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YIELD OF RICE AND ITS MINERAL CONTENTS AS INFLUENCED BY SEWAGE SLUDGE AND NITROGEN

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Abstract

A pot experiment was carried out to examine the yield of rice and mineral contents in rice grain (*Oryza sativa* L. cv. BRRI dhan-36) under five levels of sewage sludge-nitrogen fertilization, *viz*., SS_0N_{280}, $SS_{60}N_{49}$, $SS_{120}N_{35}$, $SS_{200}N_{28}$, and $SS_{300}N_{21}$. The grain yield contributing characters such as number of filled grains per panicle, dry weight of grains, and weight of 1000 grains were significantly high in the treatment $SS_{120}N_{35}$ as compared to the other treatments. However, the number of filled rice grains per panicle and weight of 1000 rice grain did not differ significantly between the treatments, SS_0N_{280} and $SS_{120}N_{35}$. The contents of N, K, Ca, Mg, Fe, Cu, Zn and Pb in rice grains increased significantly with increasing rates of sewage sludge application. Crude protein content of rice grain increased significantly in sewage sludge treated treatment grains as compared to the sewage sludge free treatment. Accumulations of P and Mn in rice grain were unfavorably affected by sewage sludge. No detectable contents of Cr, Cd and Ni were found in rice grain.

Key words: Sewage sludge, Nitrogen fertilization, Rice grain yield, Mineral contents

Introduction

Sewage sludge is one of the cheap and important sources of organic matter and plant nutrients, influencing plant growth and yield (Parat *et al.* 2005. Its use is not new in agricultural land. Its application to soils not only improves organic matter and essential nutrient contents, but also improves soil structure, aeration, water-holding capacity and microbial activities (Webber *et al.* 1996 and Parat *et al.* 2005). It has been widely used in cropped land in many countries especially Europe, America and some parts of Asia. But, this may cause a potential hazard, especially heavy metal pollution to soil, if undesirable industrial sludge is incorporated in the sewage pipe line and substantial amounts of heavy metals (Cd, Ni, Cu, Zn and others) are not removed from the sludge (Flieβbach 1991).

The compositions of sewage sludge vary from one city to another and even from one day to the next in the same city (Tisdale *et al.* 1995). Approximately 54,750 tons of sewage sludge containing about 1,000 to 1,400 tons of nitrogen and 350 to 500 tons of phosphorus are produced per year in Dhaka city, Bangladesh (BARC 1997). In Bangladesh, sewage sludge application is not extensive in agricultural land. Moreover, research regarding the potential use of sewage sludge on agricultural land and its

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consequences on soils as well as in grain and vegetable crops is inadequate in Bangladesh. Therefore, the present investigation has been conducted to find out the yield and mineral contents in rice grain under different levels of sewage sludge and nitrogen fertilization.

Materials and Methods

The experimental soil belonging to Naraibag series was collected from a depth of 0 - 15 cm. Dried sewage sludge (SS) was collected from Dhaka WASA sewage treatment plant, Pagla, Bangladesh. The collected soil and sewage sludge samples were air dried, ground and sieved through a 2 mm sieve for physical analyses as well as to grow rice. However, for chemical and physico-chemical analyses, the soil and sewage sludge samples were further sieved through a 1 mm sieve and kept in plastic container. The relevant properties of the soil and sewage sludge samples are presented in Table 1 (Kabir *et al.* 2008).

Table 1. Physical, chemical and physico-chemical properties of the soil and sewage sludge samples.

Properties	Values of soil sample	Values of sewage sludge
Sand (%)	6.44	-
Silt ,,	40.00	-
Clay ,,	53.56	-
pH	6.1	5.8
EC (μS/cm)	570	4900
CEC (cmolc/kg)	17.05	27.75
Organic matter (%)	3.10	10.15
Available N (ppm)	61.00	671.00
Available P ,,	14.00	25.00
Total N (%)	0.08	1.42
Total P ,,	0.04	0.85
Total Na ,,	0.05	0.02
Total K ,,	0.17	0.09
Total Ca ,,	0.07	0.09
Total Mg ,,	0.06	0.021
Total Fe ,,	2.24	1.55
Total Cu ,,	0.01	0.03
Total Zn ,,	0.012	0.17
Total Mn ,,	0.024	0.02
Total Pb (ppm)	50.00	100.00
Total Cr ,,	40.00	100.00
Total Cd	Below detection limit	Below detection limit
Total Ni	Below detection limit	Below detection limit
Exchangeable Na (cmolc/kg)	1.63	1.85
Exchangeable K ,,	0.38	0.77
Exchangeable Ca ,,	10.88	19.88
Exchangeable Mg ,,	3.54	4.04

Rice seedlings (BRRI dhan-36) were grown in Boro season in pots containing 6 kg soil per pot. The experiment was conducted with five treatments, *viz.*, SS_0N_{280}, $SS_{60}N_{49}$,

$SS_{120}N_{35}$, $SS_{200}N_{28}$, and $SS_{300}N_{21}$ consisting of 5 levels of SS (0, 60, 120, 200 and 300 t/ha) and 5 levels of nitrogen (280, 49, 35, 28 and 21 kg/ha) in a CRD with three replications. Five treatments together with a basal dose of TSP (200 kg P_2O_5/ha) and muriate of potassium (200 kg K_2O/ha) were applied at the time of transplantation of rice seedling. After 5 days of transplantation, 50% N in the treatment SS_0N_{280} and full dose of N in the rest of the treatments were applied. The remaining 50% N was applied in halves after 55 and 100 days of transplantation in SS_0N_{280} treatment. Eight uniform size rice seedlings of 40 days old were transplanted (2 seedlings/hill) in each pot, but after 15 days only the best four were allowed to grow. During the growing period, pots were irrigated properly with normal tap water and intercultural operations were done whenever necessary. Dry weight of grain, weight of 1000 grains and the number of filled and non-filled grains were determined at maturity.

Total nitrogen content of rice grain was determined by Micro-Kjeldhal's method (Jackson 1973). The protein content of rice grain was calculated multiplying the %N content by a factor of 6.25. The total contents of P, K, Ca, Mg, Fe, Zn, Cu, Mn, Pb, Cr, Cd and Ni were determined after wet digestion of rice grain in HNO_3-$HClO_4$ acid mixture (5 : 1). The total phosphorus content was determined colorimetrically using a Chemito visible spectrophotometer, after developing the yellow color with vanadomolybdate (Jackson 1973). Total potassium content in the extract was analyzed using Gallenkamp flame photometer. The total contents of Ca, Mg, Fe, Zn, Cu, Mn, Pb, Cd, Cr and Ni in rice grain were analyzed in the extract by using Atomic Absorption Spectrometer (Perkin Elmer 3110) (Jackson 1973). The results were statistically analyzed using DMRT (Gomez and Gomez 1976).

Results and Discussion

The yield contributing characters such as number of filled and non-filled grains per panicle, dry weight of grains and weight of 1000 grains were taken into consideration to see the influence of sewage sludge-nitrogen fertilization on the yield of rice and are presented in the Table 2. The highest number of filled grains per panicle (85.67) was recorded in the treatment SS_0N_{280}, but decreased significantly with increasing sewage sludge applications, except in the treatment $SS_{120}N_{35}$ (Table 2). Significantly the lowest number of non-filled grains per panicle (40.00) was observed in the treatment SS_0N_{280} and the highest in the treatment $SS_{300}N_{21}$ (49.33). However, no significant difference was found among most of the treatments. The significantly highest dry weight of grain (41.47 g/pot) was recorded from the treatment $SS_{120}N_{35}$ while statistically similar values were found in rest of the treatments. Weight of 1000 rice grains was found the highest in the treatment SS_0N_{280} (23.06 g) whereas decreased with increasing sewage sludge applications, but no significant difference was found between SS_0N_{280} and $SS_{120}N_{35}$, and $SS_{200}N_{28}$ and $SS_{300}N_{21}$ treatments. The yield contributing characteristics were always significantly best in the treatment $SS_{120}N_{35}$ compared as to all other treatments. It might be due to the fulfillment of nutrient requirements provided by the treatment $SS_{120}N_{35}$.

Table 2. Effects of different levels of sewage sludge-nitrogen on selected parameters of rice grain.

Treatments	Number of grains/panicle		Dry weight of grains (g/pot)	Weight of 1000 grains (g)
	Filled	Non-filled		
SS_0N_{280}	85.67 a	40.00 b	35.07 b	23.06 a
$SS_{60}N_{49}$	70.00 b	40.33 b	36.87 b	21.00 b
$SS_{120}N_{35}$	84.67 a	42.33 b	41.47 a	23.03 a
$SS_{200}N_{28}$	64.33 c	45.67 ab	37.53 b	20.80 c
$SS_{300}N_{21}$	54.33 d	49.33 a	34.67 b	20.00 c

Means followed by the same letter(s) in a column do not differ significantly from each other deferent at 5% level of DMRT.

Optimum doses of essential nutrient elements ensure the highest yield of a crop (Noggle and Fritz 1976). Lavado (2006) found increased yield of sunflower due to supply of nutrient from sewage sludge.

The contents of nitrogen, potassium, calcium and magnesium in the grain were significantly lowest in SS_0N_{280} treatment, but increased gradually with increasing sewage sludge applications and it was significantly higher in the treatment $SS_{300}N_{21}$ (Table 3). Sewage sludge influenced the accumulation of nitrogen in rice grain especially at higher rates of application. This might happen due to the high dose of nitrogen supply particularly from sewage sludge mineralization. The higher content of nitrogen in oat (*Avena sativa*) from soil amended with sewage sludge was observed by Peterson *et al.* (2003). The results of the present investigation are in well agreement with the earlier findings of Tamura *et al.* (1988) and Gupta *et al.* (1989). The maximum potassium content in grain was found in the treatment $SS_{300}N_{21}$ as compared to other treatments,

Table 3. Effects of different levels of sewage sludge-nitrogen on the mineral and crude protein contents of rice grain.

Treatments	Mineral content (%)					Crude protein content (%)
	N	P	K	Ca	Mg	
SS_0N_{280}	1.61 b	0.833 a	0.538 c	0.466 d	0.137 c	10.06 b
$SS_{60}N_{49}$	1.70 ab	0.750 b	0.580 c	0.550 c	0.143 c	10.60 a
$SS_{120}N_{35}$	1.71 ab	0.720 b	0.670 b	0.600 c	0.150 bc	10.71 a
$SS_{200}N_{28}$	1.75 a	0.650 c	0.740 ab	0.660 b	0.155 b	10.94 a
$SS_{300}N_{21}$	1.79 a	0.566 d	0.800 a	0.750 a	0.170 a	11.17 a

Means followed by the same letter(s) in a column do not differ significantly from each other deferent at 5% level of DMRT.

but no significant difference was observed in most of the cases. Rice grains accumulated more K probably due to its availability from applied sewage sludge. Grain accumulated more Ca and Mg in all sludge treated plants than that of the sewage sludge free treatment (SS_0N_{280}). This might be due to the availability of Ca and Mg after being added sewage sludge (Hinesly *et al.* 1979). Application of combined sewage sludge and nitrogen fertilization affected phosphorus content in rice grain (Table 3). The significantly highest amount of phosphorus (0.883%) in rice grain was observed in the treatment SS_0N_{280} and the lowest amount in the treatment $SS_{300}N_{21}$. The P content in rice grain decreased significantly with increasing sewage sludge application. Crude protein content in rice grain increased significantly in sewage sludge treated grains as compared to the sewage sludge free treatment (SS_0N_{280}), but no significant difference was found among the sewage sludge treated grains. Pandya *et al.* (1988) found that application of sewage sludge increased the total protein contents in rice.

Heavy metal contents in plants were affected by the application of sewage sludge (Devkota and Schmidt 2000, Frost and Ketchum 2000). In the rice grain the significantly highest amounts of heavy metals (Fe, Cu, Zn and Pb) were found in $SS_{300}N_{21}$ treatment and the lowest in the treatment SS_0N_{280} (Table 4). The accumulation of Fe, Cu, Zn and Pb in the rice grain increased gradually with increasing rates of sewage sludge application as compared to SS_0N_{280} treatment (sewage sludge free treatment). No significant difference was found between SS_0N_{280} and $SS_{60}N_{49}$, and $SS_{60}N_{49}$ and $SS_{120}N_{35}$ treatments, but significant differences were found among the remaining treatments.

Table 4. Effects of different levels of sewage sludge-nitrogen on the heavy metal content (µg/g) of rice grain.

Treatments	Fe	Cu	Mn	Zn	Pb	Cr	Cd	Ni
SS_0N_{280}	340 ^{d}	16.67 ^{c}	62.67 ^{a}	54.00 ^{d}	11.67 ^{c}	-	-	-
$SS_{60}N_{49}$	380 ^{cd}	24.00 ^{c}	54.00 ^{b}	60.00 ^{cd}	15.00 ^{bc}	-	-	-
$SS_{120}N_{35}$	430 ^{c}	30.00 ^{bc}	48.00 ^{c}	66.67 ^{c}	16.67 ^{bc}	-	-	-
$SS_{200}N_{28}$	500 ^{b}	36.67 ^{b}	43.33 ^{d}	76.00 ^{b}	21.67 ^{b}	-	-	-
$SS_{300}N_{21}$	590 ^{a}	55.00 ^{a}	39.00 ^{d}	89.33 ^{a}	30.00 ^{a}	-	-	-

Means followed by the same letter(s) in a column do not differ significantly from each other deferent at 5% level of DMRT.

Copper, lead and zinc concentrations in maize grain were reported high in Zimbabwe due to heavy fertilization with sewage sludge (Muchuweti *et al.* 2006). In wheat grain the uptake of Fe, Cu, Zn and Pb increased with the increase in sewage sludge application (Hinesly *et al.* 1979). Ullah and Gerzabek (1991) reported that Cu uptake by maize plant was increased due to sewage sludge application. Zinc content was found high due to sewage sludge application (Mullins *et al.* 1986). Manganese content in rice grain decreased significantly with increasing sewage sludge application as compared to SS_0N_{280} treatment (Table 4). This could be due to the less availability of Mn by the added sewage sludge (Hinesly *et al.* 1979, Hiroki and Fujii 1984). No detectable contents of Cr, Cd and Ni were found in grain.

The best yield response of rice grain was obtained with the treatment, $SS_{120}N_{35}$ where 120 tons of sewage sludge per hectare plus 35 kg of nitrogen per hectare were added. This might be attributed due to the optimum release of essential macro- and micronutrient elements from the applied sewage sludge.

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