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EFFECT OF FERTILIZER ON THE GROWTH AND YIELD OF BORO AND T. AMAN RICE IN THE SOILS OF INDUSTRIALLY POLLUTED AGRICULTURAL LAND AREAS OF MADHUPUR TRACT

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Abstract

A pot experiment was conducted during 2018-19 in a net house at the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, to determine fertilizer's effect on the growth and yield of *Boro* and T. *Aman* rice in the soils of industrially polluted agricultural land areas of Madhupur Tract. The study consisted of two factors, i.e., polluted soil viz., S_1: Non-polluted soil, S_2: polluted soil-1, S_3: polluted soil-2, S_4: polluted soil-3, and four fertilizer treatments viz., T_0: Control, T_1: $N_{150}P_{30}K_{60}S_{20}Zn_{3.0}$ (100%RDCF), T_2: $N_{105}P_{21}K_{42}S_{14}Zn_{2.1}$ (70%RDCF) T_3: $N_{75}P_{15}K_{30}S_{10}Zn_{1.5}$(50%RDCF) The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Among the soils, the highest *Boro* rice grain yield of 90.83 g pot^{-1} was found in S_2 (polluted soil-1) soil, and the lowest 41.66 g pot^{-1} in soil S_1 (Non-polluted soil). The treatment T_3(50% RDCF) fertilizer treatment gave the highest plant height (84.12 cm), effective tillers (42.5 hill^{-1}), straw (112.58g pot^{-1}) and grain yield (80.03g pot^{-1}) of *Boro* rice. The higher grain and straw yields of *Boro* rice were obtained from two industrially polluted soils (S_2 and S_4). The maximum grain yield (112.3g pot^{-1}) of *Boro* was found in S_2T_3 (Contaminated soil 1 and 50% RDCF) , which was statistically similar to S_4T_2 and S_4T_3 and lowest in the S_1T_0 treatment combination. The maximum T. *Aman* grain yield (38.75gpot^{-1}) was obtained in soil S_2 (polluted soil-1), which at par to S_4 (polluted soil-3). The maximum T. *Aman* rice grain yield (36.68 g pot^{-1}) was found in the T_2 treatment, which was closely by T_1 treatment. Similarly, the maximum T. *Aman* grain yield was obtained in S_2T_1 (Contaminated soil 1 and 100% RDCF) which was statistically similar to S_2T_2, S_4T_1, and S_4T_2 and lowest in the S_1T_0 treatment combination. The highest T. *Aman* straw yield was found in the S_3T_1 and lowest in the S_1T_0 treatment combination.

Introduction

Generally, industrial effluents contain several metals which are harmful to plants as well as animals. The effluents generated by textile industries contribute a substantial share of contaminants for pollution of the disposal areas. This problem is most severe in developing countries like Bangladesh. The situation in Bangladesh is too worse because of poor management and disposal of industrial effluents. Improper management and disposal of industrial effluents may cause tremendous negative impacts to our water, soil, crops, aquatic and wildlife, human, biodiversity, and environment.

There is a rapid establishment of textile and dyeing industries in many areas of Bangladesh. Bhaluka is one of the commercially important areas where industrial clusters have developed as part of the country's rapid economic growth. Although poultry farms, pharmaceutical industries, and a tannery have been established there, textile manufacturers, including dyeing and printing units, dominate the area (Chowdhury and Clemett, 2006). These industries provide employment, increase local incomes, and earn foreign exchange. But these industries have brought a range of problems, including serious environmental pollution. These industries discharge untreated effluents into the ecosystem, which local people depend on for their livelihoods. Industrial effluents contain appreciable amounts of trace metals, which may accumulate in the soil, thus creating a problem for the safe and rational utilization of agricultural soils (Chen *et al.*, 2005).

Industrial wastewater contains various toxic materials. At low concentrations, some trace elements (e.g., Cu, Mn, Ni, Se, and Zn, etc.) are essential for the healthy functioning and reproduction of microorganisms, plants, and animals, including man. However, at high concentrations, the same essential elements may pose toxicity. Trace elements are present naturally in the soil.Moreover, textile effluent is recognized as the top-ranked pollutant among all industrial sectors considering effluents' volume and composition (Vanndevivera *et al.*, 1998; Roy *et al.*, 2010). The disposal of textile effluents in crop fields decreased rice production which was responsible for environmental degradation (Setyorini *et al.*, 2002).

Usually, industrial effluents contain specific chemicals which pollute different water bodies and damages aquatic ecosystem (Moeller and Dade, 1992; Benard and Wright, 1998). It was also reported that industrial effluents were not encouraged for irrigation due to health hazards, which may harm crops and crop consumers (Ogedngbe and Akinbile, 2010). Disposal of textile effluents to crop fields decreased rice production and was responsible for environmental degradation (Setyorini *et al.*, 2002).

Most industries in Bangladesh seldom pass the effluent through water treatment plants; as a result, untreated industrial effluent floods the land, mostly rice fields surrounding the industries. Large amounts of external nutrient inputs in soil through industrial effluent and the unscientific use of fertilizers have contributed to low N and P use efficiency, resulting in serious soil degradation, eutrophication, groundwater pollution and the emission of ammonia and greenhouse gases (Qi *et al.* 2020).

The information's on crops grown in the industrially polluted soils of Bangladesh and appropriate fertilizer management is still lacking. Therefore, the study evaluated rice growth and yield in industrially polluted soils and assessed the effect of fertilizer management on the growth and yield of rice in industrially contaminated soils.

Materials and Methods

The experiment was conducted at Sher-e-Bangla Agricultural University net house from December 2018 to November 2019. The industrially polluted soils of the experiment belong to the AEZ No. 28, Madhupur Tract, in Bangladesh. The experiment was laid out in Randomized Complete Block Design with three replications. Considering the soil pollution intensity, four different soils were collected from Bhaluka industrially polluted rice growing areas. The soil texture, pH, % OC, and metal concentrations are mentioned in Table 1. There were 48 pots (4 fertilizer treatments x 4 industrially polluted soils x 3 replications) altogether, and 17 kg of soil was taken in each pot. The fertilizer treatments were used in this experiment based on BARC fertilizer recommendation guide, 2018. The required amount of inorganic fertilizers was used in this rice experiment. The initial soil samples were dried, powdered in a mill, and analyzed for nutrient content and physicochemical properties following standard methods. There were four fertilizer treatments, namely T_0: Control, T_1: $N_{150}P_{30}K_{60}S_{20}Zn_{3.0}$ (100% RDCF), T_2: $N_{105}P_{21}K_{42}S_{14}Zn_{2.1}$ (70% RDCF) T_3: $N_{75}P_{15}K_{30}S_{10}Zn_{1.5}$ (50% RDCF) in combination with 4 soils (S_1: Non-polluted soil, S_2: polluted soil-1, S_3: polluted soil-2, S_4: polluted soil-3). Traditional irrigation i.e., continuous flooding (2-3 cm water) was imposed during *Boro* and T. *Aman* rice growing period High-yielding popular rice var. BRRI dhan29 was used for *Boro* rice. Treatment-wise, required amounts of fertilizer were applied to both crops *Boro* and T. *Aman* rice. The required amount of TSP, MOP, gypsum, zinc sulphate, and one third urea was applied during the final pot preparation by considering the fertilizer treatments and weight of pot soil. The fertilizers were uniformly mixed in the soils of the pot.

The first crop var. BRRI dhan29 was transplanted in the first week of January 2019. Two seedlings were transplanted in each pot to make one hill, and intercultural operations were done as required. The crop was harvested at maturity on May 2019. The grains were separated from straw and filled and unfilled grains counted. The weights of grain and straw were recorded after drying.

After the harvest of *Boro* rice, the T. *Aman* rice (var. BRRI dhan33) was grown in the same pots to find out the residual effects of applied fertilizer to the previous crop (*Boro* rice) and newly treatment wise added fertilizer for T. *Aman* rice. The lower amounts of fertilizer were applied during T. *Aman* rice grows according to the recommended dose of chemical fertilizer ($N_{120}P_{20}K_{60}S_{10}Zn_{1.5}$). The data of yield parameters and yields were recorded.

After harvesting T. *Aman* rice, the yield and yield parameters were recorded. The data were analyzed with MSTAT-C. The initial soils were analyzed for soil organic matter, pH, total Cd, Pb, and Zn. Soil pH was measured by a glass electrode pH meter using a soil-water ratio of 1:2:5 (McLean, 1982). Organic matter content was estimated by the wet oxidation method (Nelson and Sommers, 1982). The Cd, Pb, and Zn concentrations in soil samples were determined by an atomic absorption spectrophotometer (Model: novAA400P, Brand: analytic jena) (Scott *et al.*, 1991) (Table 1).

For the determination of total Cd, Pb, and Zn concentrations, soil samples were digested using HNO_3 and $HClO_4$ and concentrations were determined by flame atomic absorption spectrophotometry. The higher levels of organic carbon, Cd and Pb were observed in the industrially polluted soils than non-polluted soils. The statistical analysis and the means were separated using Duncans Multiple Range Test as per Gomez and Gomez (1984).

Table 1. The physicochemical properties and Cd, Pb, and Zn concentrations in industrially polluted initial soils

Soils	Cd Conc. (ppm)	Pb Conc. (ppm)	Zn Conc. (ppm)	pH	% OC	Soil texture
S_1(Non-polluted Soils of industrial area)	0.52	1.91	59.0	6.4	0.76	Silt loam
S_2(Industrially polluted soil-1)	3.48	5.81	61.0	6.5	0.92	Silt loam
S_3(Industrially polluted soil-2)	3.68	6.03	64.0	6.4	1.03	Silt loam
S_4(Industrially polluted soil-3)	4.09	6.21	59.5	6.5	0.98	Silt loam

Results and Discussion

Effect of soil on the growth, yield parameters, and yield of *Boro* rice

The polluted soils significantly influenced the *Boro* rice yield parameters and straw yields (Table 2). The higher number of effective tillers hill^{-1} and panicle length were noticed in S_3 (polluted soil-2). The higher plant height, number of filled grains panicle^{-1}, thousand seed weight, and grain yield (g pot^{-1}) were found in S_2 (polluted soil-1), and lower values of the following yield parameters and yields were found in the non-polluted soil (S-1) (Table 2). The highest number of unfilled grains panicle^{-1} was obtained in S_3 (polluted soil-2) soil, This result indicates that grain unfilling increased due to industrial soil pollution. The maximum grain yield (90.83 g pot^{-1}) was found in S_2 (polluted soil-1), which was statistically similar to S_4 (polluted soil-3), and the lowest 67.87 g pot^{-1} in the S_1 (non-polluted soil). The highest straw yield (117.67 g pot^{-1}) was obtained in S_4 (polluted soil-

3), which was statistically similar to S_2 (polluted soil-1) and S_3 (polluted soil-2) soils and the lowest straw yield in the soil S_1 (Non-polluted soil). The higher and statistically similar grain and straw yields were obtained from three industrially polluted soils (S_2, S_3, and S_4).

Table 2. Effect of soil on growth, yield contributing parameters, and yield of *Boro* rice

Treatment	Effective tiller hill^{-1}	Non-Effective tillers hill^{-1}	Plant height (cm)	Panicle length (cm)	Filled grains panicle^{-1}	Un-filled grain	1000-grain wt. (g)	Straw yield (g)	Grain yield (g)
S_1	22.00c	2.92b	72.37c	23.74c	122.2a	35.5c	21.17ab	48.00b	41.658c
S_2	39.58b	3.92b	88.71a	26.95ab	136.0a	32.2c	22.00a	111.08a	90.825a
S_3	47.50a	5.92a	83.65b	27.30a	104.7b	75.7a	20.42b	112.17a	69.558b
S_4	39.33b	6.25a	84.12ab	26.15b	132.8a	44.4b	20.75ab	117.67a	90.525a
SE	1.62	0.24	1.10	0.22	3.48	1.93	0.30	2.77	2.52

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability

Here,S_1: Non-polluted soil, S_2: polluted soil-1, S_3: polluted soil-2, S_4: polluted soil-3

Effects of fertilizer on the growth, yield parameters, and yield of *Boro* rice

Different fertilizer treatments significantly affected the plant height, panicle length, effective tillers hill^{-1}, filled grains panicle^{-1}, 1000-grain weight, and grain and straw yields (g pot^{-1}) (Table 3).

Table 3. Effect of fertilizer on growth, yield contributing parameters, and yield of Boro rice

Treatment	Effective tiller hill^{-1}	Non-Effective tiller hill^{-1}	Plant height (cm)	Panicle length (cm)	Filled grains panicle^{-1}	Un-filled grain	1000-grain wt. (g)	Straw yield (g)	Grain yield (g)
T_0	28.25b	4.58b	78.50b	25.63	117.0a	43.8b	21.50	71.83c	63.058b
T_1	40.67a	6.42a	82.58ab	26.41	131.1a	54.4a	21.33	99.67b	73.575ab
T_2	37.00a	3.67b	84.96a	25.80	120.9a	43.5b	20.92	104.83ab	75.908a
T_3	42.50a	4.33b	82.82ab	26.30	126.7a	46.0ab	20.58	112.58a	80.025a
SE	1.62	0.24	1.10	0.22	3.48	1.93	0.30	2.77	2.52

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability

Here, T_0: Control, T_1: $N_{150}P_{30}K_{60}S_{20}Zn_{3.0}$ (100%RDCF), T_2: $N_{105}P_{21}K_{42}S_{14}Zn_{2.1}$ (70%RDCF) T_3: $N_{75}P_{15}K_{30}S_{10}Zn_{1.5}$ (50%RDCF)

The higher number of non-effective tillers pot^{-1} (6.42), filled grains panicle^{-1} (131.1), un-filled grains panicle^{-1} (54.4), and panicle length (26.41 cm) were found in the T_1 treatment where 100% RDCF was applied. The treatment T_2 (70 % RDCF) fertilizer gave the maximum plant height (84.96 cm) which was, statistically similar to all other treatments except the control. The maximum number of effective tillers hill^{-1} (42.50), straw (112.58g pot^{-1}), and grain yield (80.03g pot^{-1}) were obtained in fertilizer treatment T_3 (50% RDCF), which was statistically similar to T_2 (70 % RDCF) and T_1 (100 % RDCF) treatments.

The results indicate that application of lower levels of fertilizer (50% RDCF or 70% RDCF) performed better for increasing *Boro* rice yield in industrially polluted soils may be due to higher organic matter, nutrient, beneficial and toxic elements supplying capacity of industrially polluted soils.

Continuous use effluents in the industrially polluted soils for rice production could result in accumulation elements in the concentrations (Ghafoor et al., 1999). Polluted soils can supply more N, P and K and also valuable micronutrients than what crops require (Panicker, 1995) and crops gave higher yields in this study where 50% RDCF or 70 % RDCF were applied.

Interaction effects of fertilizer and manure on the growth, yield parameters, and yield of *Boro* rice

The plant height, panicle length, effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, and grain and straw yields of *Boro* rice were significantly influenced by the interaction effects of soil and fertilizer treatments (Table 4). The maximum number of effective tillers hill^{-1} (47.33) was found in S_3T_3 (polluted soil 2 and 50% RDCF) , which was statistically similar to S_4T_2, S_4T_1, S_3T_2, S_3T_1, S_2T_3, and S_2T_1 treatment combinations. All industrially polluted soils produced a higher number of tillers than non-polluted soils with different fertilizer treatments. The maximum plant height (91.47cm) was noticed in the S_2T_2 , which was statistically and closely similar to S_2T_1, S_2T_3, S_3T_2, S_3T_3, S_4T_1, S_4T_2, and S_4T_3 treatment combinations. Similar to the number of effective tillers hill^{-1}, all industrially polluted soils produced higher plant height than non-polluted soils with different fertilizer treatments.

Table 4. Effects soil and fertilizer on growth, yield contributing parameters, and yield of *Boro* rice

Treatments	Effective tiller hill^{-1}	Non-Effective tiller hill^{-1}	Plant height (cm)	Panicle length (cm)	Filled grains panicle^{-1}	Un-filled grains panicle^{-1}	1000-grain wt. (g)	Straw yield (g)	Grain yield (g)
$S_1 \times T_0$	16.67f	2.67	71.23ef	23.47fg	104.4ef	32.5f	22.33	36.33g	31.00 f
$S_1 \times T_1$	26.33ef	4.33	75.87d-f	24.93def	161.8a	28.9f	20.67	66.33 f	63.63e
$S_1 \times T_2$	18.67f	2.33	72.21d-f	22.33g	102.7ef	34.6ef	21.00	42.00g	38.93f
$S_1 \times T_3$	26.33ef	2.33	70.17f	24.21ef	120.0c-e	46.1de	20.67	47.33g	33.07f
$S_2 \times T_0$	33.00de	3.67	85.20a-c	26.40a-d	118.7c-e	33.3ef	22.33	78.33def	72.17de
$S_2 \times T_1$	45.33abc	5.33	90.20a	27.20ab	135.3bc	32.5f	22.67	142.00ab	104.60a
$S_2 \times T_2$	32.67de	3.67	91.47a	27.23ab	145.1ab	33.5ef	21.67	92.67de	74.23de
$S_2 \times T_3$	47.33a-c	3.00	87.97a	26.97ab	144.9ab	29.5f	21.33	131.33bc	112.30a
$S_3 \times T_0$	38.33cd	5.67	79.43b-d	27.47ab	119.7c-e	77.2b	20.00	96.67d	85.60cd
$S_3 \times T_1$	46.33a-c	8.00	76.73d-f	26.73a-c	89.1f	91.1a	20.67	40.33g	30.53f
$S_3 \times T_2$	50.33ab	4.33	89.58a	27.18ab	106.4d-f	56.9cd	20.67	159.33a	86.87b-d
$S_3 \times T_3$	55.00a	5.67	88.87a	27.83a	103.7ef	77.5b	20.33	152.33a	75.23de
$S_4 \times T_0$	25.00ef	6.33	78.14c-e	25.20c-e	125.3b-e	32.3f	21.33	76.00ef	63.47e
$S_4 \times T_1$	44.67a-c	8.00	87.51a	26.77ab	138.1a-c	65.1bc	21.33	150.00a	95.53a-c
$S_4 \times T_2$	46.33a-c	4.33	86.57ab	26.47a-d	129.5b-d	49.1d	20.33	125.33bc	103.60ab
$S_4 \times T_3$	41.33b-d	6.33	84.27a-c	26.17b-d	138.3a-c	30.9f	20.00	119.33c	99.50a-c
SE	3.24	0.48	2.19	0.44	6.95	3.85	0.61	5.55	5.03
CV(%)	15.14	17.42	4.62	2.95	9.72	14.21	4.98	9.88	11.93

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability

Here,S_1: Non-polluted soil, S_2: polluted soil-1, S_3: polluted soil-2, S_4: polluted soil-3; , T_0: Control, T_1: $N_{150}P_{30}K_{60}S_{20}Zn_{3.0}$ (100%RDCF), T_2: $N_{105}P_{21}K_{42}S_{14}Zn_{2.1}$ (70%RDCF) T_3: $N_{75}P_{15}K_{30}S_{10}Zn_{1.5}$ (50%RDCF)

Similarly, the maximum panicle length (27.83cm) was obtained in S_3T_3 (polluted soil 2 and 50% RDCF) treatment combination, which was statistically similar to S_3T_2, S_3T_1, S_2T_1, S_2T_2,

S_2T_3, S_4T_1, and S_4T_2 treatment combinations. The highest grains panicle^{-1} (161.8) was obtained in S_1T_1 (non-polluted soil and 100% RDCF), which was statistically comparable to S_4T_1, S_2T_2, S_2T_3 and S_4T_1 treatment combinations, and it indicates that the numbers of filled grains panicle^{-1} were increased in non-polluted soils. The highest number of unfilled grains panicle^{-1} (91.1) and non-effective tillers hill^{-1} were obtained in S_3T_1 and S_4T_1 treatment combinations, and it proves that the application of higher amounts of fertilizers in polluted soils increases the number of non-effective tillers and unfilled grains panicle^{-1}.

The highest straw yield (159.3 g pot^{-1}) was found in S_3T_2 (Contaminated soil 2 and 70% RDCF) , which was statistically similar to S_2T_1, S_3T_3, and S_4T_1 and lowest in S_1T_0 treatment combination. The maximum grain yield (112.30 g pot^{-1}) was found in S_2T_3 (Contaminated soil 1 and 50% RDCF) which was statistically comparable to S_2T_1, S_4T_1, S_4T_2, and S_4T_3 and lowest in S_1T_0 treatment combination.

The higher *Boro* rice yields were obtained in industrially polluted soils with different fertilizer treatments compared to non-polluted soil S_1. These results indicate that applying lower levels of inorganic fertilizers on polluted soils increased the grain and straw yields of *Boro* rice, and 70 or 50% recommended dose of chemical fertilizer performed better in different industrially polluted soils.

The increase in organic matter and nitrogen after wastewater addition would be beneficial for soil fertility. Many investigations, including long and short-term studies, showed that soil fertility increases as a consequence of the application of wastes (Bernal et al., 1993; Chakrabarti, 1995) in industrially polluted soils and this findings support the results of the present experiment where higher yields were obtained in industrially polluted soils by using 70 or 50% recommended dose of chemical fertilizer.

Effects of soil on the growth, yield parameters, and yield of T. *Aman* rice

The plant height, panicle length, effective tillers hill^{-1}, non-effective tillers hill^{-1}, filled grains panicle^{-1}, grain and straw yield of T. *Aman* rice were affected by different soils (Table 5).

Table 5. Effect of soil on growth, yield parameters, grain and straw yield of T. *Aman* rice

Treatment	Effective tiller number hill^{-1}	Non-Effective tiller number hill^{-1}	Plant height (cm)	Panicle length (cm)	Filled grains panicle^{-1}	Un-filled grain panicle^{-1}	Straw yield (g)	Grain yield (g)
S_1	14.83c	1.33ab	101.36	24.38a	96.33a	37.35d	27.53b	21.60b
S_2	24.00b	1.42ab	101.83	24.09ab	86.02b	50.27c	53.93a	38.75a
S_3	29.50a	1.00b	99.13	22.86b	42.85c	69.99a	54.19a	23.28b
S_4	24.50b	1.58a	99.77	24.11ab	83.09b	61.86b	47.48a	37.00a
SE	0.43	0.11	1.32	0.32	1.75	1.53	1.56	1.14

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability ,Here,S_1: Non-polluted soil, S_2: polluted soil-1, S_3: polluted soil-2, S_4: polluted soil-3,

The highest panicle length (24.38 cm) and filled grains panicle^{-1}(96.33) were found in soil-1 (non-polluted soil). The highest number of effective tillers hill^{-1}(29.50), un-filled grain panicle^{-1} (69.99) and straw yields (54.19 g pot^{-1}) were found in soil S_3 (polluted soil 2).

The highest plant height (101.83 cm) and grain yield (38.75 g pot^{-1}) were obtained in soil S_2 (polluted soil-1), and the highest grain yield was closely and statistically similar to the grain yield of soil S_4 (polluted soil 3). Like *Boro* rice, the higher grain yields were found in industrially polluted soils.

Effects of fertilizer on the growth, yield parameters, and yield of T. *Aman* rice

The plant height, panicle length, effective tillers hill^{-1}, non-effective tillers hill^{-1}, filled grains panicle^{-1}, and grain and straw yields (g pot^{-1}) were affected by different fertilizer treatments. The higher number of filled grains panicle^{-1}(97.26) and straw yield were noticed in T_1 (100% RDCF) treatment. The highest straw yield (52.57 g pot^{-1}) was statistically similar to all other fertilizer treatments except the control. The significantly different and the highest panicle length (24.82 cm), number of effective tillers hill^{-1} (25.83), and grain yield (36.68 g pot^{-1}) were found in T_2 treatment where 70% RDCF was used. The highest grain yield was statistically similar to the T_1 treatment (100% RDCF), and the lowest yield in the T_0 treatment. The single effect of fertilizer treatments shows that T_2 (70% RDCF) was suitable for industrially polluted soils.

Table 6. Effect of fertilizer on growth, yield parameters, and yield of T. *Aman* rice

Treatment	Effective tiller hill^{-1}	Non-Effective tiller hill^{-1}	Plant height (cm)	Panicle length (cm)	Filled grains panicle^{-1}	Un-filled grain panicle^{-1}	Straw yield (g)	Grain yield (g)
T_0	17.50b	1.17	96.56b	22.48b	57.53c	58.09a	31.17b	17.86c
T_1	24.92a	1.17	107.02a	24.35a	97.26a	47.68b	52.87a	36.63a
T_2	25.83a	1.50	101.70ab	24.82a	79.98b	55.55a	51.76a	36.68a
T_3	24.58a	1.50	96.82b	23.79ab	73.52b	58.15a	47.33a	29.47b
SE	0.43	0.11	1.32	0.32	1.75	1.53	1.56	1.14

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability

Here, T_0: Control, T_1: $N_{150}P_{30}K_{60}S_{20}Zn_{3.0}$ (100%RDCF), T_2: $N_{105}P_{21}K_{42}S_{14}Zn_{2.1}$ (70%RDCF) T_3: $N_{75}P_{15}K_{30}S_{10}Zn_{1.5}$ (50%RDCF)

Interaction effects of soil and fertilizer on the growth, yield parameters and yield of T. *Aman* rice

The plant height, panicle length, effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, and grain and straw yields were significantly influenced by the interaction effects of soil and fertilizer treatments (Table 7).

The maximum number of effective tillers hill^{-1} (33.0) was found in the S_3T_2 , which was statistically similar to the S_3T_1 , and the highest plant height (116.47 cm) was observed in the S_2T_1 treatment combination.The highest panicle length (25.73 cm) and grain yield were obtained in S_2T_1 (Contaminated soil 1 and 100% RDCF) treatment combination. The maximum number of filled grains panicle^{-1}(112.6) was recorded in S_1T_1 (non-polluted soil and 100% RDCF), which was statistically comparable to S_1T_2, S_1T_3, S_2T_1, and S_4T_1, and the lowest in S_1T_0 treatment combinations.

The highest number of unfilled grains panicle^{-1} (73.73) was observed in S_3T_3 (polluted soil 2 and 50% RDCF) treatment combination, which was statistically comparable to S_2T_3, S_3T_0, S_3T_1, S_3T_2, S_4T_0 and S_4T_1 treatment combinations and lowest unfilled grains panicle^{-1} in S_1T_1 . Similarly, the highest number of non-effective tillers hill^{-1} (2.0) was recorded in the S_2T_3 and lowest in the S_1T_1 treatment combination.

Table 7. Interaction effect of soil and fertilizer on growth, yield parameters, and yield of T. Aman rice

Treatment	Effective tiller hill^{-1}	Non-Effective tiller hill^{-1}	Plant height (cm)	Panicle length (cm)	Filled grains Panicle^{-1}	Un-filled grain panicle^{-1}	Straw yield (g)	Grain yield (g)
$S_1 \times T_0$	9.67h	1.00b	90.70ef	21.37e	49.80f	52.67e	13.80	8.60f
$S_1 \times T_1$	16.00g	1.00b	103.00bc	23.70b-d	112.60ab	24.53g	32.90	23.87de
$S_1 \times T_2$	16.67fg	1.67ab	105.53b	27.73a	120.13a	36.00f	31.57	27.90cd
$S_1 \times T_3$	17.00fg	1.67ab	106.20b	24.70bc	102.80b	36.20f	31.83	26.03cd
$S_2 \times T_0$	19.00f	1.00b	102.40b-d	22.03de	61.93e	49.67e	43.43	25.50d
$S_2 \times T_1$	24.67de	1.00b	116.47a	25.73ab	122.33a	30.27fg	57.07	50.37a
$S_2 \times T_2$	27.33cd	1.67ab	104.00bc	24.43bc	86.93c	54.73de	62.77	45.60a
$S_2 \times T_3$	25.00de	2.00a	84.47f	24.17b-d	72.87de	66.40a-c	52.47	33.53bc
$S_3 \times T_0$	23.00e	1.00b	93.40de	23.30c-e	42.40f	65.00a-d	38.97	20.57de
$S_3 \times T_1$	32.33ab	1.00b	102.93bc	23.26c-e	49.32f	69.70ab	63.83	24.40de
$S_3 \times T_2$	33.00a	1.00b	101.20b-d	22.09de	39.60f	71.53a	59.20	26.80cd
$S_3 \times T_3$	29.67bc	1.00b	99.00b-e	22.80c-e	40.07f	73.73a	54.77	21.37de
$S_4 \times T_0$	18.33fg	1.67ab	99.73b-e	23.23c-e	75.97cd	65.03a-d	54.77	16.77e
$S_4 \times T_1$	26.67d	1.67ab	105.67b	24.70bc	104.80b	66.20a-c	57.67	47.87a
$S_4 \times T_2$	26.33d	1.67ab	96.07c-e	25.00bc	73.27de	59.93b-e	53.50	46.43a
$S_4 \times T_3$	26.67d	1.33ab	97.60b-e	23.50b-e	78.33cd	56.27c-e	50.27	36.93b
SE	0.85	0.22	2.63	0.64	3.50	3.07	3.12	2.27
CV (%)	6.36	19.05	4.53	4.67	7.87	9.69	11.82	13.05

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability

Here,S_1: Non-polluted soil, S_2: polluted soil-1, S_3: polluted soil-2, S_4: polluted soil-3; , T_0: Control, T_1: $N_{150}P_{30}K_{60}S_{20}Zn_{3.0}$ (100%RDCF), T_2: $N_{105}P_{21}K_{42}S_{14}Zn_{2.1}$ (70%RDCF) T_3: $N_{75}P_{15}K_{30}S_{10}Zn_{1.5}$ (50%RDCF)

These results indicated that industrially polluted soils gave more non-effective tillers hill^{-1} and unfilled grains panicle^{-1} with different fertilizer treatments.

The highest straw (63.83 g pot^{-1}) yield was found in the S_3T_1 treatment and the lowest in the S_1T_0 treatment combination. Similar to *Boro* rice, higher grain yields were recorded in industrially polluted soils with different fertilizer treatments. The highest grain yield (50.37 g pot^{-1}) was found i, which was statistically similar to S_2T_2, S_4T_1, and S_4T_2 and lowest in the S_1T_0 treatment combination.

The waste water addition may increase soil fertility. Many investigations, showed that soil fertility increases as a consequence of the application of industrial wastes (Hart and Speir, 1992; Navas et al., 1998) and similar findings were obtained in the present study where higher yields were obtained in industrially polluted soils in comparison to non-polluted soil S-1

Conclusion

Boro and T. *Aman* rice yield parameters and yields varied with polluted soils and fertilizer treatments. The higher yields of *Boro* and T. *Aman* rice were obtained in three industrially polluted soils compared to one non-polluted soil of the same industrial areas of Bhaluka. The highest *Boro* and T. *Aman* rice yields were found in polluted soil-1 and the lowest in non-polluted soil. The single effect of fertilizer treatment T_1 (100% RDCF) performed better in non-polluted soil (S_1), but the application of reduced levels of fertilizer treatments70% RDCF and 50% RDCF performed better in polluted soils for increasing the yield of *Boro* and T. *Aman* rice. The higher number of tillers $hill^{-1}$, non-effective tillers $hill^{-1}$, plant height, panicle length, unfilled grains $panicle^{-1}$, grain and straw yields were found in three polluted soils compared to one non-polluted soil with different fertilizer treatments. The highest *Boro* and T. *Aman* rice grain yield were found in the contaminated soil-1 and 50% RDCF and contaminated soil-1 and 100% RDCF treatment combinations, respectively, and the lowest in the control treatment combination. The highest T. *Aman* rice yield in the combination of contaminated soil-1 and 100% RDCF was closely similar to the combination of contaminated soil-3 and 70% RDCF and the combination of contaminated soil-3 and 70% RDCF treatment combinations. Similarly, the higher yields of *Boro* and T. *Aman* rice were observed in three polluted soils with different fertilizer treatments. The application of reduced amounts of fertilizer treatments 50% RDCF or 70%RDCF could be suggested for industrially polluted soils of Bhaluka areas.

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