Research Article

Investigation on Chromium Toxicity in Tomato (*Solanum lycopersicum* L.) Crop

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Abstract

The effect of chromium toxicity on growth and yield attributes of tomato was studied. Tomato seeds were sown in pots treated with different concentrations of cr solutions. Observations such as plant height, root length, number of flowers, number of fruits, fruit weight etc were recorded. Increasing concentrations of chromium caused reduction in growth, percentage of seed germination, plant height, root length, flowering and yield. The potential of plants with the capacity to accumulate chromium compounds for bioremediation of Cr contamination has gained interest in recent years. It can be concluded that high concentration of Cr toxicity had strong inhibition and damage to the normal metabolism and cell implement structure, as well as on the function of tomato plant.

Keywords: *Solanum lycopersicum*, chromium toxicity, phytoremediation, germination percentage, yield

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Introduction

Heavy metals are major threat to the environment, animals and humans due to their extreme toxicity [1]. Chromium, in contrast to other toxic trace metals like cadmium, lead, mercury and aluminum has received little attention from plant scientists. There are many studies showing that chromium stress has adverse effects on physio-biochemistry, absorption and accumulation of crops mainly rice, wheat and vegetables [2, 3]. Chromium is a heavy metal with risk to human health. Chromium enters the food chain through consumption of plant material. A high concentration of Cr has been found to be harmful to vegetation. As the chromium concentration in plants increases, it adversely affects several biological parameters. Ultimately there is loss of vegetation and land sometimes becomes barren [4]. There are many studies on chromium toxicity in crop plants. Chromium significantly affects the metabolism of plants such as *Citrullus* [4], barley [5], Cauliflower [6], Vegetable crop [7], and *Zea mays* [8]. Due to wide industrial use, chromium is considered a serious environmental pollutant. Contamination of soil and water by chromium is of recent concern. Toxicity of Cr to plants depends on its valance state. Chromium (VI) is highly toxic and mobile whereas Cr (III) is less toxic. Since plants lack a specific transport system for Cr, it is taken up by carriers of essential ions such as sulfate or iron.

Plants used for phytoextraction must be fast growing and have the ability to accumulate large quantities of environmentally important metal contaminants in their tissues [9]. Many plant species have been screened to determine their usefulness for phytoextraction. At present, there are nearly 400 known hyperaccumulators but most of them are not appropriate for phytoextraction because of their slow growth and small size. Sara Parwin Banu *et al*. [10] observed a synergistic effect between Cr and plant growth up to a total soil Cr concentration of 750 mg kg^{-1}; above this concentration, there was a sharp decline in yield of vegetables like bhendi, brinjal and chillies.

A high concentration of Cr is harmful to plant life, reducing the protein content, inhibiting the enzyme activity and cause chlorosis and necrosis. Chromium concentration in plants adversely affects several morphological and biochemical parameters. Chromium toxicity interferes with several metabolic processes in plants, causing reduced seed germination or early seedling growth [11], biomass and photo-synthetic impairing [12]. Phytotoxicity of Cr is concerned with plant growth. Its presence in surplus amount inside the plant can cause stunted growth [13, 14]. The presence of Cr in soil disturbs the pattern of nutrient uptake in plant because of nutrient metal interaction [15].With these ideas in view, this experiment was planned to find out the effect of chromium toxicity on growth and yield of tomato.

Materials and Methods

A pot culture experiment was conducted in 2015 to find out the influence of chromium toxicity on tomato. The experiment was laid out in a completely randomized design, replicated thrice. Tomato seeds were sown in the pots filled with loamy soil and different concentrations of chromium i.e., 50, 100, 150, 200 and 250 µg g^{-1} were added per 2 kg soil and mixed thoroughly. Pots without the addition of chromium were treated as the controls. Equal numbers of sterilized seeds of tomato were sown in each pot Normal growth conditions were ensured and pots were irrigated whenever needed to keep the soil moisture to field capacity till maturity.

The plants under control and treated with chromium were compared based on growth and yield. For metal analysis, the plants were uprooted at the time of harvest, washed with deionised water and dried in over 110^{o}C for 2h. The samples were then finely powdered and digested in concentrated nitric acid until a clear solution was obtained. It was then filtered and reconstituted to the desired volume with double distilled water and analysed in Atomic absorption spectrometer (AAS, Perkin Elmer AAnalyst 400). The analysis of heavy metal chromium was done for root, stem, leaf and fruit of *Solanum lycopersicum* at low and higher concentrations. Growth in terms of root length, flowering and yield were taken at regular intervals.

Results and Discussion

Germination percentage decreased as the chromium concentration increased. The germination percentage of seedling in the control sample was 95 per cent. It decreased gradually (i.e., 91, 82, 73, 62 and 55 per cent) with increase in Cr levels (0, 50, 100, 150, 200 and 250 µg g^{-1}) added to soil. Protease activity, on the other hand, increased with the Cr treatment, which could also contributed to the reduction in germination of Cr-treated seeds. In control, the height of the plant was 63.0 cm. Plant height increased upto 50 µg g^{-1} and then a decrease in height was noticed with the increasing Cr concentrations. Plant with dark green leaves was observed in Cr 50 µg g^{-1} treated soil which also recorded higher yield. Increase in the root length was observed in Cr 50 µg g^{-1} level. Root growth was much effected in all the doses of chromium. Small roots with more lateral roots were noticed at higher concentration of Cr i.e. 250 µg g^{-1}. At Cr 50 µg g^{-1} level, increased number of flowers (**Table 1**) was noticed.

Less fruit formation was observed in Cr 250 µg g^{-1} treated soil. Higher yield was observed in Cr 50 µg g^{-1} treated soil. In control sample, the average fruit weight was 30.2 gm and fruit girth was 8.6 cm. In Cr 50 µg g^{-1} applied level, fruit weight and girth increased but fruit weight and girth decreased with increasing concentrations of Cr. From the results, the chromium content was higher in root (149 µg g^{-1}) and stem (109 µg g^{-1}) but less concentration (71µg g^{-1}) was observed in leaf. Hence, there was not much appreciable amount in fruit. Cr uptake in the different parts of tomato plant was in the following order Root > Stem > Leaves > Fruit (**Figure 1**). Chromium accumulates mainly in roots and shoots; however, root accumulation lead only a small part translocated to the shoots [16, 17]. Accumulation of Cr in the different parts of the plant was in the following order: Roots > Stem > *Leaves* > Seed [18]. In pea plants exposed to Cr, there was an increase in concentration of Cr in different parts of the plant with increase in Cr supply. Previous studies showed that chromium in higher concentrations severely affected the germination, growth and yield of plants [19, 20].

Table 1 Effect of chromium on growth parameters of tomato (*Solanum lycopersicum*)

Treatments	% of germination	Plant height (cm)	Root length (cm)	No.of flowers /plant	Average no. of fruits/plant	Fruit girth (cm)	Fruit weight (g)
T_1	95.0	63.1	10.3	7.0	6.0	8.6	30.2
T_2	91.0	65.3	10.5	9.0	8.0	8.9	32.3
T_3	82.0	62.1	10.1	6.0	5.0	8.2	26.4
T_4	73.0	59.4	9.4	5.0	4.0	7.1	20.1
T_5	62.0	57.6	8.3	5.0	3.0	6.8	17.5
T_6	55.0	45.3	7.2	4.0	2.0	6.4	15.0
Mean	76.3	58.8	9.3	6.0	4.6	7.7	23.6
SEd	1.3	0.1	0.2	0.1	0.1	0.1	0.4
CD (0.05)	2.8	2.1	0.3	0.2	0.2	0.3	0.8

T_1-Control (Soil Alone), T_2- Cr @50 µg g^{-1}+MSW @ 12.5 t ha^{-1}, T_3- Cr @100 µg g^{-1}, +MSW @ 12.5 t ha^{-1}, T_4-Cr @150 µg g^{-1} + MSW @ 12.5 t ha^{-1}, T_5- Cr @200 µg g^{-1}+ MSW @ 12.5 t ha^{-1}, T_6- Cr @250 µg g^{-1} + MSW @ 12.5 t ha^{-1}

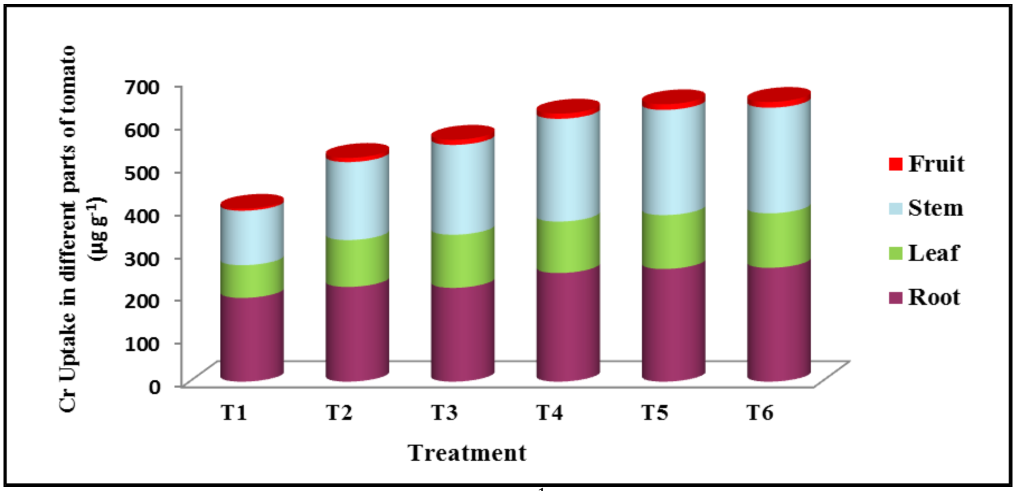

Figure 1 Chromium uptake (µg g^{-1}) in different parts of tomato

Conclusion

Accumulation of chromium showed high concentrations in root and stem but less concentration in leaf. Very minute amount of chromium was observed in fruits. The results indicated that larger quantity of Cr was in residual fraction and only a minor fraction of Cr is available for the plant uptake. This effect was further much pronounced with the application of bioamendment @ 12.5 t ha^{-1}.Such bioamendment rich in organic matter can be recommended in order to minimize the accumulation of Cr in plant parts and thereby to overcome the problem of phytotoxic effects of Cr in the contaminated soils.

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