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EFFECTS OF CHROMIUM ON SEED GERMINATION AND SEEDLING GROWTH OF MUNG BEAN *VIGNA RADIATA* (L.) R. WILCZEK (FABACEAE)

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ABSTRACT: The availability of metals in the environment due to industrial and human activities is a worldwide problem. This paper provides information about the effects of various concentration of chromium treatment on seed germination and seedling growth performance of mung bean (*Vigna radiata*) as compared to control. In this study the treatment of chromium at different concentrations (0, 25, 50, 75 and 100 ppm) responded differently on all growth parameters viz shoot, root, seedling length, seedling dry weight and root / shoot ratio of *V. radiata.* There was no significant reduction in rate of seed germination of *V. radiata* with all treatment of chromium was recorded. The treatment of chromium at 25 ppm produced significant ($p<0.05$) effects on root, shoot and seedling length of *V. radiata* as compared to control. The reduction in the seedling dry weight of *V. radiata* at 50 ppm chromium was reduced and was more prominent with the increase in concentration at 100 ppm treatments. Tolerance indices and seedling vigor index of *V. radiata* for chromium treatment decreased with the increase in chromium concentration in the substrate as compared to control. More reduction in seedling tolerance and seedling vigor indices percentage of *V. radiata* was recorded at 50 ppm for chromium treatment. There was further reduction in seedling vigor and tolerance indices of *V. radiata* at 100 ppm chromium concentration as compared to control.

KEYWORDS: chromium, seed germination, seedling growth, phytotoxicity, tolerance index.

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1. INTRODUCTION

The introduction of heavy metal in the environment has considered a serious environmental concern for vegetation of the region due to human and industrial activities. Chromium contamination posing a serious threat to the environment, emerging as a major health hazard to the biota [1]. Plants take up a number of elements and higher concentrations of some are known to be toxic for germination and growth of plants even at low concentrations. These heavy metals are not only toxic to plants but also cause severe human health hazards when leach out into food chain [2]. Heavy metals are known to pose a potential threat to terrestrial and aquatic biota [3]. Lead chloride stress at 4.5 mM concentration affected seed germination of *Lens culinaris*[4]. Chromium alone led to a significant growth inhibition and content of chlorophyll a, b and proteins in wheat seedling [5]. Among the heavy metals, chromium is an important heavy metal and could be useful for ecotoxicology studies. The effects of chromium toxicity and tolerance in *Cannabis sativa* L., lentil, soya beans, wheat, fenugreek, in certain vegetables, date palm, pea and alteration in translocation of certain nutrients in Citrullus was reported by several workers [6-13]. Chromium is toxic element and easily absorbed by plants. Chromium is a potentially toxic metal and has no any essential metabolic function in plant growth and development. Phytotoxicity behaved with the action of interfering in plant growth, nutrient uptake and photosynthesis results in deleterious effects to several physiological, morphological and biochemical processes in plants [14]. Chromium is a heavy metal and has toxic effects on plants. A significant decrease was found in photosynthetic pigments, and germination and tolerance index of seedlings of maize (*Zea mays* L.) under chromium stress concentration treatment at 100 ppm [15]. Cr is widely used in industries like steel, leather and textile [16]. The common effects are degraded pigment status, inhibition of seed germination, nutrient imbalance, antioxidant enzymes, and changes in chloroplast and membrane ultrastructure and water stress in plants [17-22]. The addition of heavy metal in the environment has been increased alarmingly all around the world since the last couple of decade and is an important cause of reduction in plant growth especially in developing countries like Pakistan. Keeping in view of the ever increase of heavy metals concentrations in the environment; there is a need to evaluate the effects of metal like chromium on an important cash crop of Pakistan. Little is known about the effect of chromium on germination and growth performance of mung bean. The aim of the present study was to evaluate the effects of varying concentration of chromium on seed germination and seedling growth performance of legume crop *Vigna radiate* (L.) R. Wilczek). The results of the study could be useful as selection criteria for cultivation in chromium-contaminated areas.

2. MATERIALS AND METHODS

The healthy legume seeds of mung bean *Vigna radiata* (L.) R. Wilczek) were collected from the market. The percentage of germination was first checked. The seeds were surface sterilized with dilute solution of Sodium hypochlorite for one minute to prevent any type of fungal contamination. The seeds were washed with double distilled water and placed in Petri dishes (90 mm diameter) on

filter paper (Whatman No. 42) at room temperature. Ten seeds were placed in each petri plate and there were three replicates. Solutions of chromium salt as potassium chromate were prepared having five 0, 25, 50, 75 and 100 ppm concentrations for treatment. The concentration of zero (0) served as control. The start of experiment, 5 ml of metal solution of 25, 50, 75 and 100 ppm concentrations to each set of respective treatment was applied. After every two days, 2 ml of 25, 50, 75 and 100 ppm solutions of chromium were added to respective treatment. The control received only 2ml of distilled water on alternate days. The experiments was designed on the basis of three replicates, the Petri dishes were kept at room temperature (32±2°C) with 240 Lux light intensity, and the experiment lasted for 10 days. The experiment was completely randomized. Seed germination, root, shoot, seedling lengths and root / shoot, ratios were recorded. The seedling dry weight was determined by drying the 3 tallest seedling from each replicate for each concentration, the one having good growth and placing the seedling in an oven at 80°C for 24 hours. Seedling dry biomass was measured with electrical balance.

Seedling vigor index (S.V.I) was determined as per the formula given by [23].

Analysis of Variance (ANOVA), standard error and Duncan's Multiple Range Test (DMRT) to determine the level of significance at $p < 0.05$ on personnel computer using COSTAT version 3, statistically analyzed the seed germination and seedling growth data.

Tolerance indices of seedlings were determined with the help of the following formula.

$$\text{Tolerance indices (T.I.)} \quad \frac{\text{Mean root length of treated seedlings}}{\text{Mean root length of control seedlings}} \times 100$$

3. RESULTS AND DISCUSSION

Chromium treatment did not produce any significant effects on seed germination percentage of *V. radiata* as compared to control (Table 1). Chromium treatments at 25 ppm significantly ($p<0.05$) affected root, shoot and seedling growth of *V. radiata* as compared to control. The results indicated that root was strongly affected by all concentration of chromium treatments as compared to shoot length of *V. radiata*. The results for shoot length of *V. radiata* showed similar trend as in case of root growth. With the increase in concentration of chromium at 100 ppm a profound effects on seedling length of *V. radiata* were recorded. Seedling size of *V. radiata* which includes the length of root and shoot was recorded as 28.95 cm for control and which decreased to 16.51 cm, 12.43 cm, 8.34 cm and 8.26 cm when treated with 25, 50, 75 and 100 ppm of chromium solution, respectively. A gradual decrease in seedling dry weight of *V. radiata,* was recorded when treated with different concentration of chromium as compared to control. The seedling dry weight of *V. radiata* was significantly decreased with increase in concentration up to 100 ppm of chromium.

Table 1: Effects of chromium on different growth parameters of *Vigna radiata*

Treatments (ppm)	Seed Germination (%)	Root length (cm)	Shoot length (cm)	Seedling Length (cm)	Seedling dry weight (g)	Root length/shoot length Ratio
00	100.00±0.00a	11.82±0.66a	17.13±0.66a	28.95±1.48a	0.090±0.006a	0.675±0.025b
25	100.00±0.00a	7.41±0.07b	9.06±0.07b	16.51±0.31b	0.066±0.001b	0.823±0.51a
50	100.00±0.00a	4.81±0.46c	7.62±0.46c	12.44±8.34c	0.046±0.004b	0.630±0.32bc
75	100.00±0.00a	2.78±0.08d	5.72±0.08d	8.34±0.23d	0.040±0.005c	0.502±0.25cd
100	100.00±0.00a	2.52±0.16d	5.71±0.16d	8.27±0.27d	0.030±0.005d	0.453±0.06d

Values followed by the same letters in same column are not significantly different ($p<0.05$) according to Duncan's Multiple Range Test.

The seedlings of *V. radiata* showed different percentage of tolerance to chromium treatment as compared to control (Fig. 1). A high percentage of tolerance to chromium treatment at 25 ppm for *V. radiata* as compared to control was recorded. The better percentage of chromium tolerance indices for *V. radiata* seedlings was recorded at 50 ppm. The lowest percentage of seedling tolerance indices for *V. radiata* was recorded at 100 ppm for chromium treatment. The tolerance in seedlings of *V. radiata* to chromium treatment were reduced with the values 52.91, 44.48 and 32.42 percent when treated with 25, 50 and 75 ppm chromium concentration as compared to control, respectively.

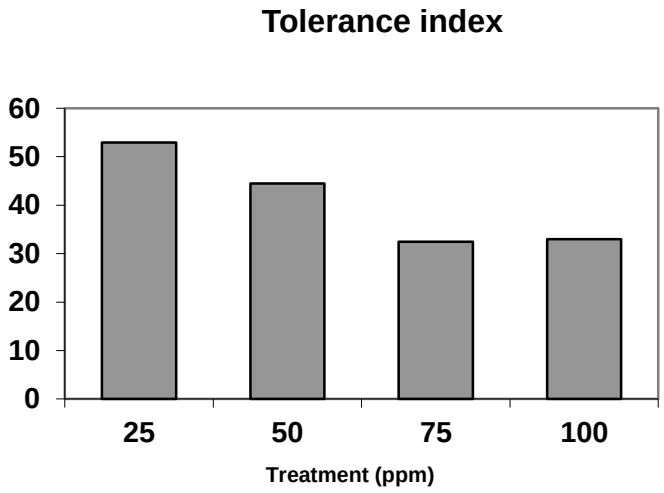

Fig 1: Percentage of tolerance in *V. radiate* using different concentration of chromium (25, 50, 75, 100 ppm)

A direct relationship between seedling vigor index and chromium treatment in seedlings of *V. radiata* was recorded. An increase in chromium concentration decreased seedling vigor index. Seedling Vigor Index (S.V.I.) for *V. radiata* was highest at 25 ppm treatment and gradually declined with the increase in concentration of Cr treatments from 25 to 100 ppm (Fig. 2). Similarly, the reduction in seedling vigor indices of *V. radiata* for chromium treatment at 100 ppm was prominent as compared to control.

The subsequent treatment of chromium at 25, 50, 75 and 100 ppm decreased the seedling vigor index in seedlings of *V. radiata* by 1651.10, 1244.40, 834.40 and 827.70 percent as compared to control (2895.30), respectively.

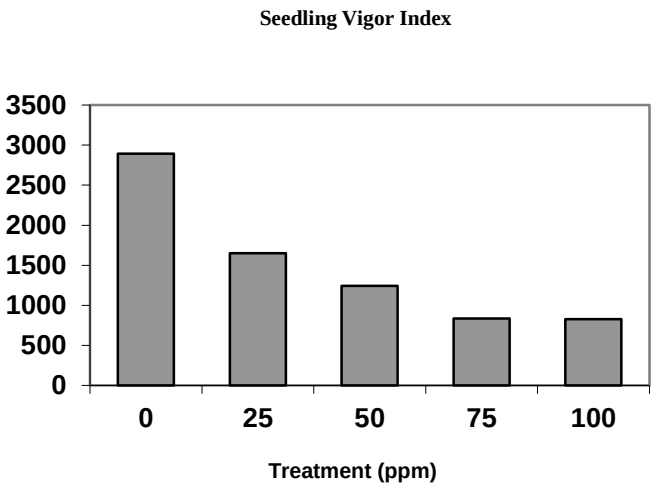

Fig 2: Seedling vigor index for *Vigna radiata*using different concentration (0, 25, 50, 75, 100 ppm) of chromium as compared to control

DISCUSSION

This study provides evidence that the application of various concentration of chromium contributes to decreased seedling growth in mung bean.There was no significant reduction in seed germination percentage of mung bean was observed which might be due to its resistance to chromium at all concentration to some extent. Germination and seedling establishment are critical stage in the life cycle of plant and can be affected in the presence of high level of metals.in the immediate environment. Heavy metals have specific function and role in plant growth. Chromium is toxic heavy metal and easily available in air, water and soil. It was observed that among the heavy metal, chromium was found toxic at higher level. The plant under stress conditions are most likely to be adversely affected by heavy metals treatments. In the present studies, the toxicity of chromium at 25, 50, 75 and 100 ppm on seedling growth and yield performances of *V. radiata* were significantly affected. *V. radiata* was subjected to different concentrations of chromium. The root growth of *V. radiata* was more affected with the Cr treatment as compared to shoot. A significant inhibition in root length of *V. radiata*was found at 100 ppm as compared to control. In another study, the toxic effect of $PbCl_2$ at 1.00 mM on the root growth of lentil (*Lens culinaris*) was recorded [24]. The roots of *P. oleracea* seedlings were more sensitive to heavy metal in comparison with shoot [25]. The results for shoot length showed similar trend as in case of root growth, the shoot length of *V. radiata* decreased with the reduction in root length, which might be due to decreased in nutrients and water uptake from the substrate. The seedling size, which includes the length of root and shoot, was greatly decreased

when treated with 100 ppm of chromium as compared to control. Tolerance in seedlings of mung bean was decreased with the increase of chromium. The results also showed that seedling dry weights of *V. radiata* were also declined with increased concentration of chromium treatment. Essential and non-essential heavy metals generally produce common toxic effects on the production of low biomass, photosynthesis, alteration in water balance and nutrient assimilation [26]. The present investigation confirmed that seed germination and seedling growth was affected under different concentrations of chromium. The response of mung bean seedlings at optimum dose of chromium at 100 ppm can help in understanding the tolerance limit to chromium stress. In addition to growth inhibition of *V. radiata,* chromium treatment reduced biomass production. The effects of Cr has been reported in several studies over the last few years. At the cellular level, oxidative stress have been reported as a common mechanism in both stress situations [27]. All results treated with different concentration of chromium when compared with the control treatment showed reduction in seedling and vigor indices of *V. radiata*and agreed with the findings of other researchers. Chromium treatment at 100 mg kg-1 in pot adversely affected seedling growth, and seedling vigor index and biochemical attributes of *Hibiscus esculentum* L. [28]. It was found that lemon grass (*Cymbopogan flexuosus* Nees ex.steud.wats.) did not tolerate Cr beyond 50 ppm in pot culture experiment [29].

4. CONCLUSION

It was concluded that the treatment of different concentration of chromium at higher concentration produced toxic effects on seedling growth of *V. radiata* along with significant reduction in yield production as compared to control treatment. Similarly, the tolerance and seedling vigor index to chromium treatment decreased with the increase in chromium application for *V. radiata* seedlings. The difference in tolerance to chromium toxicity should be considered while cultivated in chromium-contaminated areas and to cover the risk of chromium reference role in food chain. It was also concluded that chromium concentrations at 50 and 100 ppm have negative effects on germination and seedling growth of mung bean. High Cr concentration (100 ppm) caused more damage.

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CONFLICT OF INTEREST

There is no conflict of interest exists among authors.

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