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Total Nutrient Uptake by Grain plus Straw and Economic of Fertilizer Use of Rice Mutation STL-655 Grown under Boro Season in Saline Area

M. H. Kabir, N. M. Talukder, M. J. Uddin[1], H. Mahmud[1] and B. K. Biswas[1]
Department of Agriculture Chemistry, BAU, Mymensingh,
[1]UAO, DAE

Abstract
An experiment was conducted at BINA (Bangladesh Institute of Nuclear Agriculture) substation, Satkhira on slightly calcareous silty clay soil during the boro season of 2009-2010 to investigate the effects of different combinations of inorganic fertilizers in order to achieve sustainable high yield goal in the STL-655 rice mutant cultivar. The six treatment combinations were: T_1 (absolute control), T_2 (N_{60} P_{20} K_{40} S_{10} Zn_1), T_3 (N_{80} P_{25} K_{50} S_{15} $Zn_{1.5}$), T_4 (N_{100} P_{30} K_{60} S_{20} Zn_2), T_5 (N_{120} P_{35} K_{70} S_{25} Zn_3) and T_6 (N_{140} P_{40} K_{80} S_{30} Zn_4) that was laid out in a randomized complete block design (RCBD) with three replications having per plot size was 5m x 4m. The results revealed that grain and straw yields of STL-655 rice mutant responded significantly with the different treatment combinations. The highest grain (3.95 t/ha) and straw yield (7.38 t/ha) was obtained in T_6 (Soil test basis high yield goal) treatment, which was significantly higher than all other treatments. The treatment T_6 (N_{140} P_{40} K_{80} S_{30} Zn_4) caused an increase of 60% grain yield and 27% higher straw yield over the control. Nutrient uptake of N, P, K and S by grain of boro rice (STL-655 rice mutant) varied from 25.14 to 48.02, 5.40 to 8.14, 11.76 to 23.02 and 4.15 to 7.09 kg/ha, respectively. The N, P, K and S uptake by straw of boro rice (STL-655 rice mutant) varied from 20.36 to 35.85, 5.47 to 11.05, 59.01 to 159.6 and 9.54 to 12.97 kg/ha, respectively.

Key words: Saline area, Mutant cultivar, High yield goal, Inorganic fertilizers

Introduction

Declining land productivity with negative nutrient balance is the main concerns against the food security problems in the country. Fertilization is one of the most important notable measures that help to increase agricultural production. So, application of adequate amount of mineral nutrients to crop is one of the important factors in achieving higher productivity. Modern rice varieties obviously require higher amount of nutrients to give higher crop yields. The farmers of this country use only about 102 kg nutrients/ha (70kg N, 24kg P_2O_5, 6kg K_2O, 2kg S + Zn) annually, while the crop removal is nearly 200 kg/ha/yr (Islam *et al.*, 1994). The intensive cropping with modern varieties, nutrient leaching with monsoon rains and light textured soils are also favoring the emergence of micronutrient deficiency in the soil, consequently Zn and B deficiencies are frequently reported on some soils and crop (Jahiruddin *et al.*, 1995). Significant transition to the use of N, P, NP and NPKS fertilization on rice cultivation with better economic return has shifted traditional agriculture to maximum yield concept.

Salinity causes reduction in crop yield on about 10 m ha of worlds irrigated land (Rhoades & Loveday, 1990). Salinity reduces photosynthesis rate, metabolism process, carbohydrate translocation, dry matter production, leaf area index, nutrient absorption, all yield attributes and grain yield, while it increases sterility percentage of rice (Zayed *et al.*, 2007). In general, soil salinity is believed to be mainly responsible for low land use as well as cropping intensity in the area (Rahman & Ahsan, 2001). Thus, combating land salinization problem is vital for food security in the country through adoption of long-term land management strategy.

Salinity in the country received very little attention in the past. Increased pressure of growing population demand more food. Thus it has become increasingly important to explore the possibilities of increasing the potential of these (saline) lands for increased crop production. Keeping the above points in view, the present study was undertaken to ascertain optimum and economic rates of fertilizer for rice cultivation in saline area.

Materials and Methods

The experiment was conducted at BINA (Bangladesh Institute of Nuclear Agriculture) substation, Satkhira on slightly calcareous silty clay soil during the Boro season of 2009-2010 to investigate the effects of different combinations of inorganic fertilizers like N, P, K, S and Zn in order to achieve sustainable high yield goal in the STL-655 rice mutant cultivar. The six treatment combinations were: T_1 (absolute control), T_2 (N_{60} P_{20} K_{40} S_{10} Zn_1), T_3 (N_{80} P_{25} K_{50} S_{15} $Zn_{1.5}$), T_4 (N_{100} P_{30} K_{60} S_{20} Zn_2), T_5 (N_{120} P_{35} K_{70} S_{25} Zn_3) and T_6 (N_{140} P_{40} K_{80} S_{30} Zn_4) that was laid out in a randomized complete block design (RCBD) with three replications having per plot size was 5m x 4m. N, P, K, S and Zn were applied as Urea, TSP, MP, gypsum and zinc oxide, respectively. Urea was applied in three equal splits. The first split was applied during final land preparation, the second split at the active tillering stage and the remaining split at booting stage/panicle initiation stage of the crop.

Forty days old three healthy seedlings of boro rice (STL-655 rice mutant) were transplanted per hill in the experimental plots at a plant spacing of 20 cm x 15 cm on 20th December, 2010 and the crop was harvested at maturity on 25th April, 2010. All the cultural practices were done in time. Ten plants were randomly selected from each plot for data collection. Grain and straw samples were analyzed for the determination of N, P, K and S concentrations. The uptakes of these nutrients were also calculated from the yield and the nutrient concentration of grain and straw. The nutrient uptake was calculated by % of minerals constituent x grain/yield weight (kg/ha) divided by 100. All the data were statistically analyzed following the F-test and the mean comparisons were made by DMRT (Gomez and Gomez, 1984) at the 5% level.

Results and Discussion

1.1 Nitrogen concentration in grain and straw

Data in Table 1 indicated that the different treatment combinations had significantly influence on N concentration both in grain and straw of STL-655 rice mutant. The N concentration of grain varied from 0.87 to 1.21% (Table 1). The highest grain N concentration 1.21% was observed in treatment T_6. The next highest grain N concentration was obtained in T_2 and significantly higher than the rest of the treatments.

The lowest grain N concentration was obtained in treatment T_1. In straw, the N concentration ranged from 0.34 to 0.53% (Table 1). The highest N content (0.53%) was observed in treatment T_4, which was statistically identical with treatments T_5, T_3 and T_2. The lowest N concentration (0.34%) was found in treatment T_1. Similar results were observed by Rahman *et al*. 2005.

1.2 Nitrogen uptake by grain and straw

The results presented in Table 2 indicated that a wide variation in N uptake by grain and straw due to different treatment combinations. The range of N uptake by grain was 25.14 to 48.02 kg/ha. The highest N uptake (48.02 kg/ha) by grain was obtained in treatment T_6. The next highest grain N uptake was obtained in T_4, which was statistically similar to treatments T_5, T_3 and T_2. The lowest N uptake (25.14 kg/ha) by grain was found in treatment T_1 (control). Similarly, the range of N uptake by straw was 20.36 to 35.85 kg/ha. However, the highest N uptake straw was obtained in treatment T_4, which was higher than all other treatments but statistically identical with T_5, T_6 and T_3. The lowest N uptake by straw was found in treatment T_2.

Table 1. Effect of different nutrients on N, P, K and S concentration by grain and straw of STL-655 rice mutant

Treatments	Concentration (%)							
	Grain				Straw			
	N	P	K	S	N	P	K	S
T1 = Control (0)	0.8767 c	0.1833 f	0.4233 d	0.1633 c	0.3400 b	0.1033 d	1.130 f	0.1633 c
T2 = N_{60} P_{20} K_{40} S_{10} Zn_1	1.067 ab	0.2033 d	0.5267 b	0.1833 ab	0.5233 a	0.1833 a	1.700 c	0.1867 a
T3 =N_{80} P_{25} K_{50} S_{15} $Zn_{1.5}$	0.9300 bc	0.2100 c	0.4767 c	0.1667 bc	0.5067 a	0.1567 b	1.390 d	0.1667 c
T4 = N_{100} P_{30} K_{60} S_{20} Zn_2	0.9000 c	0.2133 b	0.5000 c	0.1867 a	0.5367 a	0.1467 c	2.387 a	0.1700 bc
T5 = N_{120} P_{35} K_{70} S_{25} Zn_3	1.010 bc	0.1933 e	0.4267 d	0.1567 c	0.5133 a	0.1567 b	1.887 b	0.1633 c
T6 = N_{140} P_{40} K_{80} S_{30} Zn_4	1.217 a	0.2173 a	0.5833 a	0.1700 abc	0.4500 ab	0.1500 bc	1.207 e	0.1767 b
SE	0.052	0.005	0.025	0.005	0.030	0.011	0.194	0.05
CV%	8.36	3.41	2.29	5.91	14.38	2.64	2.16	0.004

SE = Standard error of means, CV = Coefficient of variation

The range of total N uptake both by grain and straw of STL-655 was 52.79 to 81.25 kg/ha (Table 3). The highest total N uptake (81.25 kg/ha) was recorded in treatment T_6. The lowest total N uptake (kg/ha) was found in treatment T_2 (52.79). The result showed that the total N uptake both by grain and straw were more prominent due to combined application of fertilizers.

Table 2. Effect of different treatments on total nutrient uptake by STL-655 rice mutant

Treatments	Nutrient uptake (kg/ha)							
	Grain				Straw			
	N	P	K	S	N	P	K	S
T_1 = Control (0)	25.14b	5.40b	11.76d	4.15c	27.86ab	5.47b	59.01e	9.543c
$T_2 = N_{60}\ P_{20}\ K_{40}\ S_{10}\ Zn_1$	32.43b	6.21a	16.02c	5.57b	20.36b	10.85a	101.5c	11.06b
$T_3 = N_{80}\ P_{25}\ K_{50}\ S_{15}\ Zn_{1.5}$	32.74b	7.19a	14.83c	5.76b	33.31a	10.15a	91.33d	10.85b
$T_4 = N_{100}\ P_{30}\ K_{60}\ S_{20}\ Zn_2$	34.63b	8.14a	19.17b	7.09a	35.85a	9.67a	159.6a	10.92b
$T_5 = N_{120}\ P_{35}\ K_{70}\ S_{25}\ Zn_3$	34.03b	7.32a	16.35c	6.01ab	34.12a	10.27a	124.8b	11.63b
$T_6 = N_{140}\ P_{40}\ K_{80}\ S_{30}\ Zn_4$	48.02a	7.49a	23.02a	6.40ab	33.23a	11.05a	89.14d	12.97a
SE	3.044	0.403	1.574	0.403	2.355	0.845	14.06	0.457
CV (%)	14.97	18.56	8.59	10.19	16.61	10.05	4.50	3.63

SE = Standard error of means, CV = Coefficient of variation

1.3 Phosphorus concentration in grain and straw

The results shown in Table 3 indicate that the P concentration both in grain and straw differed significantly and influenced by the treatments. Phosphorus content in grain varied from 0.183 to 0.217 %. The highest P concentration (0.217 %) was found in treatment T_6, which was statistically similar to treatments T_4, T_3 and T_2. The lowest P concentration in grain was found in treatment T_1 (control). The P concentration in straw ranged from 0.103 to 0.183%. The highest P concentration in straw was observed in treatment T_2, which was statistically identical with treatments T_5, T_3, and T_4. The lowest P concentration was recorded in treatment T_1 (control).

1.4. Phosphorus uptake by grain and straw

The results presented in Table 2 showed that P uptake of grain and straw differed significantly due to different treatment combinations. The range of P uptake by grain varied from 5.40 to 8.14 kg/ha. The highest P uptake (8.14 kg/ha) by grain was recorded in treatment T_4, Which statistically identical with treatments T_5, T_6 and T_3. The lowest P uptake was recorded in treatment T_1 (control). However, P Uptake of straw showed a significant difference due to different treatments. The range of P uptake by straw varied from 5.47 to 11.05 kg/ha. The highest P uptake of straw recorded in treatment T_6, which was statistically similar to treatments T_4, T_3 and T_5. The lowest P uptake was observed in treatment T_1 (control). The total P uptake by grain and straw ranged from 10.87 to 18.54 kg/ha. The highest total P uptake (18.54 kg/ha) was obtained in treatment T_6. The lowest total P uptake was observed in treatment T_1 (control).

1.5 Potassium concentration in grain and straw

Different treatment combinations of inorganic fertilizers significantly influenced the K concentration in grain and straw. The K concentration in grain varied from 0.423 to 0.583% (Table 1). The highest K concentration in grain (0.583%) was recorded in treatment T_6, which was statistically identical with treatments T_2, T_4 and T_3. The lowest K concentration in grain (0.423%) was observed in treatment T_1 (control). The results showed that the K concentration in straw was higher than of grain in all treatments. The highest K concentration in straw was observed in treatment T_4 (2.387%), which was statistically identical with treatments T_5, T_2, and T_3. The lowest P concentration was recorded in treatment T_1 (control).

1.6 Potassium uptake by grain and straw

The results indicate that the K uptake by grain and straw of STL-655 rice mutant were significantly affected by the different treatments (Table 2). Potassium uptake by grain varied from 11.76 to 23.02 kg/ha. The highest K uptake (23.02 kg/ha) of grain was observed in treatment T_6, which was statistically similar to treatments T_4, T_5, and T_2. The lowest K uptake (11.76 kg/ha) of grain was recorded in treatment T_1, (control). K uptake by straw ranged from 59.01 to 159.6 kg/ha by the different treatments. The highest K uptake (159.6 kg/ha) by straw was recorded in treatment T_4, which was statistically similar to treatments T_5 and T_2. The lowest K uptake (59.01 kg/ha) by straw was observed in T_1 (control).

The total K uptake by grain and straw ranged from 70.77 to 178.77 kg/ha. The highest total P uptake (178.77 kg/ha) was obtained in treatment T_4. The lowest total P uptake was observed in treatment T_1 (control).

1.7 Sulphur concentration in grain and straw

The S concentration both in grain and straw were significantly influenced by different treatment combinations. The S concentration in grain varied from 0.156 to 0.186% (Table 1). The highest S concentration (0.186%) in grain was observed in treatment T_4, which was statistically similar to treatments T_2, T_6 and T_3. The lowest concentration (0.163%) in grain was recorded in treatment T_1 (control). In straw, the S concentration also influenced significantly due to different treatment combinations (Table 1). The S concentration in straw ranged from 0.163 to 0.186%. The highest S concentration (0.163%) in straw was found in treatment T_2, which was statistically identical to treatments T_5, T_6 and T_4. The lowest S concentration in straw was found in T_1 (control), which was statistically identical with T_3 treatment.

1.8 Sulphur uptake by grain and straw

The results presented in Table 2 indicate that S uptake by grain and straw influenced significantly due to different treatment combinations. The S uptake of grain ranged from 4.15 to 7.09 kg/ha. The highest S uptake of 7.09 kg/ha by grain was found in treatment T_4, which was statistically similar to treatments T_5, T_6, and T_3. The lowest S uptake of 4.05 kg/ha was found in T_1 (control). On the other hand, the S uptake by straw varied from 9.54 to 12.97 kg/ha. The highest quantity of S uptake (12.97 kg/ha) by straw was recorded in treatment T_6, which was statistically identical with the treatments T_5, T_2 and T_3. The lowest S uptake (9.54 kg/ha) by straw was found in treatment T_1 (control). The total S uptake of grain plus straw varied from 13.69 to 19.37 kg/ha. The highest quantity of total S uptake (19.37 kg/ha) was found in treatment T_6. As expected, the lowest total S uptake (13.69 kg/ha) was observed in T_1 (control).

Table 3. Effect of different treatments on total nutrient uptake by grain plus straw of STL-655 rice mutant

Treatments	Total nutrient uptake (kg/ha) of STL-655 rice mutant			
	N	P	K	S
T_1 = Control (0)	53	10.87	70.77	13.69
$T_2 = N_{60}\ P_{20}\ K_{40}\ S_{10}\ Zn_1$	52.79	17.06	117.52	16.63
$T_3 = N_{80}\ P_{25}\ K_{50}\ S_{15}\ Zn_{1.5}$	66.05	17.34	106.16	16.61
$T_4 = N_{100}\ P_{30}\ K_{60}\ S_{20}\ Zn_2$	70.48	17.81	178.77	18.01
$T_5 = N_{120}\ P_{35}\ K_{70}\ S_{25}\ Zn_3$	68.15	17.59	141.15	17.64
$T_6 = N_{140}\ P_{40}\ K_{80}\ S_{30}\ Zn_4$	81.25	18.54	112.16	19.37

2. Economic of fertilizer use

The results of partial budget analysis of STL -655 rice mutant (Table 4) demonstrated that the highest net benefit of 53,300 Tk ha^{-1} was obtained in T_4 followed by Tk. 52,465 and Tk 51,670 ha^{-1} in T_5 and T_6 treatments. Another attempt also been made to find out the marginal benefit cost ratio (MBCR) against the treatments, which is shown in Table 4.10. The highest MBCR (1.017) was obtained in T_4 followed by 0.916 and 0.789 in treatment T_3 and T_5, respectively. However, the MBCR of treatments was found to follow the sequence $T_4 > T_3 > T_5 > T_6 > T_2$. This is agreement with the findings of (Haque, 2002).

Table 4. Partial budget analysis for fertilizer use in crop production under Boro rice season at BINA substation, Satkhira

Treatment	Yield(kg/ha)		Fert. cost	Gross return	Variable cost	Net return	Marginal gross return	MBCR
	Grain	Straw						
T_1	31155	5233	0	36388	0	36388	0	0
T_2	45600	5950	6850	51550	6850	44700	8312	1.213
T_3	52650	6573	8840	59223	8840	50383	13995	1.583
T_4	57450	6687	10830	64137	10830	53307	16919	1.562
T_5	58750	6610	12895	65360	12895	52465	16077	1.246
T_6	59250	7383	14960	66633	14960	51673	15285	1.021

Grain = 15 Tk./kg; Straw = 1 Tk./kg; N = 26 Tk/kg; P = 135 Tk/kg; K = 50 Tk/kg; S = 44 Tk/kg and Zn = 150Tk/kg, MBCR = Marginal benefit cost ratio

Conclusion

Based on the results of study it may be concluded that treatment T_3 (N_{80} P_{25} K_{50} S_{15} $Zn_{1.5}$) is economically suitable for cultivation. However, the marginal farmers who are unable to invest more may go for T_3 treatment and rich farmers may be advised to follow treatment T_4 which supply balanced fertilization as the suitable one.

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