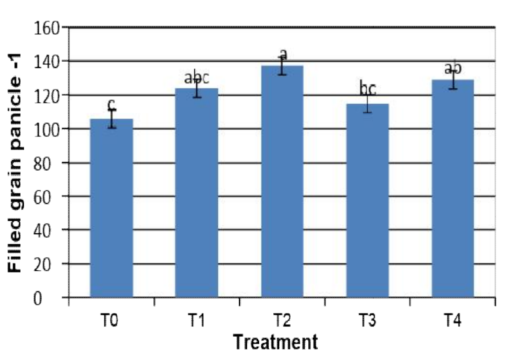

Fig. 4. Filled grain panicle^{-1} with different treatments

There found a significant *(P <0.05)* change in treatment T_0, T_1 and T_3. Here small letters denote the level of significance where common letter(s) do not differ significantly at 5% levels of significance.

The different treatments significantly increased the number of filled grains panicle^{-1} of Green Super Rice. The number of filled grains panicle^{-1} due to different treatments ranged from 106 to 137 (Fig. 4). Filled grains panicle^{-1} of Green Super Rice was influenced profoundly due to the application of organic and inorganic fertiliser alone or in combination which supports the findings of Das [18].

There found a significant *(P <0.05)* change in treatment T_0 and T_2. But insignificant in T_1, T_2, and T_4. Here small letters denote the level of significance where common letter(s) do not differ significantly at 5% levels of significance.

The 1000-grain weight of Green super Rice was influenced significantly due to the application of organic and inorganic fertiliser alone or in combination with the different procedure of applying urea (Fig. 5). The 1000-grain weight ranged from 21.0 to 22.4 g. The 1000-grain weight of rice significantly varies with the supply of a higher quantity of available nutrients including urea which was similar to the findings of Chaudhury et al. [19].

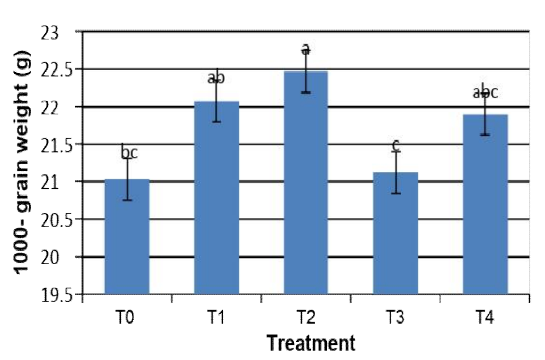

Fig. 5. 1000-grain weight with different treatments

There found a significant *(P <0.05)* change in treatment T_2 and T_3. But insignificant in T_0, T_1, and T_4. Here small letters denote the level of significance where common letter(s) do not differ significantly at 5% levels of significance.

3.2 Yield

Data on grain, straw and biological yields of Green Super Rice as affected by different treatments have been presented in Table 4.

Table 4. Effect of fertilisers on grain, straw and biological yields

Treatments	Yield (t ha^{-1})		% Increased over control		Biological yield (t ha^{-1})
	Grain	Straw	Grain	Straw	
T_0	2.79c	3.10c	-	-	5.89c
T_1	5.20b	6.30b	86.38	103.23	11.50a
T_2	5.70a	5.90a	104.30	90.32	11.60a
T_3	3.00c	3.40c	7.535	9.68	6.40c
T_4	4.90b	5.63b	75.63	81.61	10.53b
SE(+/-)	*0.22*	*0.22*	-	-	*0.37*
LSD at 5%	*0.49*	*0.49*	-	-	*0.83*
LSD at 1%	*0.70*	*0.70*	-	-	*1.17*

** Figures in a column having a common letter(s) do not differ significantly at 5% levels of significance*

Application of organic, inorganic fertiliser alone or in combination with the different procedure of the application of urea showed a positive effect on grain yield of rice. It was found that the grain yield ranged from 2.79 t ha^{-1} to 5.70 t ha^{-1}. The grain yields due to different treatments ranked in the order of T_2> T_1> T_4> T_3> T_0. Application of organic and inorganic fertiliser alone or in combination showed a positive effect on grain yield of rice which was similar to the findings of Alim [20]. The straw yield of Green Super Rice was also influenced significantly due to the application of organic and inorganic fertiliser alone or in combination with the difference in the applying process of urea. The straw yield ranged from 3.10 t ha^{-1} in T_0 to 6.30 t ha^{-1} in T_1 (Table 4). It was observed that the T_1 produced the highest straw yield, which might be the availability of nitrogen throughout the growing period. The straw yield due to different treatments ranked in the order of T_1> T_2> T_4> T_3> T_0. Application of organic and inorganic fertiliser alone or in combination showed a positive effect on straw yield and straw of rice which was similar to the findings of Alim [20]. The biological yield of Green Super Rice responded significantly to different treatments (Table 4). The biological yield due to various treatments ranged from 5.89 to 11.60 t ha^{-1}. All the treatments showed higher biological yield over control. The highest biological yield (11.60 t ha^{-1}) was obtained in T_2 which was statistically similar to those observed in T_1 and T_4 with values of 11.50 and 10.53 t ha^{-1}, respectively. The lowest biological yield (5.89 t ha^{-1}) was obtained in the treatment T_0 which was statistically different from all other treatments. The biological production of rice significantly varies with the supply of a higher quantity of available nutrients including urea [19].

3.3 Nutrient Content in Grain and Straw

The results on N, P, K and S content of grain and straw have been presented in Table 5.

Significant differences were found on nitrogen content by various organic, inorganic and mixed fertiliser application. The N content in grain varied from 0.87 to 1.18%. The treatment T_2 resulted in the maximum N content in grain (1.18%). The N content in straw due to different treatments ranged from 0.48 to 0.71% (Table 5). The highest N value (0.71% N) was found in the treatment T_1. The lowest value (0.48% N) was noted in T_0. The fertiliser dose increased the N content both in grain and straw of rice but the smaller reduction of N, P, K and S fertilisers affected the N content of grain and straw significantly. Results presented in Table 4 indicated that phosphorus content in both grain and straw of Green Super Rice was significantly influenced by different treatments under study. Similar results of N content by applying N containing fertiliser were also noted by Kadu et al. [21].

The P content in grain varied from 0.11 to 0.19%. The T_2 resulted in the maximum P content in grain (0.19%). The P content in straw due to different treatments ranged from 0.06 to 0.08% (Table 5). The highest P value (0.08% P) was found in T_2. The lowest value (0.06% P) was noted in T_0. The P content in grain was higher than that of straw in all the treatments. It indicates that the recommended fertiliser dose has pronounced effect on P content in both grain and straw. Similar findings were also found by Sachdev et al. [22].

Potassium (K) content in both grain and straw was significantly affected by different treatments (Table 5). The K content in grain varied from 0.20 to 0.25%. The treatment T_1 resulted in the maximum K content in grain (0.248%). The K content in straw due to different treatments ranged from 0.92 to 1.11% (Table 5). The highest K value (1.11% K) was found in T_2 and T_4. The application of increased fertiliser dose performed better in increasing K content both in

Table 5. Effect of fertilisers on N, P, K and S contents in grain and straw

Treatment	%N		%P		% K		%S	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_0	0.87c	0.48b	0.11c	0.06c	0.20a	0.92b	0.08b	0.05b
T_1	1.15a	0.67a	0.19a	0.08a	0.25a	1.10a	0.09b	0.07a
T_2	1.18ab	0.71a	0.19a	0.076ab	0.25a	1.11a	0.10a	0.06ab
T_3	0.89c	0.50b	0.12c	0.06bc	0.22a	0.97ab	0.08b	0.06ab
T_4	0.93bc	0.51b	0.16b	0.062abc	0.24a	1.11a	0.09ab	0.07ab
SE(+/-)	*0.10*	*0.05*	*0.00*	*0.00*	*0.02*	*0.05*	*0.00*	*0.00*
LSD at 5%	*0.22*	*0.11*	*0.00*	*0.00*	*0.04*	*0.11*	*0.00*	*0.00*
LSD at 1%	*0.32*	*0.16*	*0.00*	*0.00*	*0.06*	*0.16*	*0.00*	*0.00*

grain and straw of Green Super Rice. Similar findings where potassium fertiliser is used proportionately with nitrogen and phosphorous content were also found by Wan et al. [23].

Results in Table 5 indicated that sulfur content in both grain and the straw of Green Super Rice was significantly influenced by different treatments used in the experiment. The S content in grain varied from 0.08 to 0.10%. In this case, T_2 resulted in the maximum S content in grain (0.1%). The S content in straw due to different treatments ranged from 0.05 to 0.07% (Table 5). The highest S value (0.07% S) was found in T_1 and T_4. The lowest value (0.05% S) was noted in T_0. It indicates that the recommended fertiliser dose had pronounced effect on S content in both grain and straw and the reduction of the fertilisers dose significantly decreased S content of rice grain and straw. S content increased with the rate of increasing available nutrients along with sulfur content. The highest S content was found in T_2 which was statistically similar with other treatments except for T_0 which was identical with the findings of Islam et al. [24].

3.4 Nutrient Uptake

Nutrient uptake by Green Super Rice was calculated by multiplying the yield data with respective nutrient concentrations in grain and straw. Total uptake has been calculated as the sum total of grain and straw uptake.

Nitrogen uptake by Green Super Rice was significantly influenced by various treatments which are shown in Table 6. Nitrogen uptake ranges from 21.66 to 67.26 kg ha^{-1}. The highest N uptake (67.26 kg ha^{-1}) by grain was recorded in T_2 which was significantly different from all other treatments. In the case of straw, the result varies from 15.19 to 41.89 kg ha^{-1}. The highest N uptake (41.89 kg ha^{-1}) by straw was observed in T_1 which was statistically identical to that recorded in T_1 with N uptake of 42.21 kg ha^{-1}, respectively. Nitrogen uptake was significantly affected by various treatments while the highest uptake was found in T_2 where urea was field dipped. In case of deep placement of urea, the availability of nitrogen is higher to the root zone except for the traditional application system. Nitrogen uptake and use efficiency were significantly affected due to organic and inorganic treatments alone or in combination which was similar to Jahan [17].

Phosphorous uptake by Green Super Rice was significantly influenced by various treatments which are shown in Table 6. Its uptake ranges from 2.84 to 10.83 kg ha^{-1}. The highest P uptake (10.83 ha^{-1}) by grain was recorded in T_2 which was significantly different from all other treatments. In the case of straw, the result varies from 1.77 to 5.04 kg ha^{-1}. The highest P uptake (5.04 kg ha^{-1}) by straw was observed in T_1 which was statistically identical to that recorded in T_2 with the uptake of 4.54, respectively. Phosphorous uptake was significantly different with various organic and inorganic treatments alone or in combination. Similar findings were also found by Sachdev et al. [22].

Potassium uptake by Green Super Rice in both grain and straw was significantly influenced by various treatments (Table 7). The K uptake by grain varied from 5.05 to 14.08 kg ha^{-1}. The highest K uptake (14.08 kg ha^{-1}) by grain was noted T_2 which was statistically identical to that recorded in T_1 and T_4 with K uptake of 12.90 and 11.71 kg ha^{-1}, respectively. In the case of straw, the uptake of K varies from 28.37 to 69.55 kg ha^{-1}. The highest K (69.55 kg ha^{-1}) was observed in T_1 which was statistically identical to that recorded in T_2 and T_4 with K uptake of 65.31 and 62.49 kg ha^{-1}, respectively. It was observed that K uptake by rice straw was much higher than that of K uptake by rice grain which was similar to the findings of Wan et al. [23].

Table 6. Effect of fertilisers on N and P uptake (kg ha^{-1})

Treatment	N uptake			P uptake		
	Grain	Straw	Total	Grain	Straw	Total
T_0	21.66c	15.19c	36.85	2.84c	1.77c	4.61
T_1	59.80a	42.21a	102.01	9.88a	5.04a	14.92
T_2	67.26a	41.89a	109.15	10.83a	4.54a	15.37
T_3	26.70c	17.00c	43.70	3.60c	2.04c	5.64
T_4	45.57b	28.71b	74.28	7.84b	3.49b	11.33
SE(+/-)	*4.39*	*1.95*	-	*0.44*	*0.26*	-
LSD at 5%	*9.79*	*4.35*	-	*0.98*	*0.58*	-
LSD at 1%	*13.92*	*6.18*	-	*1.39*	*0.82*	-

Table 7. Effect of fertilisers on K and S uptake (kg ha^{-1})

Treatment	K uptake			S uptake		
	Grain	Straw	Total	Grain	Straw	Total
T_0	5.05c	28.37b	33.42	2.02c	1.67b	3.69
T_1	12.90ab	69.55a	82.45	4.42b	4.22a	8.64
T_2	14.08a	65.31a	79.39	5.70a	3.54a	9.24
T_3	6.48c	33.05b	39.53	2.49c	1.94b	4.43
T_4	11.71b	62.49a	74.20	4.41b	3.66a	8.07
SE(+/-)	*0.98*	*3.84*	-	*0.20*	*0.34*	-
LSD at 5%	*2.19*	*8.56*	-	*0.45*	*0.76*	-
LSD at 1%	*3.11*	*12.17*	-	*0.63*	*1.08*	-

Sulfur uptake by Green Super Rice in both grain and straw was significantly influenced by various treatments (Table 7). The S uptake by grain varied from 2.02 to 5.70 kg ha^{-1}. The highest S uptake (5.70 kg ha-1) by grain was noted in T_2 which was statistically identical to that recorded in T_1 and T_4 with S uptake of 4.42 and 4.41 kg ha-1, respectively. In the case of straw the uptake of S varies from 1.67 to 4.22 kg ha^{-1}. The highest S (4.22 kg ha^{-1}) was observed in T_2 which was statistically identical to that recorded in T_4 and T_1 with S uptake of 3.66 and 3.54 kg ha^{-1}. Uptake of S was different due to various organic and inorganic treatments alone or in combination. S uptake increased with the rate of applying sulfur (while in case of T_0, T_3 and T_4 no additional sulfur was applied) which was similar with the findings of Islam et al. [24].

3.5 Economic Analysis

It includes the cost of production and benefit to analyse the suitability of the treatments. The following table (Table 8) shows the economic analysis of all the treatments which shows that the cost of production is higher in the case of T_1 and T_2 while the highest benefit comes from T_2. The lowest income, as well as benefit than cost, has come from T_0.

Table 8. Economic analysis of the treatments for the production

Treatment	Economic yield (kg ha^{-1})		The total cost of production (Tk. ha^{-1})	Gross income (Tk. ha^{-1})	Net income (Tk. ha^{-1})	Benefit-cost ratio (BCR)
	Grain	Straw				
T_0	2490	3100	26200	43120	16930	1.65
T_1	5200	6300	30060	90200	60140	3.00
T_2	5700	5900	30060	98700	68640	3.28
T_3	3000	3400	29200	52800	23600	1.81
T_4	4900	5630	31120	85100	53980	2.73

4. CONCLUSION

The experiment was conducted to investigate the macronutrient (N, P, K, S) uptake of Green Super Rice and effective placement method of urea ensuring higher uptake. Yield contributing characters like plant height, effective tillers hill^{-1}, panicle length, filled grains panicle^{-1} and 1000-grains weight were significantly influenced by treatments at different fertilisers rate along with different placement method of urea. Among the treatment, T_2 produced the tallest plant (91.2 cm) and highest 1000-grain weight (22.4 g) whereas plant height was statistically similar to all other treatments except T_0 and 1000-grain weight was statistically similar with T_1, T_3 and T_4 over T_0. The shortest plant height and 1000-grain weight were observed in T_0 with the values of 67.9 cm and 21.0 g. Panicle length and filled grains panicle^{-1} was higher (22.7 cm and 137, respectively) in T_2 whereas among all other treatments except control were statistically similar to panicle length and filled grains panicle^{-1} production. A number of tillers hill^{-1} was higher in T_1 which was statistically similar to all other treatments except T_0. There was also a significant effect of different rate of fertilisers on the grain and straw yield of rice. The grain yields due to various treatments ranged from 2.79 to 5.70 t ha^{-1}. The maximum grain yield (5.70 t ha^{-1}) was observed in T_2 whereas it was statistically similar to those recorded in T_1, T_3 and T_4 with the values of 5.20, 3.00 and 4.90 t ha^{-1} respectively. The lowest grain yield (2.79 t ha^{-1}) was obtained in T_0 which was statistically different from other treatments. The yield of straw ranged from 3.10 to 6.30 t ha^{-1}. T_1 gave the highest straw yield (6.30 t ha^{-1}) while it was statistically similar to those recorded in T_2 and T_4 with the values of 5.90 and 5.63 t ha^{-1}, respectively. The lowest straw yield (3.10 tha^{-1}) was produced fromT_0 which was statistically different from other treatments.

Nitrogen, phosphorus, potassium and sulfur uptake of Green Super Rice were significantly influenced due to different rates of fertiliser treatments and placement of urea under this study. Among the nutrient content, N content by grain and straw were higher in treatment T_2. The higher N uptake by grain was observed in T_2 and straw in T_1 and total were also observed in T_2. Phosphorus content and uptake showed significant variation. As a result, T_2 and T_1 obtained the higher P content by grain and straw while the maximum P uptake by grain was recorded in the treatment T_2 and the highest P uptake by straw was recorded in the treatment T_1. Observation of K content by grain was higher in T_1 and T_2 while T_2 and T_4 recorded the higher content by straw. In the case of K uptake, T_2 obtained the higher K uptake by grain and T_1 obtained the higher K uptake by straw and total. Treatment T_1 and T_2 obtained the higher S content by total. The higher S uptake by grain was obtained in T_2, by straw was obtained in T_1 and by total was recorded in the treatment T_2. A close relationship between nutrient uptake and grain yield was observed. Nutrient uptake increased with increasing grain yield and nitrogen uptake increased in the case of field dipped urea of Green Super Rice. Loss of nutrients occurs due to use of a higher amount of fertiliser which not only causes the higher cost of production but also degrade soil fertility and productivity. So, selection of potential variety and proper management of fertilisation can play a crucial role to increase grain yield and national income.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Appendix 1

Ploughing and intercultural operations done during field study

Ploughing and Intercultural operations	Date
First ploughing of the field	15.01.2015
Second ploughing and laddering	18.01.2015
Third ploughing and laddering	21.01.2015
Final ploughing plot preparation and application of fertilizer (TSP, MOP, gypsum)	22.01.2015
Transplanting of seedlings (Green Super)	24.01.2015
First weeding	08.02.2015
First split application of urea	14.02.2015
Second weeding	20.02.2015
Second split application of urea	24.02.2015
Third weeding	03.03.2015
Third split application of urea	25.03.2015
Harvesting	10.05.2015
Threshing	16.05.2015

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