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Assessment of Chromium toxicity on the selected nutrients of *Gossypium hirsutum* L.

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Abstract

In recent years, the impact of chromium ions to the agronomic products are quite increased due to their enormous utilization in the industrial sectors. The emerging Cr ions into the soil are gradually entered into the plants and developed an abiotic stress which resulted in the irregular mineral uptake, decreased photosynthetic activity and growth. Different concentrations (10, 25, 50, 75, 100 and 250mgkg^{-1}) of Chromium are exposed to the selected *Gossypiumhirsutum* (L.) for 90 days. Treated plants selected macro and micronutrients (nitrogen, phosphorous, potassium, calcium, sodium, magnesium, copper and manganese) levels are significantly ($P<0.05$ & 0.01) reduced as increased concentrations of the Cr concentrations. Our results concluded that Cr exposure for 90 days resulted the decreased mineral uptake mechanism in the tested cotton plants, *Gossypium hirsutum* L.

Key word : Chromium toxicity, macronutrient, micronutrient, *Gossypium hirsutum* L.

In our biosphere, soil is one of the most significant component which is considered as genuine environment for the plant growth and biota life[2,21]. Chromium is the second heavy metal and also the common freshwater, groundwater pollutant. Industrial usage and discharge are the most common source of Chromium (Cr) to the ecosystem and also present in different forms in the ecosystem due to their oxidation and reduction potential which makes them hydrophilic[1,12]. Presence of Cr ions in the soil degrade the physiochemical properties of soil and agronomic properties which pose a serious threat to the agricultural crops[11].

Due to the various anthropogenic activities in the industrial activities such as leather refining, tanning and processing, mining, paint and textile industries and their products utilization became a serious impact on the soil, sediment and water system[6]. Hexavalent and trivalent are the stable forms of Cr whereas tetravalent is considered as the most toxic due to the oxygen association[3]. Cr ions are toxic to the both vegetation and

reproduction phase of plantsdue to their long half-life period[7,19]. Generally, Cr ions are not translocated by the plants for their metabolism[9]. Ayurveda has been the first to give an intricate depiction of this sickness, its clinical highlights and the examples and its administration by home grown or herbomineral drugs. Plant drugs are regularly viewed as less harmful and liberated from results than manufactured ones[22].

Entry of Cr ions into the plants resulted in the reduced water absorption, increased lipid peroxidation with altered membrane permeability, ROS increased levels, decreased starch storage, enzyme denaturation, minerals uptake inhibition, deformed germination and morphology of seedlings, inhibitory activity on enzymes involved in major pathways such as photosynthesis, respiration and nitrogen metabolism[4,5,8]. The accumulation of Cr ions from plants into the humans stimulates various severe conditions such as hypoglycemia, irregular heartbeat, liver disorders, renal malfunctions and cancer risk[25,26]. The main objectives of the study are to analyze the effect of chromium ions on the macro and micronutrients of the cotton plant *Gossypium hirsutum* L. after 90 days treatment through soil.

Experimental plant :

From Cotton Research station (Tamilnadu Agricultural University, Coimbatore), the *Gossypium hirsutum* (L.), commonly known as gankakavery cotton certified seeds are procured. The plant *G. hirsutum* (L.) are cultivated under aseptic conditions[10] in Botanical Garden, Department of botany Government Arts College (Dharmapuri, Tamilnadu).

Chromium treatment :

Potassium dichromate are purchased from Sigma Aldrich for the preparation of different concentrations (10, 25, 50, 75, 100 and 250mgkg^{-1}) of Chromium are mixed with the potted soil (3kg). After 90 days, the selected nutrients levels in the plant leaves are analysed. Mature green leaves are collected and air dried. Nitrogen, phosphorous, potassium, calcium, sodium, magnesium, copper and manganese levels in the powdered plant samples are analysed by standard procedures[17,18] with the help of AAS, UV spectrophotometer and flame emission spectrophotometer.

Statistical analysis :

The triplicate results are analysed by SPSS (17.0 version). The mean and standard deviation of each group/nutrient are analysed. The homogenous subset between the tested mean values are analysed by Duncan Post hoc homogenous test. The mean differences between the treatment groups are analysed by One-way ANOVA (F value) with significant value ($P<0.01$ or 0.05).

Nitrogen and phosphorous are the major macronutrients which are essential for the various activities of the plants including protein synthesis, phosphorylation reactions, nucleic acid formation, energy compound and enzyme synthesis. In control plant, the mean±S Dnitrogen levels are found as 172.11±3.22µg g^{-1} dry weightwhereas the different concentration of Cr toxicity (10, 25, 50, 75, 100 and 250mgkg^{-1}) effect on *Gossypium hirsutum* L. after 90 days treatment showed significant changes in the N_2 levels (167.32±6.11 to 95.11±4.46µg g^{-1} dry weight) (Table-1).

Table-1. Micro and macronutrient (mean±SD) analysis (µg g^{-1} dry weight) of *Gossypium hirsutum* L. treated by different concentrations of chromium (90 days)

Concen-tration of Cr in soil	Nitrogen	Phospho-rous	Potassium	Calcium	Sodium	Magnesium	Copper	Manganese
Control	$172.11\pm3.22^{e,f}$	$4.99\pm0.34^{f,g}$	$89.03\pm4.11^{e,f}$	$40.8\pm1.85^{e,f}$	2.04 ± 0.11^{f}	8.11 ± 0.30^{f}	24.53 ± 0.83^{f}	$61.22\pm2.04^{e,f}$
10mgkg^{-1}	$167.32\pm6.11^{e,f}$	4.03 ± 0.26^{f}	$93.11\pm3.46^{f,g}$	$39.4\pm1.45^{f,g}$	2.89 ± 0.12^{g}	7.99 ± 0.22^{g}	29.24 ± 1.95^{g}	60.35 ± 2.58^{g}
25mgkg^{-1}	152.09 ± 2.34^{e}	$3.99\pm0.23^{d,e}$	$83.17\pm2.87^{d,e}$	$33.9\pm1.24^{d,e}$	2.03 ± 0.07^{e}	7.82 ± 0.34^{e}	$23.46\pm0.65^{d,e}$	59.43 ± 2.05^{e}
50mgkg^{-1}	141.42 ± 6.11^{d}	3.21 ± 0.12^{d}	$80.20\pm3.36^{c,d}$	$30.1\pm1.11^{c,d}$	1.89 ± 0.08^{d}	7.11 ± 0.28^{d}	$20.63\pm0.61^{c,d}$	51.74 ± 2.03^{d}
75mgkg^{-1}	127.26 ± 5.66^{c}	3.01 ± 0.18^{c}	79.14 ± 2.73^{c}	$29.1\pm1.21^{b,c}$	1.67 ± 0.09^{c}	6.99 ± 0.12^{c}	19.59 ± 0.91^{c}	47.39 ± 1.54^{c}
100mgkg^{-1}	101.61 ± 4.93^{b}	2.88 ± 0.25^{b}	72.27 ± 2.63^{b}	$26.8\pm1.19^{a,b}$	1.51 ± 0.06^{b}	6.78 ± 0.37^{b}	17.94 ± 0.88^{b}	35.25 ± 1.68^{b}
250mgkg^{-1}	95.11 ± 4.46^{a}	2.49 ± 0.22^{a}	70.47 ± 5.35^{a}	25.7 ± 1.08^{a}	1.33 ± 0.07^{a}	6.13 ± 0.31^{a}	12.53 ± 0.55^{a}	29.22 ± 2.00^{a}
F value (Sig)	5.23 ($P<0.01$)	17.11 ($P<0.05$)	5.13 ($P<0.05$)	7.11 ($P<0.01$)	5.11 ($P<0.01$)	26.28 ($P<0.01$)	7.34 ($P<0.05$)	4.11 ($P<0.05$)

Control – without chromium in soil; Superscripts (a-g) – Duncan post hoc homogenous subset

The phosphorous levels in the control plant are found as 4.99±0.34µg g^{-1} dry weight whereas the treated groups are ranged between 4.03±0.26 to 2.49±0.22µg g^{-1} dry weight. Control group nutrient levels are observed as 4.99±0.34, 89.03±4.11, 40.8±1.85, 2.04±0.11, 8.11±0.30, 24.53±0.83 and 61.22±2.04 µg g^{-1} dry weight for P, K, Ca, Na, Mg, Cu and Mn. Treated groups showed significantly reduced concentrations of nutrients than compared to the control. Potassium and sodium are the intercellular and extracellular ion which are actively involved in the membrane transport. Chromium treated group potassium and sodium levels are observed as 93.11±3.46 to 70.47±5.35µg g^{-1} dry weight and 2.89±0.12 to 1.33±0.07µg g^{-1} dry weight respectively.

Calcium and Magnesium levels are observed as 39.4±1.45 to 25.7±1.08 µg g^{-1} dry weightand 7.99±0.22 to 6.13±0.31µg g^{-1} dry weight respectively. Similarly, Copper and manganese levels are observed as 29.24±1.95 to 12.53±0.55 and 60.35±2.58 to 29.22±2.00µg g^{-1} dry weight respectively. Duncan post hoc testing compare the mean between the control and treated group nutrients values. Various studies reported the toxicity of Cr to the food crops such as soyabean, bush bean, maize, sunflower, tomato and the evidenced the altered uptake of nutrients such as nitrogen, phosphorous, potassium, iron, magnesium, manganese, molybdenum, zinc, copper, calcium and boron[15,16].

Sharmin *et al.*[20] reported the toxicity of different concentrations of chromium (0, 50, 100, 200, 300, 500,750, 1,000 µmol/L) on *Miscanthus sinensis* as reduced nitrogen and other nutrients. Chromium treated *Spinacia oleracea* L. and *Brassica napus* L. plants showed reduced uptake of macro and micro-nutrients and remobilization of minerals[23,24]. Heavy metal exposure resulted antagonistic activity of phosphorous, sulphur and zinc uptake into the plants[13,14].

Chromium is one of the major heavy metal pollutant cause serious issues to both terrestrial and aquatic ecosystems. Due to the Cr toxicity in the soil, the *Gossypium hirsutum* L. mineral uptake are significantly reduced. Drastic decreased levels of micro and macro nutrients resulted due to the increased concentrations of the Cr ions in the soil.

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