Journal of
Environmental & Analytical Toxicology

Ghani, et al., J Environ Anal Toxicol 2015, 5:3
DOI: 10.4172/2161-0525.1000273

Research Article | Open Access

Response of Wheat (*Triticum aestivum*) to Exogenously Applied Chromium: Effect on Growth, Chlorophyll and Mineral Composition

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Abstract

Heavy metals are very dangerous to environment and harm to all living organisms e.g. plants and animals etc. They enter the plant through soil and damage the internal mechanisms of plants. Chromium is very toxic to plants as well as animals. It has negative influences on plant growth, mineral nutrients and chlorophyll contents.

Increasing its concentration causes reduction in plant growth, Chlorophyll contents and mineral nutrients in Wheat (*Triticum aestivum L.*). All the parameters were found to be reduced if there is increase in the concentration of chromium.

Keywords: Plant growth; Chlorophyll; Mineral nutrients; Wheat (*Triticum aestivum* L.) mechanism.

Introduction

Chromium is very toxic Heavy metal to living bodies and dangerous to human health and plant vegetation's. Pollution of the environment is increasing with increase in the world population. Plant material consumes the chromium and it enters the food chain in this way. High concentrations of chromium were found to be very toxic to vegetation. Sometime excess concentration of chromium cause barren land but on the other hand in different countries, chromium is used on large scale including chemical Production, paper and pulp production, tanning, wood preservation, electroplating, production of pigments and in metallurgy [1]. These industries [2] have a major role in the spreading of Cr pollution which create serious threats to living creature both animals and plants. Chromium phytotoxicity has adverse effects on the growth parameters of plants such as stoppage of early seedling development, decrease in biomass, reduction in root growth and chlorosis (1995).There were many studies were concluded on chromium toxicity in crop plants. All the mechanisms of plants such as photosynthesis, respiration and defensive mechanisms etc were significantly affected by Chromium [3].

There are two sources through which chromium becomes available to the environment, natural and anthropogenic, burning of oil and coal, fertilizers, oxidants, metal plating tanneries, chromium steel and oil well drilling [4]. It is highly toxic metal to plants and microorganisms [5]. Different types of enzymes such as catalases, peroxidases, reductases are affected by chromium.

Lose of chlorophyll and accidental death of plant tissues and organs occur by chromium toxicity [5]. When there is direct contact of metal with cellular components then variety of metabolic responses leading to shift in the growth of plants [6]. Soil quality decreases due to accumulation of chromium in the soil and soil unable to produce yielding in normal quantity. Most of the soil nutrients are not easily available to plants for the development of new organs and production of yield. Toxic material transfer from one place to other through discharging from factories into water streaming and damage the water life including algae, fungi, phytoplankton's and other microorganisms [7].

Material and Method

The seeds of Wheat (*Triticum aestivum* L.) were sown in earthen pots which were filled with loamy soil. Eight (08) seeds were sown in each pot and five plants were kept after germination in each pot for thinning process. Soil water applied to the plants when required. Completely randomize designs were made for the experiment with three replicates. To eliminate the experimental bias the treatments were randomized. Eight levels of chromium 3, 6, 9, 12,15, 18, 21, 24 ppm per kg soil with distilled water and applied to wheat 15 days old seedlings which were grown in the soil with pH 8. No plant survived beyond 24 ppm because chromium level selected for this study were 0 (control) 6, 12, 18 and 24 ppm. Normal growth conditions were provided to plants for their germination. These levels of chromium were applied to Wheat (*Triticum aestivum* L.) seedlings and plants were grown for 15 days after treatment application before harvest. The composition of nutrients follows: as Ca (NO_3)3.4 mM; KNO_3 5 mM; $MgSO_4$-2 mM, KH_2PO_4-1.02 mM; as ppm–H_3BO_3 92.2 µM; $MnSO_4$ 2.19 µM, $ZnCl_2$ 1.62 µM $CuSo_4$ 0.69 µM, Na_2MoO_4; 0.29 µM Na-Fe-EDTA 0.15 µM each. All the salts were dissolved and mixed after autoclaving separately. Final pH of the solution was adjusted as 6.7.

Chlorophyll (a, b, and total) analysis

By using the formula of the pigment contents of 15 days old plants were extracted. The leaves were cut into small pieces that were extracted with 70% acetone. The absorbance was measured at 643 nm and 665 nm for chlorophyll a, b and total chlorophyll respectively by using spectrophotometer.

Chlorophyll a, b and total chlorophyll were calculated according to the Lichtenthaler and Wellburn (1983) formulae.

Chl a (mg g^{-1} leaf fresh weight) = [12.7(OD663) -2.69 (OD645)] × V/1000 × W.

Chl b (mg g^{-1} leaf fresh weight) = [22.9(OD645) -4.68 (OD663)] × V/1000 × W.

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Received December 16, 2014; **Accepted** January 27, 2015; **Published** February 03, 2015

Citation: Ghani A, Khan I, Umer S, Ahmed I, Mustafa I, et al. (2015) Response of Wheat (*Triticum aestivum*) to Exogenously Applied Chromium: Effect on Growth, Chlorophyll and Mineral Composition. J Environ Anal Toxicol 5: 273. doi:10.4172/2161-0525.1000273

Parameters	Treatments Chromium Concentrations					
	Control	**6 ppm**	**12 ppm**	**18 ppm**	**24 ppm**	**C.D at 5%**
shoot Length(cm)	11.50 ± 0.286	10.370 ± 0.366	9.750 ± 0.07	9.350 ± 0.215	8.390 ± 0.212	1.14
Root length (cm)	10.745 ± 0.024	8.92 ± 0.082	7.950 ± 0.022	6.190 ± 0.089	5.980 ± 0.078	0.21
Root dry weight (g)	2.90 ± 0.023	2.20 ± 0.025	2.11 ± 0.022	1.13 ± 0.027	1.09 ± 0.024	0.11
Shoot dry weight (g)	4.80 ± 0.024	4.01 ± 0.022	4.01 ± 0.024	2.97 ± 0.025	2.01 ± 0.028	0.13
Chlorophyll concentration (mg/g F.W)	2.950 ± 0.000	2.650 ± 0.000	2.660 ± 0.000	2.520 ± 0.000	2.470 ± 0.000	0.03

Value represented in mean ± SD with three replicates.

Table 1: Effect of different concentrations of chromium on growth and chlorophyll contents of Wheat (*Triticum aestivum* L.).

	Elements						
	N	P	K	Na	Ca	Fe	Zn
	Treatment ppm Cu mg/100g air dry weigh						
0	2.08 ± .3	2.32 ± 0.05	4.98 ± 0.3	1.46 ± 0.06	5.6 ± 0.3	524 ± 5	239 ± 3
6	2.09 ± .3	2.26 ± .06	2.89 ± .1**	1.86 ± .2***	3.32 ± .3	465 ± 5	244 ± 3
12	2.18 ± .3	1.95 ± 0.02**	2.83 ± 0.1**	1.56 ± 0.1***	3.09 ± 0.3	398 ± 4***	244 ± 1
18	2.12 ± 3**	1.69 ± 0.03***	2.52 ± 0.4	1.81 ± 0.02*	2.9 ± 0.2**	494 ± 3**	211 ± 1**
24	1.82 ± 0.2***	1.66 ± 0.01***	1.84 ± 0.05***	1.7 ± 0.02*	2.63 ± 0.02**	425 ± 3**	101 ± 2***

Statistical significant: *= P ≤ 0.1 **= P ≤ 0.05 ***= P ≤ 0.01

Table 2: Effect of different chromium concentrations on mineral contents of Wheat (*Triticum aestivum* L.)

Total Chl (mg g^{-1} leaf fresh weight) = [20.2(OD645)-8.02(OD663)] ×V/1000 × W.

Where

OD = Optical Density.

V = Volume of sample.

W = Weight of sample.

Chromium Chloride was used to produce Cr (VI) concentration of 6, 12, 18 and 24 ppm. Growth parameters such as shoot length, root length, shoot dry weight, root dry weight were taken after regular period of time. Minerals nutrients and pigment contents such as chlorophyll a, b and mineral nutrients were estimated respectively by the method of Dubais et al., Lowry et al. [8,9].

Results and Discussion

There is significant reduction in the shoot length, root length, shoot dry weight, root dry weight at 6, 12, 18 and 24 ppm of chromium as compared to control. At the same level of chromium treatment chlorophyll contents also reduced (Tables 1 and 2).

Symptoms due to chromium toxicity like reduction in root and shoot growth, chlorosis, necrosis and decolourization were reported [10,11].

Due to the presence of chromium metal in the mineral nutrients the growth of tomato plant reduced [12].

Table 2 showing the concentration which is increasing from 6-24 ppm in the soil and Ca, N, K, P and iron contents decreased in *Triticum aestivum* shoot system. Membrane functions of root broken down due to which reduced uptake of these minerals take place. The amount of Nitrogen, Potassium, Phosphorus and Calcium were less than the concentration which required for plant growth. All show response as a strong inhibitor for Calcium and Magnesium uptake [13].

Translocation of iron in wheat (*Triticum aestivum* L.) is negatively affected by the excess amount of chromium. Chlorophyll biosynthesis is inhibited in wheat (*Triticum aestivum* L.) and in algae due to chromium metal [14,15]. Photosynthetic mechanism reduced due to metal by closure of stomata and intercellular spaces also reduced due to alterations in chloroplast [16,17]. Excess amount of copper, iron and chromium had negative effects on the concentration of iron, biomass, protein and catalase activity and chlorophyll "a" and "b", in cauliflower [18-36].

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