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# Remediation of Phytotoxic effect of Chromium by Different Amendments in Berseem Crop Grown in Sewage and Tubewell Water Irrigated Soils

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## ABSTRACT

A screen house experiment was carried out to study the direct effect of chromium(Cr) application in the presence and absence of amendments in berseem crop grown on sewage and tube well water irrigated soils with three replications under factorial completely randomized block design. The results indicated that berseem dry matter yield (DMY) decreased significantly due to direct effect of Cr application but the presence of amendments increased the dry matter yield up to 80 mg/Kg of applied Cr. No harvestable yield was obtained at higher levels of chromium application. The chromium content and chromium uptake also increased significantly with increase in levels of applied chromium. The application of amendments decreased the chromium content and uptake. The toxic effect of Cr on crop could be mitigated more effectively with FYM application than lime and reduce risk of health hazards for human beings and animals.

**Key Words:** Chromium, amendments, Berseem, Remediation, Sewage water, tube well water.

## INTRODUCTION

Chromium (Cr) is the most abundant metal found in the earth's crust and due to its huge industrial use, it is considered to be important environmental contaminant released into the atmosphere. Chromium exists in two different stable oxidation states, trivalent ($Cr^{3+}$) and hexavalent ($Cr^{6+}$) chromium. Both these forms differ in terms of mobility, bioavailability and toxicity. $Cr^{6+}$ is more toxic than $Cr^{3+}$. $Cr^{6+}$ forms chromate and dichromate and is highly soluble in water. $Cr^{3+}$ is comparatively less soluble in water and is required in trace amounts as an inorganic nutrient for animals. Both chromate and dichromate are considered to be negatively charged and there is a limited chance of it being adsorbed by organic materials. $Cr^{6+}$ is thus considered to be more mobile than that of $Cr^{3+}$. Chromium is easily found in soil, water and biological material and occurs in the range from 5 to 1000 mg/kg in soils.

Chromium is extensively used in industries like steel, leather, textile, etc. The hexavalent form of Cr is a biologically toxic oxidation state and to date there is no evidence indicating any potential biological role in plants. Both oxidized forms have the capacity to form complexes with other species. Cr can alter chloroplast membrane and ultra structure in plants. The phytotoxicity of both $Cr^{3+}$ and $Cr^{6+}$ has been studied in many higher and lower plants. $Cr^{3+}$ is thought essential for animals in trace amounts, can be toxic and induces oxidative stress. $Cr^{3+}$ is toxic to plants even at low concentration and reported to causes severe oxidative damage to plant cells. It can affect growth, water balance, pigment content and initiate lipid peroxidation causing oxidative damage to plants. On the other hand, $Cr^{6+}$ is more phytotoxic than $Cr^{3+}$ (Han *et al*, 2004) and retards growth, reduces the number of palisade and spongy parenchyma cells in leaves and increases the number of vacuoles and electron dense material. Irrigation of agricultural soil with sewage contaminated water with heavy metals from industrial effluents such as Cr has also been known to affect soil and plants. Chromium disturbs the metabolic processes

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causing toxicity to plants. Toxic effect of Cr on plant growth and development include alterations in the germination process as well as in the growth of roots, stems and leaves which may affect total dry matter production and yield. Chromium also causes harmful ion effects on plant processes such as photosynthesis, water relations and mineral nutrition (Shankar *et al* 2004). The problem of Cr toxicity may become more problematic in future if these soils are fed continuously with untreated industrial effluents. The effect of Cr application on crops has been studied by many scientists but the effect of amendments in addition to Cr application has not been studied on crops. Keeping this point in mind, the experiment was undertaken.

## MATERIAL AND METHODS

A screen house study was conducted to determine the effect of bioavailability of Cr to crop. For this purpose, two types of soil samples, one from sewage irrigated and second from tube well irrigated soils were collected. Tube well water irrigated soil has total Cr, 50.15 mg/kg and DTPA-Cr content of 0.017 mg/kg.The sewage water irrigated soil has total Cr of 189.70 mg/kg and DTPA-Cr content 0.119 mg/kg. All other chemical properties were analyzed by methods given by Jackson (1973). The berseem was chosen as the test crop. It was grown for 90 d and direct effect of native and applied Cr with and without amendments was studied on it. The bulk samples of both sewage and tube well water irrigated soils were collected, dried and sieved to pass through 2mm sieve. Eight kg of this processed soil was added to each pot lined inside by polythene sheet. The required amount of ground FYM and lime supplying 0 and 1% FYM and 1% lime were thoroughly mixed in the soil. Chromium levels (0, 40, 80, 160 and 320 mg/kg) soil was added in the solution form using potassium dichromate of AR grade. The soil in the pot was subjected to alternative wetting and drying to maintain equilibrium. Thereafter, specimen soil samples from each pot were taken with the help of steel tube augar. The soil samples were air dried, ground, sieved and stored in polythene bags for chemical analysis. Each of the treatment was replicated thrice. Fifteen seeds of berseem variety BL 42 were sown in pots under optimum moisture conditions. The recommended basal dose of nitrogen, phosphorus and potassium were applied through analytical grade urea and potassium di-hydrogen phosphate in solution form at the time of sowing. Thinning was done to maintain ten plants per pot after germination. The crop was irrigated regularly with deionised water. The crop was harvested after 90 d of growth. The data were analyzed using Factorial completely randomized (Factorial CRD) given by Cheema et al (1991).

## RESULTS AND DISCUSSION

**Effect of chromium level**

The dry matter yield (DMY) of berseem decreased significantly with the increase in levels of applied Cr in both the soils. The mean DMY decreased significantly from 15.49 g/pot to 11.56 g/pot and 4.79 g/pot with the increase in added Cr from 0, 40 and 80 mg/kg soil, respectively (Table 1). At higher levels (160 and 320 mg Cr/kg soil), no harvestable yield was obtained. In non amended treatment, the DMY decreased significantly from 14.92 g/pot to 10.90 and 3.06 g/pot with the application of respective levels of chromium.

The application of farm yard manure (FYM) not only increased the DMY from 14.92 to 17.01 g/pot at no applied Cr but also reduced the toxic effect of Cr on DMY at each level. At 40 mg/kg level of added Cr, berseem DMY increased from 10.90 g/pot in non amended treatment to 14.18 g/pot with the application of FYM. Application of lime was not effective in increasing the DMY. Among the amendments, the magnitude of reduction of toxic effect of Cr on DMY of berseem was relatively higher by only using FYM than lime. Application of FYM increased the mean DMY of berseem from 9.62 g/pot (non amended) to 13.18 g/pot. The highest yield was obtained with the application of FYM followed by control and lime at any level of applied Cr. Comparison among soils have shown that the DMY of berseem was higher at each level of applied Cr in TWI than SWI soils. In non amended treatment, the mean DMY of berseem in TWI soil was 10.16 g/pot and in SWI soil was 9.09 g/pot. When FYM was applied, the mean DMY in SWI soil was 12.53 g/pot in comparison to 13.83 g/pot in TWI soil. Similarly, when lime was applied, mean DMY in SWI soil was 9.03 g/pot and in TWI soil, it was 9.04 g/pot. Luna *et al* (2009) found that the root and shoot lengths of wheat, oat and sorghum decreased as Cr concentrations increased in tannery sludge treatment. A toxic effect of tannery sludge Cr on root growth could have directly affected shoot growth. The interaction of chromium, amendments and soils were found to be significant.

**Chromium concentration in berseem**

The chromium concentration in berseem shoot increased significantly with increase in level of applied Cr. The mean Cr content increased significantly from 3.14 mg/kg, 22.21 mg/kg and 40.57 mg/kg with increase in applied Cr from 0, 40 and 80 mg Cr/kg soil, respectively (Table 2). In non amended treatment, mean Cr content increased significantly from 3.42 mg/kg, 23.70 and 46.53 mg/kg. Application of FYM not only decreased the Cr content but also reduced the toxic effect of Cr by improving the dry matter yield. At 40 mg/kg of added Cr, chromium content decreased to 19.93 mg/kg from 23.70 mg/kg in non amendment treatment and at 80 mg/kg of applied Cr, mean Cr content decreased to 30.61 from 46.53 mg/kg.

Application of lime also decreased the Cr content at each level of applied chromium in comparison to where no amendment was applied. The Cr content decreased from 3.42 mg/kg to 3.20 mg/kg with the application of lime. At 40 mg/kg of applied Cr, mean Cr content decreased to 23.01 mg/kg from 23.70 mg/kg, Similarly, at 80 mg/kg of applied Cr, mean Cr content decreased to 44.57 mg/kg from 46.53 mg/kg.

Among the amendments, magnitude of reduction of Cr content was relatively higher by using FYM than using lime. Application of FYM decreased the mean Cr content to 17.78 mg/kg from 24.55 mg/kg whereas with lime application, the extent of reduction was 23.59 mg/kg from 24.55 mg/kg where no amendment was applied. Therefore, FYM was more effective in reducing the tissue concentration resulting in more biomass than lime and control. Among the soils, the Cr content of berseem was higher at each level of applied Cr in SWI than TWI soil. The mean Cr content in TWI soil was 24.00 mg/kg and in SWI soil, it was 25.10 mg/kg .When FYM was applied, the mean Cr content of berseem in SWI soil was 20.04 mg/kg in comparison to 15.52 mg/kg in TWI soil. Similarly, when lime was applied, mean Cr content in SWI soil was 24.64 mg/kg and in TWI soil, it was 22.54 mg/kg. Higher concentration of Cr in sewage water irrigated soil might be due to the fact that this soil had inherent content of chromium, amounts was available to the plants.

The interaction of Cr levels and amendments was found to be significant in both the soils. The interaction of chromium, amendments and soils were also found to be significant. Bhatti *et al* (2016) found that maximum amount of chromium was found in berseem samples from site II (43.43 mg/kg) and minimum content was observed at site III (25.92 mg/kg). They also suggested that Cr contents were alarmingly higher than the maximum permissible limits for fodder set by tolerance limit of heavy metals for feed of China. Soil to berseem metal bio-accumulation factor was above 1 for chromium confirming that berseem for this studied area was unsafe for human consumption. Dheri (2007) found that higher concentration of Cr were observed in the shoots of berseem grown on sewage irrigated and partially sewage water irrigated soils as compared to tubewell irrigated soils. The mean concentration of chromium in berseem growing on sewage water irrigated soils was 4.20 times higher than their concentration in tube well water irrigated plants. Kumar *et al* (2011) found higher concentration of Cr in berseem plant grown on sewage irrigated soil and it was 4.97 mg/kg. Thus,

**Table 1. Direct effect of applied Cr and amendments on dry matter yield of Berseem (g/pot) in soils.**

| Cr Level | Dry matter yield ( g/pot) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Control | | Mean | FYM | | Mean | Lime | | Mean | Total Mean |
| | TWI | SWI | | TWI | SWI | | TWI | SWI | | |
| 0 | 15.18 | 14.66 | 14.92 | 17.28 | 16.73 | 17.01 | 14.60 | 14.46 | 14.53 | 15.49 |
| 40 | 11.91 | 9.88 | 10.90 | 14.95 | 13.41 | 14.18 | 9.37 | 9.86 | 9.62 | 11.56 |
| 80 | 3.40 | 2.72 | 3.06 | 9.26 | 7.46 | 8.36 | 3.14 | 2.78 | 2.96 | 4.79 |
| 160 | - | - | - | - | - | - | - | - | - | - |
| 320 | - | - | - | - | - | - | - | - | - | - |
| Mean | 10.16 | 9.09 | 9.62 | 13.83 | 12.53 | 13.18 | 9.04 | 9.03 | 9.03 | |
| Total Mean | SWI= 10.22 ,TWI = 11.01 | | | | | | | | | |
| | CD(0.05) Soil= 0.11, Amendments =0.13, Cr levels =0.17, Soil X factor=0.184, Soil X levels=0.24, Factor X level= 0.29, Soil X factor X levels =0.41 | | | | | | | | | |

**Table 2. Direct effect of applied Chromium and amendments on chromium content in Berseem (mg/kg) in soils.**

| Cr Level (mg/kg) | Cr Content (mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Control | | Mean | FYM | | Mean | Lime@ 1 percent | | Mean | Total Mean |
| | TWI | SWI | | TWI | SWI | | TWI | SWI | | |
| 0 | 3.42 | 3.42 | 3.42 | 2.67 | 2.94 | 2.81 | 2.86 | 3.53 | 3.20 | 3.14 |
| 40 | 22.26 | 25.14 | 23.70 | 18.22 | 21.63 | 19.93 | 20.86 | 25.15 | 23.01 | 22.21 |
| 80 | 46.33 | 46.73 | 46.53 | 25.66 | 35.56 | 30.61 | 43.90 | 45.24 | 44.57 | 40.57 |
| 160 | - | - | | - | - | | - | - | | |
| 320 | - | - | | - | - | | - | - | | |
| Mean | 24.00 | 25.10 | 24.55 | 15.52 | 20.04 | 17.78 | 22.54 | 24.64 | 23.59 | |
| Total Mean | TWI= 20.69, SWI = 23.26 | | | | | | | | | |
| | CD(0.05) Soil= 0.25, Amendments =0.30, Cr levels =0.39, Soil X factor=0.43, Soil X levels=0.55, Factor X level= 0.68, Soil X factor X Cr levels =0.96 | | | | | | | | | |

TWI – Tube well water irrigated soil SWI – Sewage water irrigated soil

**Table 3 Direct effect of applied Cr and amendments on chromium uptake by Berseem (µg pot-1) in soils**

| Cr Levels (mg/kg) | Cr uptake (µg/pot) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Control | | Mean | FYM @1% | | Mean | Lime@ 1% | | Mean | Total Mean |
| | TWI | SWI | | TWI | SWI | | TWI | SWI | | |
| 0 | 52.03 | 50.13 | 51.08 | 46.21 | 49.16 | 47.69 | 41.90 | 50.96 | 46.43 | 48.40 |
| 40 | 265.54 | 248.51 | 257.03 | 272.52 | 290.08 | 281.30 | 195.58 | 248.04 | 221.81 | 253.38 |
| 80 | 157.59 | 127.31 | 142.45 | 237.67 | 265.21 | 251.44 | 137.80 | 125.93 | 131.87 | 175.25 |
| 160 | - | - | - | - | - | - | - | - | - | |
| 320 | - | - | - | - | - | - | - | - | - | |
| Mean | 158.39 | 141.98 | 150.18 | 185.47 | 201.48 | 143.47 | 125.09 | 141.64 | 133.36 | |
| Total Mean | TWI = 156.32, SWI = 161.70 | | | | | | | | | |
| | CD(0.05) Soil= 3.08 Amendments = 3.77, Cr levels = 4.87, Soil X factor=5.33, Soil X Cr= 6.88, Amendment X Cr= 8.43, Soil X Amendments X Cr = 11.92 | | | | | | | | | |

TWI – Tubewell water irrigated soil SWI - Sewage water irrigated soil

the concentration of Cr in plants was higher as compared to the suggested permissible tolerance level.

**Chromium uptake**

The chromium uptake by berseem shoot also increased significantly with increase in level of applied Cr up to 40 mg/kg. The mean Cr content increased significantly from 48.40 µg/pot to 253.38 µg/pot in respectively (Table 3). In the absence of applied amendment, mean Cr uptake increased significantly from 51.08 µg/pot to 257.03 µg/pot. Application of FYM decreased the Cr uptake in berseem. At 40 mg/kg of added Cr, chromium uptake increased to 281.30 µg/pot from 257.03 µg/pot (where no amendment applied) and at highest level of applied Cr, it increased from 142.45 µg/pot to 251.44 µg/pot . Application of lime decreased the Cr uptake of berseem shoots at each level of applied chromium in comparison to when no amendment was applied. The Cr content decreased from 51.08 µg/pot (no amendment applied) to 46.43 µg/pot. At 40 mg/kg of applied Cr, mean Cr uptake decreased to 221.81 µg/pot from 257.03 µg/pot.

The magnitude of increase of Cr uptake was relatively higher by using FYM than using lime. Application of FYM decreased the mean Cr uptake of berseem to 143.47 µg/pot from 150.18 µg/pot and with lime application, the extent of reduction was 133.36 µg/pot from 150.18 µg/pot (where no amendment was applied). FYM was more effective in reducing the tissue uptake resulting in more biomass than lime and control.

The Cr uptake of berseem was higher at each level of applied Cr in SWI than TWI soil. The mean Cr uptake in TWI soil was 141.98 µg/pot and in SWI soil, it was 158.39 µg/pot .When FYM was applied, the mean Cr uptake of berseem in SWI soil was 201.48 µg/pot in comparison to 185.47 µg/pot in TWI soil. When lime was applied, mean Cr uptake of berseem in SWI soil was 141.64 µg/pot and in TWI soil, it was 125.09 µg/pot. Higher uptake of Cr in sewage water irrigated soil might be due to the fact that this soil had inherent content of chromium, amounts was available to the plants. Interaction of Chromium, soils and amendments were found to be significant. Dheri et al (2007) observed that different crops showed wide variation in uptake and accumulation of toxic metals. Spinach accumulated the highest concentration of chromium followed by berseem. The crops grown on sewage water irrigated soils may be more harmful for human and animal consumption.

## CONCLUSION

It may be concluded that the DMY of berseem decreased with increase in the level of applied Cr. Chromium content and chromium uptake also increased with increase in level of applied chromium but application of farm yard manure was found to be more fruitful than lime in terms of mitigating chromium toxicity which results in improved dry matter yield and decreased chromium content and uptake.

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