CULTIVATION OF PORTULACA OLERACEA PLANTS IN CR(VI) SPIKED SOIL

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ABSTRACT

Soil contamination by Cr is a serious environmental problem in many countries caused from antropogenic activities and/or natural processes. The most abundant Cr species in nature are Cr(III) and Cr(VI). Cr(III) is of low bioavailability and toxicity and an essential element for human and animal physiology, whereas Cr(VI) is highly bioavailable and toxic. We aimed at evaluating Cr(VI) stress to plant in the presence of a major nutrient, i.e., N. In a pot experiment we had 10 treatments (5 Cr(VI) levels x 2 N levels x 10 replicates) with 10 replicates each. We measured chlorophyll content, plant height and photosynthesis rate, and at the end of the growth period, leaf weight, total plant weight, plant height, leaf area and tissue water content were measured. We found that Cr(VI) stress severely inhibited the growth of *Portulaca oleracea*, especially in the concentration of 200 ppm. More specifically, added hexavalent Cr caused a 70-90% decrease in leaf weight, total plant weight and leaf area, while chlorophyll content and photosynthesis rate decreased by 40-50%, water content percentage of the above ground tissue was found 2% lower in the Cr(VI)-stressed plants (Table 1), but the difference was significant. Furthermore, in the N-added treatments, superior results were obtained in every measured parameter. We conclude that *Portulaca Oleracea* growth was severely affected from Cr(VI) stress. Due to the dramatically reduced biomass, the plant cannot be proposed for large scale cultivation in severely Cr(VI)-polluted soils.

Table 1. Parameters related to plant growth for the 0 and 200 ppm Cr(VI) treatments.

	Total plant Weight (g)	Plant height (cm)	Leaf area (cm^2)	Chlorophyll Content Index (CCI)	Photosynthetic rate (μmol CO_2/m^2s)	Water content (%)
Cr(0) N(0)	13.4	30.7	114.5	12.76.6		92.8
Cr(0) N(1)	29.5	32.5	381.5	13.17.9		92.1
Cr(200) N(0)	2.4	12.8	41.0	5.53.1		90.5
Cr(200) N(1)	3.5	14.1	49.9	7.03.9		90.0

KEYWORDS

Cr(VI); Plant Stress; Polluted soil; *Portulaca Oleracea*

1. INTRODUCTION

Soil contamination is a widespread problem, affecting plants, animals, and humans alike. Potentially toxic elements (PTEs) are of primary concern due to the fact that they are consistent and non-biodegradable pollutants. In many regions around the world hexavalent chromium (Cr(VI)) contaminated soils have been a well-known toxic substance with high potential mobility from soil to plant. The reason is that Cr(VI) is found as an anion species in soil solution (the predominant form being chromate CrO42-, and dichromate Cr2O72-); hence, it is very weakly retained by negatively charged soil colloids [1]. As a result, Cr(VI) is highly bioavailable to plants once it is introduced to soil environment. Some plant species may tolerate high Cr(VI) concentration in soils; such plants may be used as phytoremediation species for contaminated areas. Over the years, there have been several phytoremediation species proposed in the literature. Purslane (*Portulaca oleracea*) is a known tolerant species towards various abiotic stresses, thus a candidate as a phytoremediation species, although to our knowledge this species has never been tested before for remediation purposes. Accumulator species may exhibit a better efficiency towards PTE uptake provided growth restricting factors are eliminated. Thus, nitrogen fertilization may help in obtaining higher accumulator behaviour, although the combination of testing the role of nitrogen in Cr(VI) uptake, to our knowledge, has never been tested before. In this work, we aimed at investigating Cr(VI) toxicity to parsley with band without nitrogen in soils with added concentrations of Cr(VI).

2. METHODOLOGY

An alkaline soil (pH 7.8, EC 850 μS/cm, O.M 1.5%, CaCO3 10.4% and of loam texture) was used to establish a 10- treatment pot experiment (Table 1).

Table1.Cr (VI) in ppm (mg kg^{-1} soil) and nitrogen in rates equivalent to kg ha^{-1} for each treatment

Treatment	***Cr(VI) (ppm)***	***N***
Cr(0) N(0)	0	0
Cr(0) N(1)	0	400
Cr(50) N(0)	50	0
Cr(50) N(1)	50	400
Cr(100) N(0)	100	0
Cr(100) N(1)	100	400
Cr(150) N(0)	150	0
Cr(150) N(1)	150	400
Cr(200) N(0)	200	0
Cr(200) N(1)	200	400

The soil was equilibrated with Cr(VI) solution 14 days before transplanting and the soil was thoroughly mixed every 3 days. Nitrogen was applied in 3 doses; on the date of the Cr(VI) addition, on the transplanting date and 30 days after transplanting. *Portulaca oleracea* plants were transplanted in 2-L pots (10 treatments x 10 replicates = 100 pots)
Plants were left for 60 days to grow and irrigation was applied according to the plant needs. A week before the harvest, photosynthetic rate was measured at a constant light intensity (250 μmol/cm2s) using a LI-Cor Li 6400 XT instrument and Chlorophyll Content Index was measured using the OPTI-SCIENCES CCM-200 chlorophyll content meter. After harvest, total plant weight, plant height, leaf area, leaf weight, and tissue water content were measured.

Two-way ANOVA was conducted using the IBM SPSS statistics 21 package.

3. RESULTS AND DISCUSSION

3.1 Parameters measured and differences between treatments

3.1.1 Chlorophyll content index (CCI)

CCI had a decreasing trend with increasing

Cr(VI) concentrations (P<0.001) (*Fig. 1*). Statistical analysis showed that nitrogen application resulted in higher CCI values (P<0.001).

3.1.2 Photosynthetic rate

Photosynthetic rate was significantly reduced at concentrations of Cr(VI) higher than 50 ppm (Fig. 2) (P<0.001). In the treatments where nitrogen was applied, photosynthetic rate was significantly enhanced (P=0.032).

3.1.3 Total plant weight

Total plant weight as was severely affected by the Cr(VI) additions (Fig. 3) (P<0.001). As expected, in treatments where nitrogen was applied, the total plant weight measured was significantly higher (P<0.001).

3.1.4 Plant height

Plant height was significantly influenced even in the lowest Cr(VI) addition (Fig. 4) (P<0.001). The influence of Cr(VI) on this growth parameter was so strong that nitrogen application had no statistically significant effect on the height of plants (P=0.289).

3.1.5 Leaf area

The leaf area parameter showed a decreasing trend with increasing Cr(VI) soil concentrations (Fig. 5) (P<.001). Nitrogen application resulted in higher leaf area values (P<0.001).

3.1.6 Leaf weight

Cr(VI) additions resulted in reduced leaf weight values (Fig. 6) (P<0.001), while nitrogen application had a positive effect in the leaf weight (P<0.001).

3.1.7 Water content (%)

Cr(VI) stress resulted in significantly lower values of the percentage of water content (Fig. 7) (P=0.002). On the other hand, nitrogen application had no effect (P=.324*)*

3.2 Figures and tables

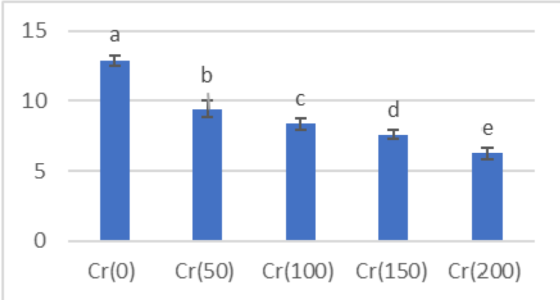

Figure 1. Chlorophyll content index

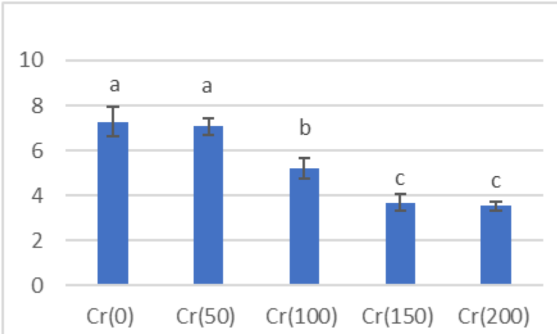

Figure 2. Photosynthetic rate (μmol CO_2/m^2s)

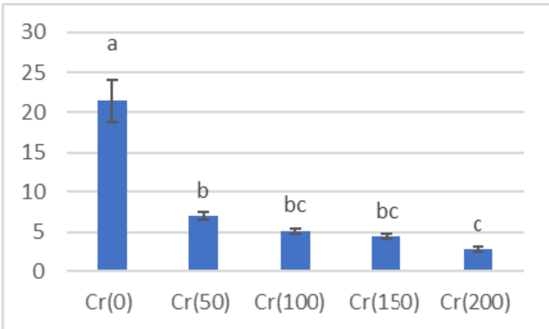

Figure 3. Total plant weight (g)

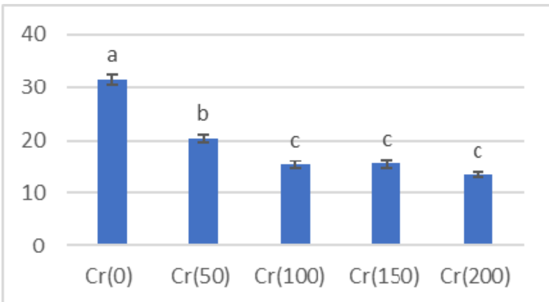

Figure 4. Plant height (cm)

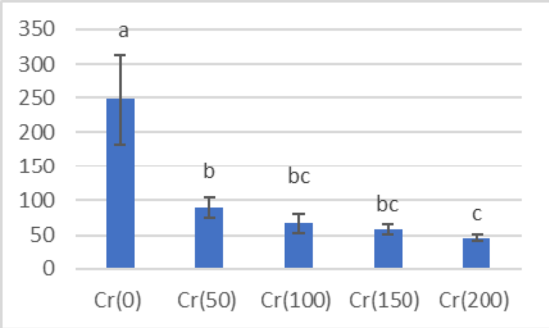

Figure 5. Leaf area (cm^2)

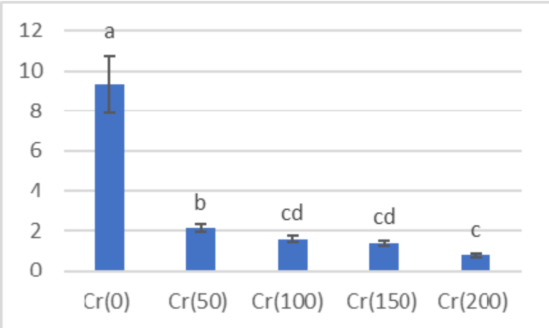

Figure 6. Leaf weight (g)

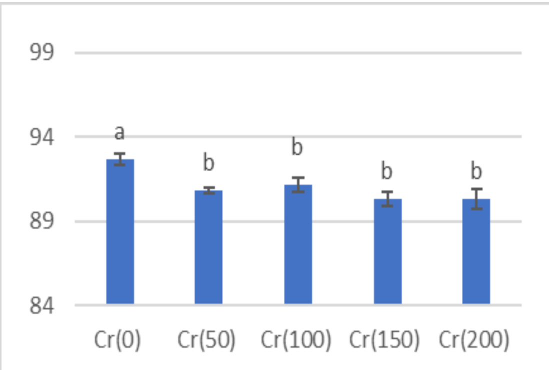

Figure 7. Water content (%)

4. CONCLUSIONS

The effect of Cr(VI) stress on photosynthetic rate and chlorophyll content index (CCI) was minimal compared to the effect that Cr(VI) stress exerted to the parameters relevant to the produced plant biomass (total plant weight, leaf area and leaf weight). These results indicate that plants in order to address Cr(VI) stress minimize their growth rate. Nitrogen, on the other hand, promoted biomass production under Cr(VI) stress and the measured parameters relevant to photosynthesis (photosynthetic rate and chlorophyll content index (CCI)) had significantly higher values compared to the non- fertilized treatments.

Cr(VI) has been reported to cause ultrastructural changes in the chloroplasts in many plant species leading to reduced photosynthetic rate [2] .Also, Cr species affect root cells leading to plasmolysis and the wilting of plants [3].

Overall the results of the present study indicate that plants under Cr(VI) stress minimized their growth rate as a mechanism to protect vital physiological functions. In order to have conclusive result for the effect of Cr(VI) on physiological functions and the induction of stress-alleviating mechanisms on *Portulaca oleracea* plants further studies are necessary.

ACKNOWLEGEMENTS

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