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Effects of chromium on seed germination and early seedling growth of *Vigna radiata* (L.) Wilczek

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Abstract

In the present project work the effects of chromium on the seed germination and early seedling growth of *Vigna radiata* (L.) Wilczek were studied. The seeds of *V. radiata* were surface sterilized and allowed to germinate in Petri plates lined with cotton which were soaked with different concentrations of chromium solution. The percentage of germination of seeds in each concentration was noted. Moreover, the seedling growth parameters like shoot length, fresh weight, dry weight, dry weight percentage and moisture content percentage were also analyzed under different concentrations of chromium and compared with control plants. From the results, it was found that chromium reduced the germination percentage of seeds and also caused significant reduction in the early seedling growth of *Vigna radiata* (L.) Wilczek.

Key words: Chromium, dry weight, fresh weight, germination, seedling

Introduction

Plants are exposed to various environmental conditions throughout their life period. Some of these environmental conditions become adverse to the growth and development of plants. These environmental factors include biotic and abiotic factors which interfere with the growth and development of plants. Abiotic stress cause changes in soil-plant-atmosphere continuum and is responsible for reduced yield in several major crops. Therefore, the subject of abiotic stress response in plants is gaining considerable significance in the contemporary world. The major abiotic stresses for which plants are exposed include extreme temperature, drought, salinity, heavy metals etc. These stresses are the most significant factors which cause substantial and unpredictable loss in the crop production (Jakab *et al*. 2005).

Heavy metals are the most crucial component of the environment that frequently accumulate in the soil due to unplanned municipal waste disposal, mining, use of extensive pesticides and chemical fertilizers. These are metallic chemical elements with a high atomic weight and density much greater (at least five times) than water. They are highly toxic and cause ill effects even at very low concentrations and the includes mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Ti), lead (Pb), copper (Cu), zinc (Zn), manganese (Mn), iron (Fe), and magnesium (Mg). Hyper accumulation of heavy metals may lead to toxic effect in human, animals, plants and other microorganisms and create a serious threat to biota and the environment. Phytotoxicity of heavy metals hinders physiological as well as biological process of plant which collectively affects plant

development and growth (Kramer and Clemens 2005).

Among these heavy metals chromium is an important one. Chromium (Cr) is a heavy metal that causes serious environmental contamination in soil, sediments, and groundwater (Shanker *et al*. 2005). Toxicity of chromium has been studied in many plants. Excess of Cr causes inhibition of plant growth, chlorosis in young leaves, nutrient imbalance, wilting of tops, and root injury (Sharma *et al*. 2003; Scoccianti *et al*. 2006).

In the present project work the effects of chromium on the seed germination and early seedling growth of *Vigna radiata* (L.) Wilczek were investigated by analyzing the germination percentage and the various growth parameters of the seedlings.

Materials and methods

Plant material

The research was carried out with the seeds of *Vigna radiata* (L.) Wilczek were procured from stores at Kodungallur.

Methods

Incubation of seeds in the Petri dishes

Healthy and plumby seeds of *V. radiata* were washed with 0.1% mercuric chloride, detergent solution and distilled water to remove any dirt present on the seed surface. The washed seeds were surface dried by using filter paper. All the seeds were allowed to germinate in Petri dishes containing absorbent cotton soaked with distilled water (control) and different concentrations of chromium (treatment). In order to prepare different concentrations of chromium, 1M stock solution of potassium dichromate was prepared first and then it was diluted to lower concentrations (2mM, 4mM, 6mM, 8mM and 10mM) at the time of experiments. All the Petri dishes were kept in the culture racks under controlled light and temperatures. Seeds were allowed to germinate and examined regularly for the data collection.

Determination of germination percentage

For the determination of germination percentage, the number of seeds germinated in each sample at specific intervals was noted and percentage of germination was calculated by using the following formula.

$$\text{Germination percentage} = \frac{\text{No. of seeds germinated}}{\text{Total No. of seeds}} \times 100$$

Determination of Shoot length, fresh weight, dry weight, dry weight percentage and moisture content percentage.

Shoot length of seedlings were measured by using scale. Measurements were taken in seedlings which were nine days old. The seedlings were weighed using electronic balance. For fresh weight and dry weight measurements, the seedlings were blotted and wrapped separately in pre-weighed labelled aluminium foils. Fresh weight of the samples was determined by weighing them immediately after wrapping. For dry weight measurements the samples were kept in a hot air oven at 100^0 C for one hour followed by at 60^0C for overnight. After 48 h, the samples were transferred to a desiccator, allowed to cool and then weighed. The samples were reweighed as described above at regular intervals (24h), until the weights became constant. The dry weight percentage was calculated by using the following formula:

$$\text{Dry weight percentage} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Moisture content percentage was calculated by using the following formula

$$\text{Moisture content percentage} = \frac{\text{Fresh weight - Dry weight}}{\text{Fresh weight}} \times 100$$

Statistical analysis

The results were analysed by using Microsoft excel. Standard deviation and standard error were determined for each category of data.

Results

Germination percentage

As far as the germination percentage of seeds were concerned, we got 100% seed germination in control set while the germination percentage was found to be reduced in the higher concentrations of chromium (2mM, 4mM, 6mM, 8mM and 10mM). The germination percentage was found to be very less (10%) in the concentration of 10mM (Fig. 1A).

Shoot length, fresh weight, dry weight, dry weight percentage and moisture content percentage

Among the different treatments, shoot length, fresh weight and moisture content percentage were found to be maximum in the seedlings which were raised in control and it was 19 cm. In the treatments the shoot length of seedlings was very less and it showed a decrease in increasing concentrations of chromium. Fresh weight of seedlings also found to be higher in control seedlings (0.31g) and it decreased with increased concentrations of chromium. But the dry weight and dry weight percentage was found to be less in control seedlings and it was higher in chromium treatments. The dry weight was found to be maximum (0.034 g) in the seedlings which were raised in 2mM chromium solution. While the dry weight percentage was found to be maximum in the seedlings which were raised in 10mM chromium solution. Moisture content percentage was found to be more in control seedlings when compared to treatments (Fig. 1B, 2A, 2B, 3A, 3B).

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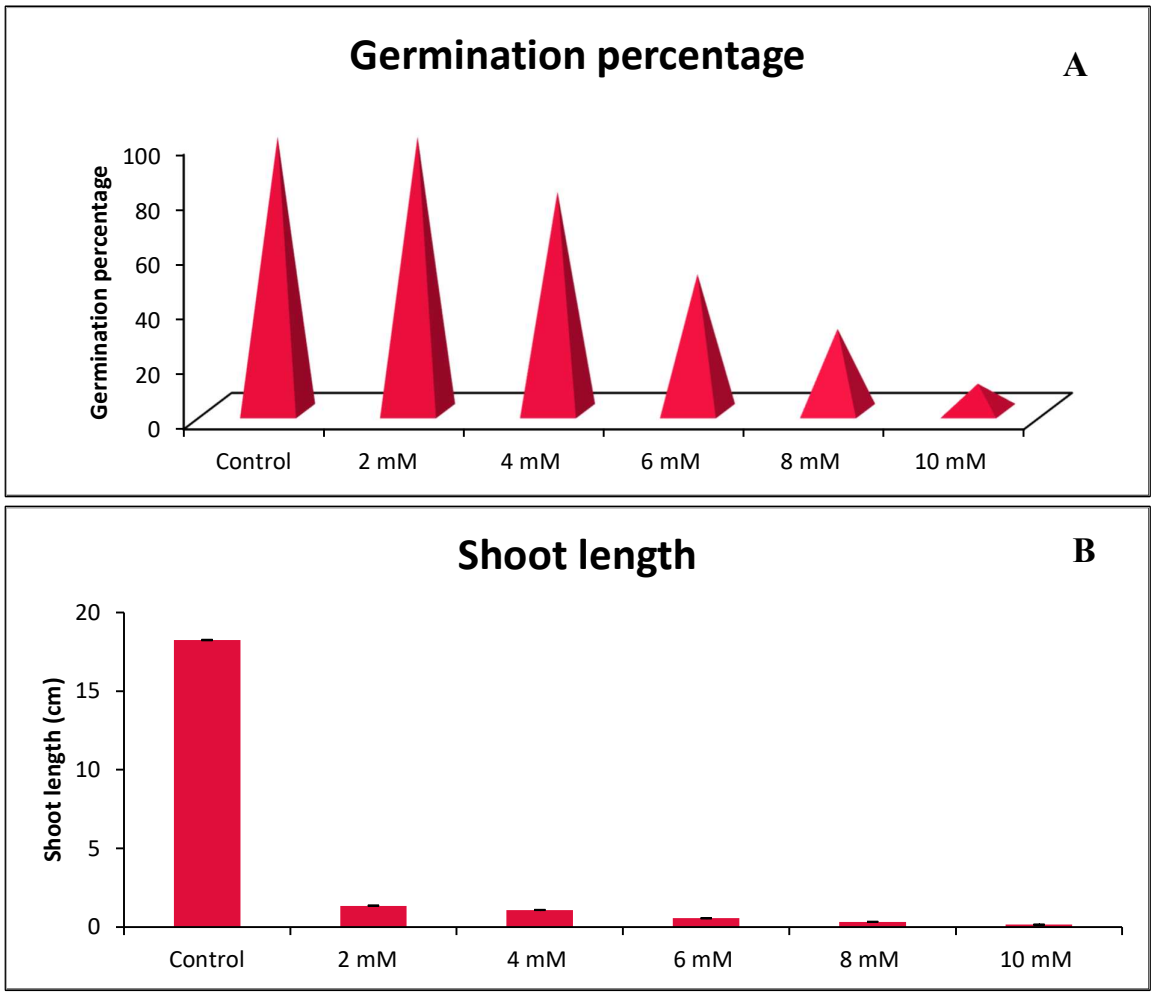
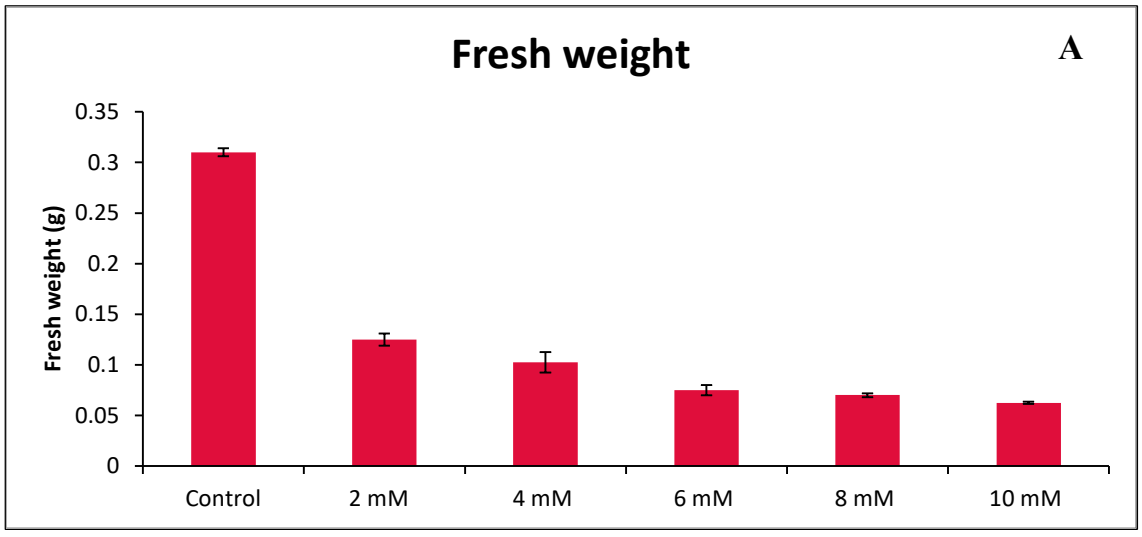


Fig.1: Germination percentage (**A**) and Shoot length (**B**) of *Vigna radiata* L. Wilczek raised under control and different concentrations of chromium (2mM, 4mM, 6mM, 8mM, 10mM). The vertical bars represent SE of the mean value of recordings from three independent experiments each with a minimum of three replicates.



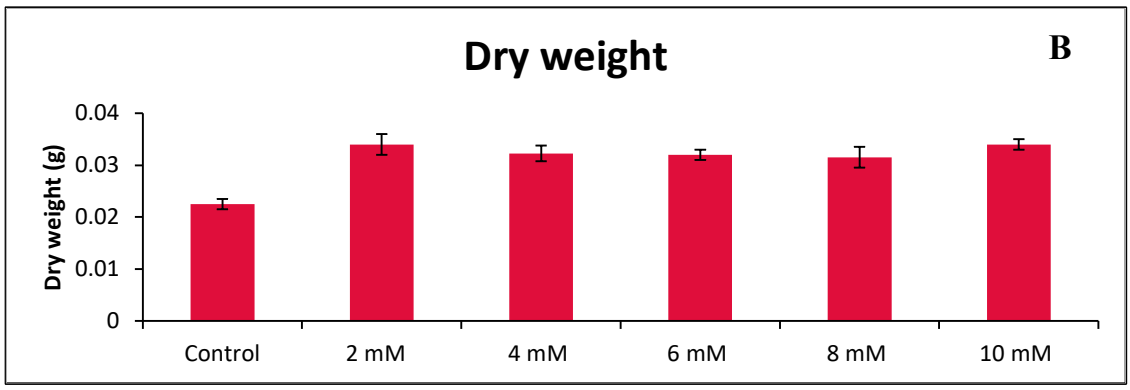
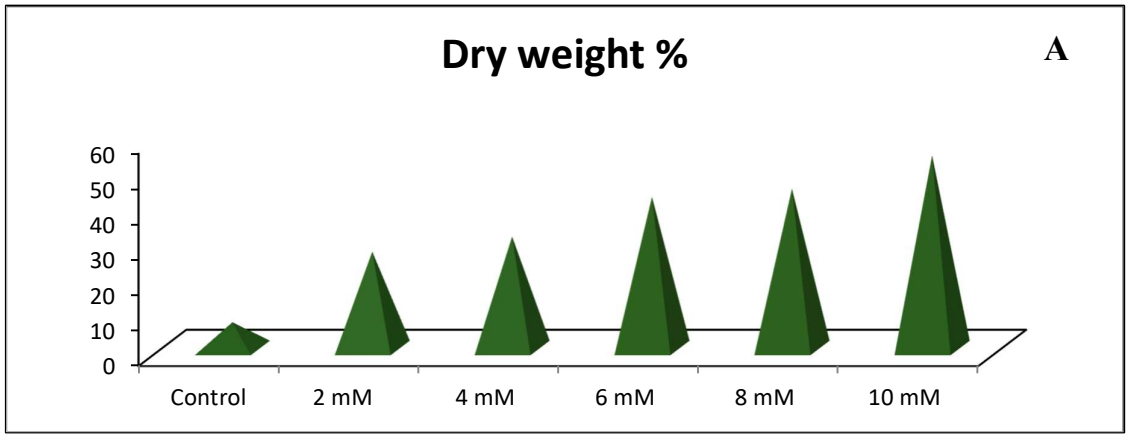


Fig.2: Fresh weight (**A**) and Dry weight (**B**) of *Vigna radiata* L. Wilczek seedlings raised under control and different concentrations of chromium (2mM, 4mM, 6mM, 8mM, 10mM). The vertical bars represent SE of the mean value of recordings from three independent experiments each with a minimum of three replicates.



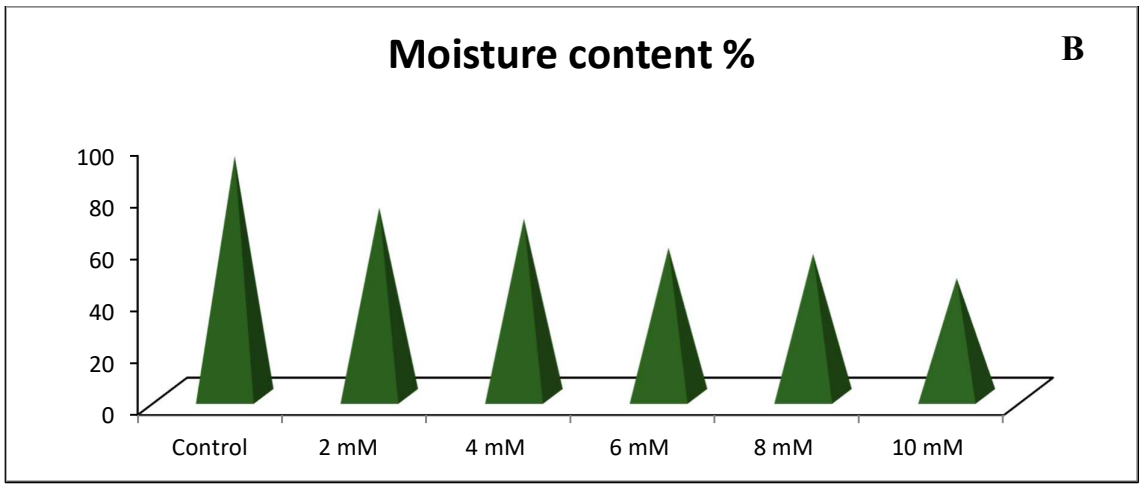


Fig.3: Dry weight percentage (**A**) and Moisture content percentage (**B**) of *Vigna radiata* L. Wilczek seedlings raised under control and different concentrations of chromium (2mM, 4mM, 6mM, 8mM, 10mM). The vertical bars represent SE of the mean value of recordings from three independent experiments each with a minimum of three replicates.

Discussion

Nowadays, environmental stress is an important factor that causes significant reduction in crop yield. Heavy metals contribute much of these environmental issues. Chromium is one of the heavy metal which significantly affect the growth and development of various plants. In the present research work, the effects of various concentration of chromium on the seed germination and early seeding growth of *V. radiata* were studied. From the results, it was found that chromium reduced the germination percentage of *V. radiata* seeds indicating the negative effects of this heavy metal on the seed germination. According to Zeid (2001), the reduced germination of seeds under Cr stress would be due to the depressive effect of Cr on the subsequent transport of sugars to the embryo axis. Protease activity increases simultaneously with the chromium treatment which could also contribute to the reduction in germination of chromium treated seeds (Zeid, 2001).

In the present study, the seedling growth was also found to be varied under different treatments. As far as the shoot length and fresh weight of seedlings were concerned, it was found to be higher in the seedlings which were exposed to lesser concentrations of chromium when compared to higher chromium concentrations. The reduction in shoot length and fresh weight of seedlings may be due to the reduced root growth and consequent lesser nutrient and water transport to the above parts of the plant. In addition to this, chromium transport to the aerial part of the plant can have a direct impact on cellular metabolism of shoots contributing to the reduction of plant height (Shankar *et al.* 2005). The result showed an increased dry weight of seedlings as the concentration of chromium increased. It again indicates that the water content of the seedlings under stress get reduced which ultimately resulted in high dry matter.

Thus the present research work indicates that chromium has a significant negative effect on the seed germination and early seedling growth of *Vigna radiata* (L.) Wilczek.

Summary and conclusion

In the present project work the effects of chromium on the seed germination and early seedling growth of *Vigna radiata* (L.) Wilczek were studied. The seeds of *V. radiata* were surface sterilized and allowed to germinate in Petri plates lined with cotton which were soaked with different concentrations of chromium solution. The percentage of germination of seeds in each concentration was noted. Moreover, the seedling growth parameters like shoot length, fresh weight, dry weight, dry weight percentage and moisture content percentage were also analyzed under different concentrations of chromium and compared with control plants. From the results, it was found that chromium reduced the germination percentage of seeds and it was found that germination percentage was very less in higher concentration of chromium (10mM). The high concentration of chromium also caused significant reduction in the early seedling growth of *Vigna radiata* (L.) Wilczek and was evident from the growth attributes of seedlings.

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