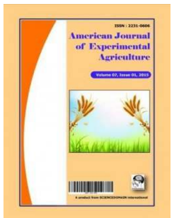

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Effects of Missing Elements (NPS) on Chemical Properties of Soil and Nutrient Uptake of Rice Var. BRRI dhan29

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at the BRRI Regional Station, Habigonj, Bangladesh during December 2012 to May 2013 (dry season) to study the effect of missing elements (NPS) on the soil properties and nutrient uptake of rice var. BRRI dhan29. The experiment was laid out in a randomized complete block design with three replications. The experiment consisted of six treatments viz., $N_{85}P_{35}K_{50}S_9$, $P_{38}K_{50}S_9$ (-N), $N_{85}K_{50}S_9$ (-P), $N_{85}P_{38}K_{50}$ (-S), $K_{50}S_9$ (-NP) in kg/ha, and $N_0P_0K_0S_0$ (control). Results indicated that elements N, P and S either missing alone or in combination with each other significantly affected the chemical properties, nutrient concentration and nutrient uptake of BRRI dhan29. Grain and straw yields were highest with $N_{85}P_{38}K_{50}S_9$ (8.31, 9.71 t ha^{-1}) and the lowest with $K_{50}S_9$ (-NP) (4.76, 5.30 t ha^{-1}). Soil chemical properties changed such as available P and exchangeable K as compared to initial soil due to missing elements treatments and other remained similar. Nutrient contents and nutrients uptake were the highest in the treatment $N_{85}P_{38}K_{50}S_9$. The results revealed application of balanced fertilizer @ $N_{85}P_{38}K_{50}S_9$ was better (among the treatments) for obtaining higher grain and straw yield; and nutrient uptake of rice var. BRRI dhan29.

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Keywords: Missing elements; chemical properties of soil; nutrient content; yield; rice.

1. INTRODUCTION

Rice is the dominant food crop of Bangladesh; accounting for about 75 percent of agricultural land use (and 28 percent of GDP) [1]. The soil and climate of Bangladesh are favorable for rice production. Rice provides 80% of the calorie intake for Bangladeshis and is the principal dietary source of essential nutrients including selenium (Se) and zinc (Zn) [2].Out of the 13.7 million ha of arable land, rice is grown on 10.27 million ha (75 percent) producing 94 percent of total food grain requirement [3]. Rice as well as other crops depends on the supply of available nutrients like N, P, K and S as well as from soil. Most of the soils in Bangladesh on which rice is cultivated are deficient in N, P and S, consequently the response of modern rice varieties to nitrogen application have always been remarkably high [4]. When one or more essential nutrient elements are limited in the soil, plant growth slows down and the grain yield decreases. The supply of essential nutrient through fertilizers has positive effects on chemical properties of soil and nutrient uptake by plants. The changes in chemical properties of soil and amount of nutrient uptake essentiality can be judged through missing element study. Soils of BRRI regional station Habigonj have low to very low nitrogen and phosphorus; and sulfur status is low to optimum. The present study was undertaken to determine the effect of N, P and S on the chemical properties of soil; and nutrient content and nutrient uptake of BRRI dhan29 through the missing elements (NPS) study.

2. MATERIALS AND METHODS

The experiment was conducted at the Regional Station, Habigonj of Bangladesh Rice Research Institute (BRRI) during the period from December, 2012 to May, 2013. The soil belongs to Baniachong soil series under the Agro-ecological zone of Old Meghna Estuarine Floodplain (AEZ 19). The soil of the experimental area was acidic (pH 5.1) and has clay texture. The experimental field was first ploughed on December 29, 2012 with the help of a power tiller, later on January 05, 2013. The field was prepared by three successive ploughings and cross ploughings with a power tiller and subsequently leveled by laddering. All weeds and other plant residues of previous plants were removed from the field. Immediately after final land preparation, the experimental layout was made on January 06, 2013 according to experimental treatments. Total number of plots were 18, the unit plot size was 5 m × 3 m. The initial soil and post harvest soil samples were collected before land preparation and after harvesting from 0-15 cm soil depth. Then the samples were air dried and sieved for physical and chemical analysis. Seeds were sown on the seedbed on December 02, 2012 for raising nursery seedlings. Transplanting was done at 07 January 2013 using 35-day old seedlings. Two hand weedings were done for each plot, first weeding was done at 25 days after transplanting followed by second weeding at 40 days after first weeding. Standing water was maintained 2-3 cm in the field throughout the growing period. Recommended cultural practices were followed for better crop establishment. Forty days old seedling was transplanted in 20 cm × 20 cm spacing. Block to block distance 1 m and plot to plot distance 0.45 m was maintained during layout of the experiment. There were six treatments viz. $N_{85}P_{38}K_{50}S_{9,}$ $P_{38}K_{50}S_9$ (-N), $N_{85}K_{50}S_9$ (-P), $N_{85}P_{38}K_{50}$ (-S), $K_{50}S_9$ (-NP) in kg/ha, and $N_0P_0K_0S_0$ (control). The experiment was laid out in a randomized complete block design (RCBD) with three replications. Treatments were achieved through the application NPKS @ 85-38-50-9 kg ha^{-1} from urea, triple superphosphate, muriate of potash and gypsum. Urea N was applied in three equal splits i.e., one-third at 10 days after transplanting (DAT), one-third at active tillering stage (35 DAT) and one-third before panicle initiation stage (60 DAT). The total amount of triple superphosphate, muriate of potash and gypsum were applied during final land preparation except where missing treatments were designated. BRRI dhan29, a high yielding variety of rice, was used as a test crop. The rice plants were harvested just above ground level leaving 5-7 cm straw at full maturity (when 80% of the grains attained physiologically maturity and became golden yellow in color) at 158 DAT. The crop was harvested from 5 m^2 area at the center of each plot (total 18 plots) avoiding the border lines to avoid border effect. The harvested crop of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The grains were separated from each bundle by beating with bamboo sticks and grains were dried in the sun to reach at about 12% moisture content. Then moisture content of the grain was measured with moisture meter (GMK-303RS). The representative grain and straw samples from each plot were dried in an oven at 60℃ for about 48 hours and then ground by a grinding machine. Then chemical analyses were done for nutrient contents in grain and straw. Total nitrogen was estimated by following Micro Kjeldahl method [5]. For available P, extracted with 0.5 M $NaHCO_3$ solution [6] and developed blue colour by $SnCl_2$ and measured the colour colorimetrically [7]. Using flame photometer (Jenway, PF-27), exchangeable K was estimated on the normal ammonium acetate extract at pH 7.0 [7]. Extracted by acetic acid and NH_4OAC extracting solution. Then added acid seed solution and $BaCl_2$ solution and determined available S by Spectrophotometer (Analytik Jena, Specord 205). Nutrient uptake by BRRI dhan29 was calculated by multiplying the yield data with respective nutrient contents in grain and straw. Total uptake was calculated as the sum total of grain and straw uptake. The statistical analysis of the data was done by using computer package program MSTAT and the means were separated using LSD test at 0.05% level of probability.

3. RESULTS AND DISCUSSION

3.1 Effect of Missing Elements on Grain and Straw Yield (T Ha^{-1}) of Rice var. BRRI dhan29

There was a significant reduction in yield of rice var. BRRI dhan29 due to absence of N, P and S alone or combinations of them (Table 1). The grain yield varied from 4.76 to 8.31 t ha^{-1}. The highest grain yield (8.31 t ha^{-1}) was obtained in the treatment $N_{85}P_{38}K_{50}S_9$ which was statistically identical to the treatments $N_{85}K_{50}S_9$ (-P) and $N_{85}P_{38}K_{50}$ (-S). The lowest grain yield (4.76 t ha^{-1}) was obtained in the treatment $K_{50}S_9$ (-NP) which was similar to the treatments $P_{38}K_{50}S_9$ (-N) and $N_0P_0K_0S_0$ having the corresponding yield of 5.38 and 5.29 t ha^{-1}. The straw yield of BRRI dhan29 rice varied from 5.30 to 9.71 t ha^{-1}. Like grain yield, the treatment $N_{85}P_{38}K_{50}S_9$ also produced the highest straw yield (9.71 t ha^{-1}) which was statistically similar with the treatments $N_{85}K_{50}S_9$ (-P) and $N_{85}P_{38}K_{50}$ (-S). The lowest straw yield (5.307 t ha^{-1}) was obtained in the treatment $K_{50}S_9$ (-NP).

3.2 Soil Chemical Properties

Status of the soil pH, organic carbon (OM), total N, available P, exchangeable K and available S in the initial soil and at harvest are presented in Table 1. There were little changes in soil pH and organic matter (OM) due to abscence of N, P and S alone or combinations of them. The total N status of soil ranged from 0.135% to 0.148% (initial level 0.14). The available P content ranged from 3.95 to 9.35 mg kg^{-1} (initial level 4.20 mg kg^{-1}). That is application of P fertilizer increased soil P level by > 100%. Exchangeable K was found the highest due to the treatment $K_{50}S_9$ (-NP) and the lowest in control. Chemical fertilizers increased the S status of soils. The S level ranged from 37.68 to 42.55 mg kg^{-1} (initial status 39.37 mg kg^{-1}). It was observed that the addition of chemical fertilizers increased the S, P and K status of soils [8]. Our finding agreed with observations of Parthasarathey et al. [8].

3.3 Nutrient Content in Grain and Straw of Rice var. BRRI dhan29

Missing elements (NPS) alone or in combination of them did not affect the N, P, K and S content in grain and straw of BRRI dhan29 rice (Table 2). The N content in rice grain and straw ranged from 1.19% to 1.21% and 0.59% to 0.64%, respectively. In case of grain, phosphorus content varied from 0.203% in $N_{85}K_{50}S_9$ (-P) to 0.215% in $P_{38}K_{50}S_9$ (-N). In case of straw, phosphorus content varied from 0.085% in $N_{85}P_{38}K_{50}S_9$ to 0.079% in $K_{50}S_9$ (-NP). Potassium content in grain varied from 0.221% in control to 0.237% in $N_{85}P_{38}K_{50}S_9$ treatment. In case of straw, potassium content ranged from 1.56% to 1.64%. In case of grain, the highest S content was found in the treatment $N_{85}P_{38}K_{50}S_9$. The lowest S content was recorded in treatment $N_0P_0K_0S_0$ (control). In case of straw, sulfur content varied from 0.062% to 0.071% [9]. Application of sulfur increased S content in grain numerically but not statistically. Our finding agreed with observations of Tiwari et al. [9].

3.4 Nutrient Uptake by BRRI dhan29 (Grain and Straw)

Nutrient uptake by grain and straw in BRRI dhan29 was significantly influenced due to different treatments (Table 3).

3.5 Nitrogen Uptake

The highest N uptake (100.6 kg ha^{-1}) by grain was recorded in $N_{85}P_{38}K_{50}S_9$ treatment which was statistically similar to the treatments $N_{85}K_{50}S_9$ (-P) and $N_{85}P_{38}K_{50}$ (-S). The lowest N uptake of 57.40 kg ha^{-1} was recorded in the treatment $K_{50}S_9$ (-NP). In case of straw, the highest N uptake (62.10 kg ha^{-1}) was recorded in $N_{85}P_{38}K_{50}S_9$ and the lowest N uptake of 32.87 kg ha^{-1} was recorded in the $K_{50}S_9$ (-NP) treatment. Similar trend was showed in total N uptake by grain and straw in BRRI dhan29 due to different treatments.

Table 1. Straw and grain yields of rice var. BRRI dhan29 and soil chemical properties as influenced by missing element (NPS) in BRRI regional station, Habigonj

Treatments	Straw yields (t ha^{-1})	Grain yields (t ha^{-1})	pH	Organic matter (%)	Total N (%)	Available P (mg kg^{-1})	Exchangeable K (c mol kg^{-1})	Available S (mg kg^{-1})
Initial soil			5.1	2.80	0.14	4.20	0.24	39.37
Post harvest soil								
$N_{85}P_{38}K_{50}S_9$	9.71	8.31	5.0	2.71	0.148	9.35	0.26	42.55
$P_{38}K_{50}S_9$ (-N)	6.47	5.38	5.0	2.80	0.135	8.12	0.25	42.00
$N_{85}K_{50}S_9$ (-P)	9.38	8.28	5.1	2.75	0.145	3.95	0.28	42.22
$N_{85}P_{38}K_{50}$ (-S)	9.45	8.29	5.2	2.81	0.146	6.87	0.26	37.68
$K_{50}S_9$ (-NP)	5.30	4.76	5.0	2.74	0.140	4.00	0.30	43.85
$N_0P_0K_0S_0$ (control)	6.21	5.29	5.1	2.77	0.138	4.08	0.23	39.25
CV (%)	5.59	6.22	31.05	10.0	18.57	24.39	38.53	4.65
LSD	0.788*	0.761*	2.88^{NS}	0.505^{NS}	0.57^{NS}	2.707*	0.182^{NS}	3.520^{NS}

**: Significant at 0.05% level of significance; NS: Non Significant*

Table 2. Effect of missing elements (NPS) on the nutrient concentration of grain and straw of BRRI dhan29

Treatment	**Nutrient concentration** (%)							
	Nitrogen		**Phosphorus**		**Potassium**		**Sulfur**	
	Grain	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
$N_{85}P_{38}K_{50}S_9$	1.21	0.64	0.212	0.085	0.237	1.64	0.087	0.070
$P_{38}K_{50}S_9$ (-N)	1.20	0.59	0.215	0.082	0.235	1.59	0.085	0.069
$N_{85}K_{50}S_9$ (-P)	1.20	0.63	0.203	0.080	0.233	1.58	0.085	0.071
$N_{85}P_{38}K_{50}$ (-S)	1.21	0.65	0.210	0.084	0.236	1.61	0.082	0.069
$K_{50}S_9$ (-NP)	1.19	0.60	0.204	0.079	0.232	1.62	0.083	0.062
$N_0P_0K_0S_0$ (control)	1.19	0.61	0.205	0.081	0.221	1.56	0.080	0.063
CV (%)	1.65	3.83	4.28	7.52	2.52	4.04	5.74	8.84
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Effect of missing elements (NPS) on the nutrient (nitrogen and phosphorus) uptake by grain and straw of BRRI dhan29

Treatment	**Uptake of different nutrients (kg ha-1)**					
	Nitrogen			**Phosphorus**		
	Grain	**Straw**	**Total**	**Grain**	**Straw**	**Total**
$N_{85}P_{38}K_{50}S_9$	100.6	62.10	162.7	17.57	8.23	25.8
$P_{38}K_{50}S_9$ (-N)	64.60	38.23	102.83	11.53	5.43	16.96
$N_{85}K_{50}S_9$ (-P)	99.33	59.17	158.5	16.80	7.33	24.13
$N_{85}P_{38}K_{50}$ (-S)	100.3	61.50	161.8	17.40	8.36	25.76
$K_{50}S_9$ (-NP)	57.40	32.87	90.27	9.80	4.36	14.16
$N_0P_0K_0S_0$ (control)	62.57	37.83	100.4	10.67	5.06	15.73
CV (%)	2.81	4.71	2.38	14.08	12.91	11.70
$LSD_{0.05}$	4.127	4.165	4.346	3.576	1.516	4.346

Table 4. Effect of missing elements (NPS) on the nutrient (potassium and sulfur) uptake by grain and straw of BRRI dhan29

Treatment	Uptake of different nutrients (kg ha^{-1})					
	Potassium			Sulfur		
	Grain	Straw	Total	Grain	Straw	Total
$N_{85}P_{38}K_{50}S_9$	19.60	159.4	179	7.26	6.83	14.09
$P_{38}K_{50}S_9$ (-N)	12.67	102.8	115.47	4.70	4.43	9.13
$N_{85}K_{50}S_9$ (-P)	19.33	148.5	167.83	7.10	6.70	13.8
$N_{85}P_{38}K_{50}$ (-S)	19.57	152.3	171.87	6.86	6.53	13.39
$K_{50}S_9$ (-NP)	11.07	88.53	99.6	3.97	3.50	7.47
$N_0P_0K_0S_0$ (control)	11.40	97.07	108.47	4.20	3.93	8.13
CV (%)	10.18	2.09	11.93	11.83	9.90	8.65
$LSD_{0.05}$	2.889	4.740	29.75	1.233	0.959	1.734

3.6 Phosphorus Uptake

The highest P uptake (17.57 kg ha^{-1}) by grain was recorded in $N_{85}P_{38}K_{50}S_9$ treatment which was statistically similar to the treatments $N_{85}K_{50}S_9$ (-P) and $N_{85}P_{38}K_{50}$ (-S). The lowest P uptake was recorded in the $K_{50}S_9$ (-NP) treatment which was statistically similar to the treatments $P_{38}K_{50}S_9$ (-N) and $N_0P_0K_0S_0$ (control). In case of straw, the highest P uptake (8.36 kg ha^{-1}) by straw was recorded in treatment $N_{85}P_{38}K_{50}$ (-S) and the lowest P uptake was recorded in the $K_{50}S_9$ (-NP) treatment. Similar trend was observed in total P uptake by grain and straw of BRRI dhan29 rice due to different treatments.

3.7 Potassium Uptake

The highest K uptake of 19.60 kg ha^{-1} by grain was recorded in $N_{85}P_{38}K_{50}S_9$ and the lowest K uptake of 11.07 kg ha^{-1} in grain was recorded in $K_{50}S_9$ (-NP). In case of grain, the highest K uptake of 159.4 kg ha^{-1} by straw was recorded in $N_{85}P_{38}K_{50}S_9$ treatment. The lowest K uptake by straw was recorded in the treatment $K_{50}S_9$ (-NP) [10]. A significant increase in K uptake in different treatments over control treatments with K application was found.

3.8 Sulfur Uptake

Sulfur uptake by grain and straw in BRRI dhan29 rice was significantly affected by different treatments. In case of grain, the highest S uptake of 7.26 kg ha^{-1} was recorded in $N_{85}P_{38}K_{50}S_9$ and the lowest S uptake of 3.96 kg ha^{-1} in $K_{50}S_9$ (-NP). In case of straw, the highest S uptake was recorded in $N_{85}P_{38}K_{50}S_9$ treatments which was statistically similar to $N_{85}K_{50}S_9$ (-P) and $N_{85}P_{38}K_{50}$ (-S) treatments, while the lowest S uptake was in $K_{50}S_9$ (-NP). The treatment $N_{85}P_{38}K_{50}S_9$ showed the highest total S uptake and the lowest S uptake was in $K_{50}S_9$ (-NP) [11]. Application of sulfur enhanced significantly sulfur uptake by rice. Our findings agreed with observations of [11].

4. CONCLUSION

The result of the present study indicated that application of balanced fertilizer @ $N_{85}P_{38}K_{50}S_9$ was found to produce maximum grain and straw yield; and nutrient uptake for rice var. BRRI dhan29. Soil chemical properties and nutrient uptake were not significantly affected due to missing elements treatments. However, further experimentation is needed to confirm the results as one year's trial is not enough for final recommendation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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