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ASSESSING THE HAZARDOUS IMPACTS OF CHROMIUM ON GROWTH AND YIELD OF BORO RICE

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ABSTRACT

The experiment was conducted at the net house of Agro-environmental Chemistry Laboratory of the Department of Agricultural Chemistry of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from December 2016 to May 2017. The study was undertaken to evaluatethe toxic effect of chromium on growth, yield and nutritional attributes of BRRI dhan69 and BRRI dhan74. The experiment comprised of two factors, Factor A: two rice cultivars i.e. V_1= BRRI dhan69, V_2= BRRI dhan74; and six levels of Cr application i.e. T_1= 0 mg Cr/kg soil, T_2= 12.5 mg Cr/kg soil, T_3= 25 mg Cr/kg soil, T_4= 50 mg Cr/kg soil, T_5= 75 mg Cr/kg soil, T_6 =100 mg Cr/kg soil. The experiment was laid out in Completely Randomized Design (CRD) with four replications. Data on different growth parameters, yield attributes, yield and Cr contents were recorded and analyzed. The control treatment attributed the highest values of vegetative growth, yield and yield contributing character, and nutrient content (P, K, S and Na) with V_2 variety. Data revealed that the tallest plant was found in T_1V_1 and shortest plant was found in T_6V_1 combination also similar trends found in other character. The grain yield of rice ranges from 5.02 t ha^{-1} to 8.13 t ha^{-1} while T_1V_2 produced the highest grains yield and T_1V_6 produced lowest grains yield. The highest chromium content was found in T_6V_2. In case of root, there was no value of chromium was found. This might be due to that, applied chromium was transferred from root to grain and straw.

Key words: Chromium, growth, yield, BRRI dhan69, BRRI dhan74.

Introduction

Chromium (Cr) is the 17th most abundant element in the Earth's mantle (Avudainayagam *et al*., 2003). Due to this wide anthropogenic uses of Cr, the consequent environmental contamination increased and has become an increasing concern in the last years (Zayed and Terry, 2003). Cr (VI) in the forms of chromate (CrO_4^{2-}), dichromate (CrO_4^{2-}), and CrO_3 is considered the most toxic forms, as it presents high oxidizing potential, high solubility, and mobility across the membranes in living organisms and in the environment. Cr (III) in the forms of oxides, hydroxides, and sulphates is less toxic as it is relatively insoluble in water, presents lower mobility, and is mainly bound to organic matter in soil and aquatic environments. Moreover, Cr (III) forms tend to form hydroxide precipitates with Fe at typical ground water pH values. With increasing worldwide industrialization and rapid urbanization, pollution of trace metals (i.e., heavy metals) in the terrestrial environment has become a global problem (Lee *et al*., 2006). Therefore, many regulatory bodies in different countries, such as the Ministry of Health of China, the United States Environment Protection Agency (US EPA), the Food and Agriculture Organization (FAO) and Word Health Organization (WHO) of United Nations, have strictly regulated the maximum permitted concentrations of toxic trace metals in foodstuffs. For Chromium (Cr), the maximum permissible limit in rice grain is 1 mg kg^{-1} in China, and such standards have the force of law. The harmfulness of chromium to the soil-plant system has been identified by scientists and aroused public attention. Zayed *et al*. (2010) investigated the uptake and accumulation of Cr^{3+} and CrO_4^{2-} by 11 vegetable species. Chromium contamination in rice grain is a serious threat to human health especially for those with a rice based food diet. Therefore, defensive measures are needed to decrease uptake of Cr to reduce the risk of health hazards in response to Cr-polluted field. The changes of antioxidant enzymes activities, photosynthetic rate and growth of rice cultivars are reduced by Cr toxicity. The differences in acceptance of different cultivars against Cr toxicity provide a base to study the effects of Cr tolerance in crops.

Materials and Methods

The study was conducted at the net house and laboratory of Agro-Environmental Chemistry Laboratory of Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka. The location of the site is $23^0 74'$N latitude and $90^0 35'$E longitude with an elevation of 8.2 meter from sea level. The soil belongs to "The Modhupur Tract", AEZ-28 (FAO, 1988). In this research work, two inbreed varieties i.e. BRRI dhan69 and BRRI dhan74 were used as plant materials. The seeds were collected from the Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh. The experiment comprised of two factors, Factor A: two rice cultivars i.e. V_1= BRRI dhan69, V_2= BRRI dhan74; and six levels of Cr application i.e. T_1= 0 mg Cr/kg soil, T_2= 12.5 mg Cr/kg soil, T_3= 25 mg Cr/kg soil, T_4= 50 mg Cr/kg soil, T_5= 75 mg Cr/kg soil, T_6 =100 mg Cr/kg soil. The experiment was laid out in Completely Randomized Design (CRD) with four replications. The layout of the experiment was prepared for distributing the varieties and Cr concentration. Seed were sown in the seed bed @ 70 g m^{-2} on 01 November, 2016 and The seedlings were transplanted in the main field on December 14, 2016. The pots were filled with soil of the central experiment field. Weeds free soil was used and before transplanting the seedling herbicide was also applied. Fertilizers are applied according to BRRI, 2013 recommended dose. Whole amount of cow-dung, TSP, MP, Gypsum and Zinc and one third of urea were applied at the time of final pots preparation. Half of the rest two third of urea was applied at 20 DAT and the rest amount of urea was applied at 45 DAT. After transplanting all intercultural operations viz. Irrigation and drainage, Gap filling, Weeding, Application of pesticides and other were carried out on time. The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each pot. Maturity of crop was determined when 80-90% of the grains become golden yellow in color.

Cr analysis: Total chromium concentrations were determined from the digest by Analytik Jena GmbH - novAA 400 P - fully automated AAS spectrometer (Analytik Jena, 2017, country of origin: Germany).

Statistical Analysis: The data obtained for different characters were statistically analyzed using statistics 10 software to observe the significant difference among the treatment. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatment means were estimated by the Tukey's test at 5% level of probability.

Results and Discussion

Plant height: The interaction effect of chromium and variety produced statistically significant plant height at all sampling dates. The interaction effect the height of rice plant ranges from 39.25 to 45.25, 65.50 to 83.75, 75.00 to 96.25 and 76.25 to 97.75 cm at 30 DAT, 60 DAT and 90 DAT and harvest time, respectively. The tallest plant was found from BRRI dhan74 produced in control treatment (T_1V_2) and the shortest plant was found in BRRI dhan69 cultivated with highest amount of Cr (T_6V_1) combination compared to the others combination (Table 1).

Number of tillers hill^{-1}: The interaction effect of chromium and variety showed non-significant impact on number of tillers hill^{-1}. In spite of having non-significant effect, the number of tillers hill^{-1} ranges from 16.00 to 19.25, 34.00 to 45.25, 48.25 to 65.00 and 57.75 to 63.25 at 30 DAT, 60 DAT, 90 DAT and harvest time, respectively while T_1V_1 produced the maximum number of tillers and T_6V_1 produced minimum number of tillers (Table 2).

Number of effective tillers hill^{-1}: The interaction effect of chromium and variety showed significant impact ($p \leq 0.05$) on number of effective tillers hill^{-1}.The number of effective tillers hill^{-1} ranges from 25.75 to 42.25 while T_1V_1 produced the maximum number of effective tillers and T_6V_1 produced the minimum tillers i.e. effective tillers hill^{-1} was significantly decreased with higher amount of Cr (Table 3).

Panicle length: Combined effect of chromium and variety showed positively significant variations on panicle length of rice (Table 3). The T_1V_2 produced the height value of panicle length and the combination T_6V_1 produced the lowest value of panicle length. The panicle length ranges from 20.25 cm to 34.00 cm.

Weight of 1000 grains: For combined effect, the 1000 grains weight ranges from 30.75 g to 22.25 g. The highest 1000 grains weight found in T_1V_2 and lowest 1000 grains weight was found in T_6V_1 combination compared to the others combination.

Yield: Combined effect of chromium and variety showed positively significant variations on grains yield of rice (Table 3).The grain yield of rice ranges from 5.02 t ha^{-1} to 8.13 t ha^{-1} while T_1V_2 produced the highest grains yield and T_1V_6 produced lowest grains yield.

Chromium content: Combined effect of chromium and variety showed positively significant impact on chromium content (Table 4). The values of chromium content were ranges from 0.000 to 0.363 and 0.178 to 0.422 ppm while T_1V_1 produced the lowest value of chromium content in grain and straw, respectively. The highest chromium content was found in T_6V_2. In case of root, there was no value of chromium was found. This might be due to that, applied chromium was transferred from root to grain and straw.

Table 1. Combined effect of chromium and variety on plant height

Treatment	Plant height (cm) at			
	30 DAT	60 DAT	90 DAT	Harvest
T_1V_1	41.25 bc	74.75 b	87.75	88.00 bcd
T_2V_1	40.50 bc	72.75 bc	85.00	86.00 cde
T_3V_1	40.50 bc	70.00 cd	83.25	84.50 ef
T_4V_1	39.50 bcd	65.50 e	81.00	82.25 f
T_5V_1	38.00 d	69.00 d	77.75	78.25 g
T_6V_1	38.00 d	65.75 e	75.00	76.25 g
T_1V_2	45.25 a	83.75 a	96.25	97.75 a
T_2V_2	41.75 b	82.75 a	95.00	96.75 a
T_3V_2	41.25 bc	65.50 e	90.75	90.00 b
T_4V_2	39.25 cd	70.25 cd	88.75	89.00 bc
T_5V_2	40.00 bcd	65.75 e	86.00	87.00 bcde
T_6V_2	39.75 bcd	66.00 e	84.25	85.75 de
SE (±)	0.68	0.83	NS	0.91
Level of significance	**	**	NS	*
CV (%)	2.39	1.66	-	1.48

Table 2. Combined effect of chromium and variety on number of tillers $hill^{-1}$

Treatment	Number of tiller at			
	30 DAT	60 DAT	90 DAT	Harvest
T_1V_1	19.25	45.25	65.00	65.00
T_2V_1	17.50	43.50	62.25	62.25
T_3V_1	18.25	39.00	58.50	58.50
T_4V_1	17.25	38.25	56.50	56.50
T_5V_1	16.75	36.00	54.25	54.25
T_6V_1	16.00	34.00	49.25	49.25
T_1V_2	22.75	46.50	64.75	64.75
T_2V_2	19.75	42.00	60.50	60.50
T_3V_2	19.00	41.75	59.50	59.50
T_4V_2	19.00	38.75	55.75	55.75
T_5V_2	17.50	36.25	53.75	53.75
T_6V_2	16.25	34.75	48.25	48.25
SE (±)	NS	NS	NS	NS
Level of significance	NS	NS	NS	NS
CV (%)	-	-	-	-

DAT= Day after transplanting

T_1= 0 mg Cr/kg soil, T_2= 12.5 mg Cr/kg soil, T_3= 25 mg Cr/kg soil, T_4= 50 mg Cr/kg soil, T_5= 75 mg Cr/kg soil, T_6 =100 mg Cr/kg soil; V_1= BRRI dhan69, V_2= BRRI dhan74.

Table 3. Combined effect of chromium and variety on yield and yield attributes of boro rice

Treatment	Number of effect tiller	Panicle length (cm)	1000 grain weight (g)	Yield (t ha^{-1})
T_1V_1	42.25 ab	28.00 d	27.75 bc	7.54 abcd
T_2V_1	38.75 cd	26.75 de	26.00 cd	7.31 abcd
T_3V_1	36.75 def	25.25 fg	25.00 de	7.12 bcd
T_4V_1	35.00 ef	24.00 gh	23.50 ef	6.89 cd
T_5V_1	30.50 g	23.00 hi	23.00 f	6.45 d
T_6V_1	25.75 h	20.25 j	22.25 f	5.02 e
T_1V_2	43.50 a	34.00 a	30.75 a	8.13 ab
T_2V_2	40.00 bc	31.50 b	28.25 b	7.96 abc
T_3V_2	39.25 cd	29.50 c	26.50 bcd	7.65 abc
T_4V_2	37.75 cde	26.50 ef	25.00 de	7.18 bcd
T_5V_2	34.50 f	22.75 hi	23.50 ef	8.36 a
T_6V_2	30.25 g	21.75 i	23.00 f	6.43 d
SE (±)	0.83	0.42	0.52	3.33
Level of sig.	*	*	*	*
CV (%)	3.27	2.3	2.93	6.58

Table 4. Combined effect of chromium and variety on chromium content

Treatment	Chromium content (ppm)		
	Grain	Straw	Root
T_1V_1	0.000 d	0.000	0.000
T_2V_1	0.000 d	0.222 i	0.000
T_3V_1	0.000 d	0.261 g	0.000
T_4V_1	0.000 d	0.305 f	0.000
T_5V_1	0.144 c	0.354 d	0.000
T_6V_1	0.192 c	0.385 c	0.000
T_1V_2	0.000 d	0.242 h	0.000
T_2V_2	0.000 d	0.262 g	0.000
T_3V_2	0.000 d	0.321 e	0.000
T_4V_2	0.181 c	0.352 d	0.000
T_5V_2	0.283 b	0.392 b	0.000
T_6V_2	0.363 a	0.422 a	0.000
SE (±)	0.0216	5.7840	-
Level of significance	*	*	-
CV (%)	31.40	0.27	-

T_1= 0 mg Cr/kg soil, T_2= 12.5 mg Cr/kg soil, T_3= 25 mg Cr/kg soil, T_4= 50 mg Cr/kg soil, T_5= 75 mg Cr/kg soil, T_6 =100 mg Cr/kg soil; V_1= BRRI dhan69, V_2= BRRI dhan74.

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