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Combined effect of Cr^{+6} and chelating agents on growth and Cr bioaccumulation in flood susceptible variety of rice *Oryza sativa* (L.) cv. Swarna

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Abstract: Flood susceptible variety of Rice (Swarna) were grown in both water logged & water deficit condition. The experimental seedlings were treated with Cr^{+6} (10mg) and Cr^{+6} (50mg) both in the presence & in the absence of chelating agents (EDTA-Ethylene Diamine Tetra Acetic Acid, SA-Salicylic Acid, CA-Citric Acid). The results showed that the enhancement of Cr bioavailability in plants occurs by supplementing Cr^{+6} with chelating agents. This clearly depicts that the role of chelating agents increases the toxic effects of Cr^{+6} simultaneously increasing the rate of Cr accumulation in rice seedlings.

Key words: $Cr^{+6;}$ Chelating agents; Cr bioaccumulation; Flood susceptible rice.

Introduction

Developmental progress leads to contamination of soil with toxic heavy metal like Chromium in mining and industrial areas. This type of heavy metal soil contamination presently is a growing problem for mankind (Rouphael *et al.,* 2008). Growing crops of the contaminated sites or the sites present in the close vicinity of them could uptake and accumulate these metals in their organs (Jarup, 2003; Mohanty *et al.,* 2015). The exposure of plants to toxic metals can lead to numerous physiological disorders (Ali *et al.,* 2011, Patra *et al.,* 2015). Cr^{+6} is most toxic and carcinogenic out of its two forms. The toxic effect of the same increases in the presence of chelating agent. Addition of chelates in the soil helps in the mobilization of Chromium from soil to the plants parts and also increases the accumulation of Chromium by the plants. Hence, there is a great need for reliable and inexpensive technologies that are capable of reducing toxic heavy metals to environmentally acceptable level. Phytoremediation could provide an affordable way to restore the economical value of contaminated land. This technology employs a plant's natural ability to concentrate essential and non-essential elements in their tissues.

The main objective of the presence study is to analyses the change and accumulation of Cr in root and shoot of flood susceptible variety of rice *Oryza sativa* (L.) cv. Swarna during plant growth. Chromium bioavailability in the root and shoot system of 15 days old rice seedlings have been undertaken both in the presence and in the absence of various chelating agents grown under water logged and water deficit condition. The objective of this research is to study the effect of chelating agents on Chromium bioaccumulation by rice plants and to evaluate the applicability of phytoremediation for environmental restoration of soil contaminated with Chromium.

Materials and Methods

The flood susceptible cultivar of *Oryza sativa* (L.) cv. Swarna was used for the present work. Here, Potassium Dichromate ($K_2Cr_2O_7$) was used as the source of hexavalent Chromium. Graded dry uniform seeds of flood susceptible rice were surface sterilized by soaking in 0. 1% $HgCl_2$ solution for 5 minutes and then thoroughly washed with tap water and distilled water. Then the seeds were germinated in pots supplementing with Cr^{+6} (10mg), Cr^{+6} (50mg)/ Kg of soil with and without various chelating agents. Separate sets of plants were grown in both water logged & water deficit condition. Cr^{+6} (10mg), Cr^{+6} (50mg), EDTA- Cr^{+6} (10mg), EDTA- Cr^{+6} (50mg), CA- Cr^{+6} (10mg), CA- Cr^{+6} (50 mg), SA- Cr^{+6} (10mg) and SA- Cr^{+6} (50 mg) were supplemented to the seedlings.

Analysis of Cr uptake:

All the rice seedlings of 15 days old grown under control and various experimental conditions were grinded followed by oven drying (Bonet et al; 1991). The grinded samples were digested by adding Nitric acid and Perchloric acid in the ratio of 10:1 in a microwave digestion unit (MDS-8; Shanghai Sineo Microwave Chemistry Technology Co. Ltd., Shanghai, China). The acid digested solution was analysed with the help of an Atomic Absorption spectrophotometer (Perkin Elmer, AAnalyst 200, USA) for the estimation of Cr content in the root and shoot of the plant samples under different treatment condition.

Results

The photographs of rice plants under different treatment were given in plate1 and 2. A decrease in root & shoot length was noticed at higher concentration of Cr supplementation with all the chelating agents treated separately (Fig. 1A, B-2A, B). The fresh and dry weight of root and shoot also showed a reduction in biomass content in the seedlings treated with chelating agents than the seedlings treated with Chromium only (3A, B-6A, B). The plants treated with Only Chromium showed higher growth status in comparison to the other plants treated with chelated Chromium. The seedlings treated with EDTA- Cr^{+6} (50 mg) showed lowest root length, shoot length, fresh weight and dry weight than the seedlings treated with SA- Cr^{+6} (50mg), CA- Cr^{+6} (50mg). The uptake of Cr in shoot was decreased as compared to root in the seedlings both grown under water logged and water deficit condition (7A, B-8A, B).

Discussion

In the present study, the drought susceptible cultivar 'Swarna' seedlings showed more Cr mobilization in EDTA-Cr^{+6} (50mg) combination than other combination in water deficit condition than the water-logged condition. More Cr was accumulated in the rice root than whole shoot and grain reported by Bahmanyar, 2008; Mantry and Patra, 2015. Sauerbeck, (1991) reported that lower Cr concentration was found in the grains than roots of rice. Low translocation of Cr from root to aerial

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parts in temperate trees was reported by Pulford *et al.,* 2001; Mohanty and Patra, 2015. Davies *et al.,* (2001) reported that the uptake of Chromium to the shoot was enhanced by micronutrient and organic acid. Mohanty and Patra, (2012) reported that addition of EDTA as chelators was used to enhance the bioavailability of heavy metal for plant uptake. Chelating agents enhances the metal uptake because they have high metal extraction potential (Nowack *et al.,* 2006). The enhancement of metal uptake in the presence chelating agents was observed by several researchers (Zhao *et al.,* 2010; Cao *et al.,* 2007). Vernay *et al.,* (2008) reported that *Datura innoxia* plants grown in presence of hexavalent Chromium reduced growth leading to reduction in root and shoot biomass.

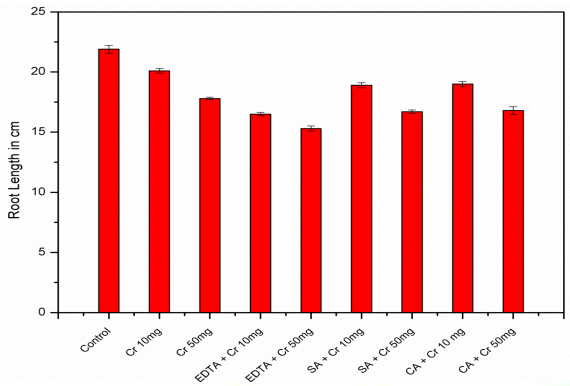

Fig.1A: Effect of Cr^{+6} and chelating agents on root length of 15 days old flood susceptible rice (Swarna) seedlings grown under water logged condition.

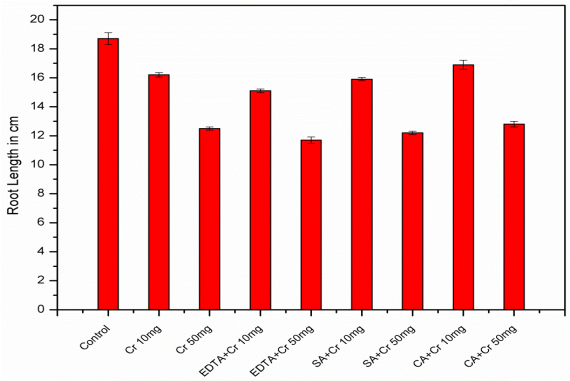

Fig.1B: Effect of Cr^{+6} and chelating agents on root length of 15 days old flood susceptible rice (Swarna) seedlings grown under water deficit condition.

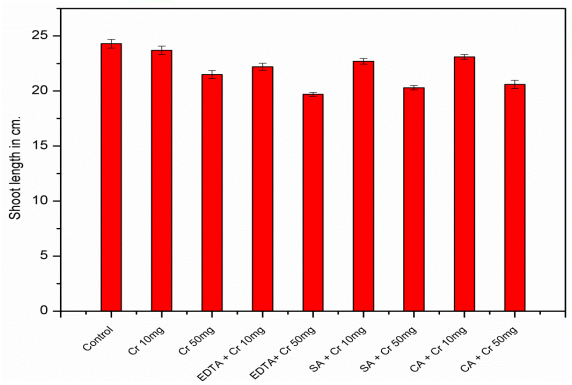

Fig.2A: Effect of Cr^{+6} and chelating agents on shoot length of 15 days old flood susceptible rice(Swarna) seedlings grown under water logged condition.

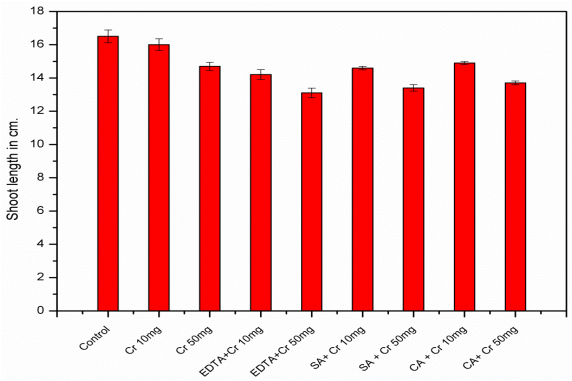

Fig.2B: Effect of Cr^{+6} and chelating agents on shoot length of 15 days old flood susceptible rice(Swarna) seedlings grown under water deficit condition.

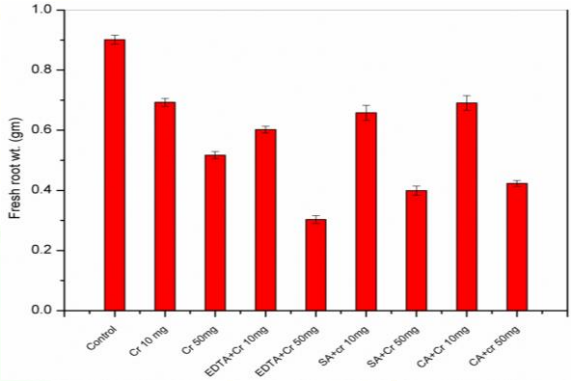

Fig.3A: Effect of Cr^{+6} and chelating agents on fresh root wt. of 15 days old flood susceptible rice(Swarna) seedlings grown under water logged condition.

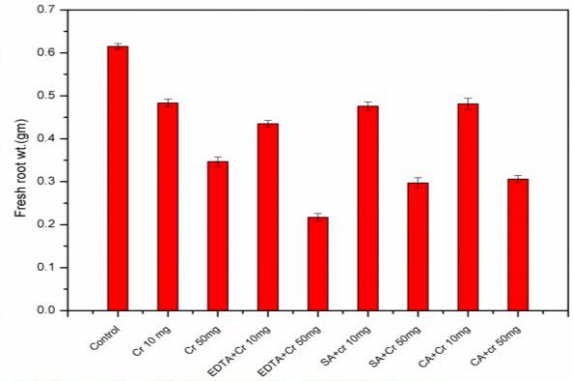

Fig.3B: Effect of Cr^{+6} and chelating agents on fresh root wt. of 15 days old flood susceptible rice (Swarna) seedlings grown under water deficit condition.

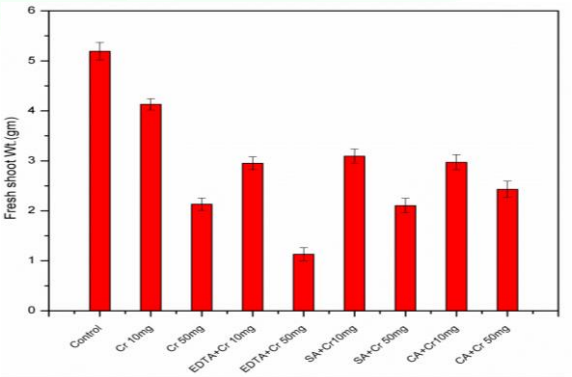

Fig.4A: Effect of Cr^{+6} and chelating agents on Fresh shoot wt. of 15 days old flood susceptible rice (Swarna) seedlings grown under water logged condition

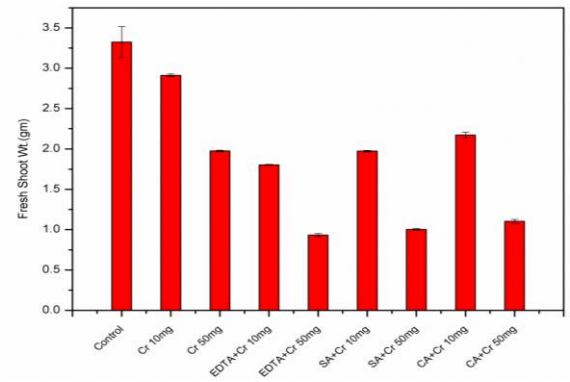

Fig.4B: Effect of Cr^{+6} and chelating agents on Fresh shoot wt. of 15 days old flood susceptible rice (Swarna) seedlings grown under water deficit condition

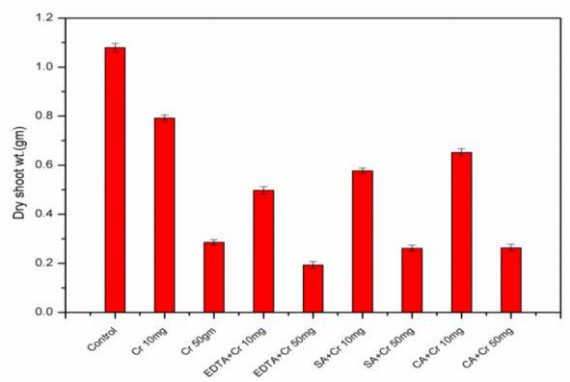

Fig.6B: Effect of Cr^{+6} and chelating agents on Dry shoot wt. of 15 days old flood susceptible rice (Swarna) seedlings grown under water deficit condition.

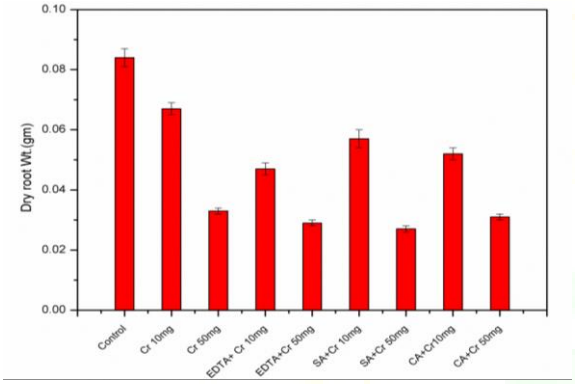

Fig.5A: Effect of Cr^{+6} and chelating agents on Dry root wt. of 15 days old flood Susceptible rice (Swarna) seedlings grown under water logged condition.

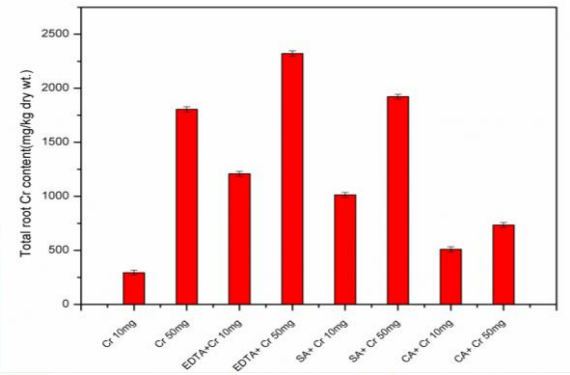

Fig.7A: Effect of Cr^{+6} and chelating agents on Total root Cr content of 15 days old flood susceptible rice (Swarna) seedlings grown under water logged condition.

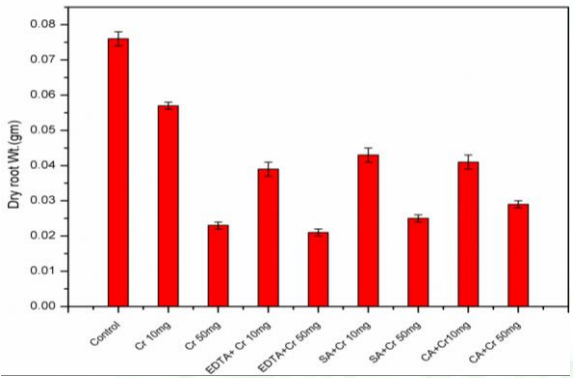

Fig.5B: Effect of Cr^{+6} and chelating agents on Dry root wt. of 15 days old flood susceptible rice (Swarna) seedlings grown under water deficit condition.

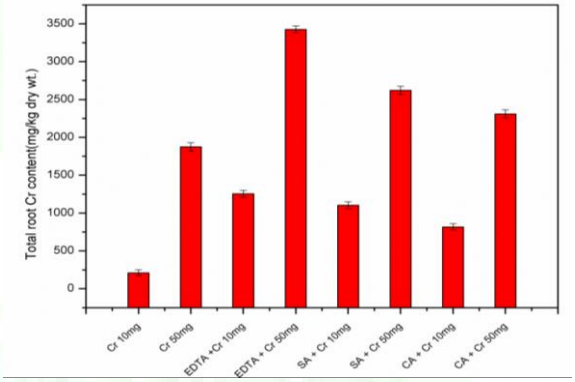

Fig.7B: Effect of Cr^{+6} and chelating agents on Total root Cr content of 15 days old flood susceptible rice (Swarna) seedlings grown under water deficit condition.

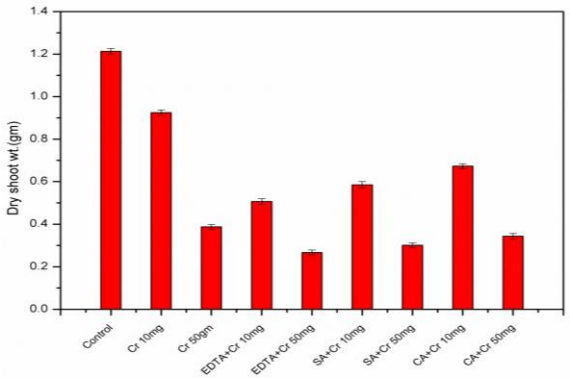

Fig.6A: Effect of Cr^{+6} and chelating agents on Dry shoot wt. of 15 days old flood susceptible rice (Swarna) seedlings grown under water logged condition.

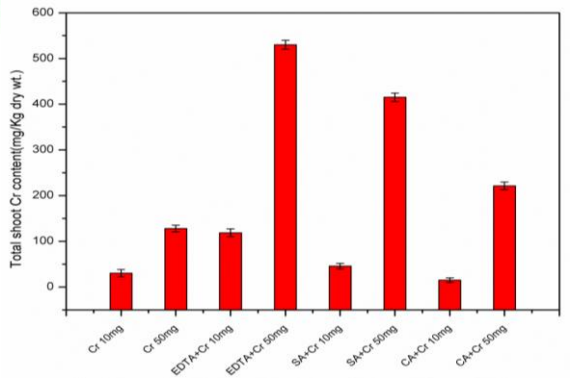

Fig.8A: Effect of Cr^{+6} and chelating agents on Total shoot Cr content of 15 days old flood susceptible rice (Swarna) seedlings grown under water logged condition.

Plate 1: Effect of Cr+6 and chelating agents on 15 days old seedlings of flood susceptible rice (Swarna) grown under water logged condition.

Plate 2: Effect of Cr+6 and chelating agents on 15 days old seedlings of flood susceptible rice (Swarna) grown under water deficit condition.

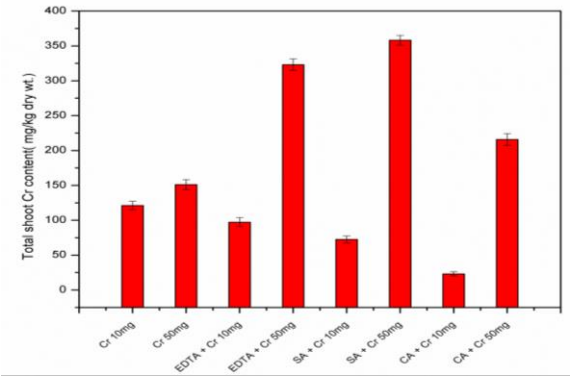

Fig.8B. Effect of Cr^{+6} and chelating agents on Total shoot Cr content of 15 days old flood susceptible rice (Swarna) seedlings grown under water deficit condition.

Conclusion

The seedlings of Flood susceptible rice cultivar 'Swarna' grown under treatment of EDTA-Cr^{+6} (50mg) showed decreased root, shoot length and much reduced biomass content in comparison to control condition and others. Application of EDTA in combination with Cr^{+6} (50mg) showed high root Cr bioaccumulation in flood susceptible rice seedlings. Uptake of Cr in root was high in rice seedlings when treated with EDTA-Cr^{+6} (50mg). Addition of chelating agents increases the mobilization of Chromium from soil to plants parts and also increases the Chromium accumulation by the plants. The study reveals the effective role of chelating agents in enhancing metal uptake. Hence in the undergoing research, the experimental plant 'flood susceptible rice cultivar' might also be effectively used in pollution prevention and waste reduction programme.

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