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CHANGES IN BEAN PLANT GROWTH IN LEAD-CONTAMINATED SOIL

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Abstract: Heavy metals are the stress factors that cause important problems in plant production and environment. Among the heavy metals that cause a decrease in plant growth and development, lead can have an important effect depending on its concentration. Higher concentrations in root rhizosphere can negatively impact plant growth and yield. In this study, parameters related to plant growth were investigated in beans grown in soil contaminated with lead at different concentrations (0, 1000, 1500, 2000 mg kg^{-1}). The potting soil prepared in the greenhouse study was first treated with the indicated doses of lead and left to incubate for three weeks, and then seeds were sown in to the pots. In the study, the effect of lead application was evaluated on stem diameter, plant height, leaf area, leaf fresh weight, shoot fresh weight, root fresh weight, leaf dry weight, shoot dry weight, root dry weight, SPAD value, chlorophyll a, chlorophyll b, total chlorophyll, electrical leakage (EL) and leaf relative water content (LRWC) of bean seedlings. Findings of the study indicated that there was a significant decrease in growth and chlorophyll contents of bean seedlings in parallel with the increased lead dose. Also, with increasing lead level, LRWC decreased while EL increased. As a result, it has been determined that lead led to reduce in growth and development in bean seedlings, and seen that in the next stage, it will cause significant reductions in yield leads to economic loss of income for the producer.

Keywords: bean, heavy metal stress, lead, plant growth

Introduction

Today, heavy metals, which have started to accumulate widely in the environments of ecosystems such as soil, water and air, have become an important environmental problem that threatens the life of all organisms on the earth's surface. Increasing industrialization and urbanization activities in recent years causes serious environmental problems such as heavy metal toxicity (Nas et al., 2018). Increasing heavy metal pollution lead to great problems for the development of sustainable agriculture (Faiz et al., 2022). Lead (Pb), which is considered the second most harmful metal, has a toxic effect for all living things even at very small concentrations (Chen et al., 2022). Pb, which enters the plant cell with the help of roots, negatively affects many properties of plants (Kohli et al., 2019; Chen et al., 2022).

In *Zea mays*, Pb has been reported to significantly reduce germination, lengths of shoots and roots lengths, biomass weights, photosynthetic rate, water use efficiency (Ahmad et al., 2011). *Lactuca sativa* exposed to Pb stress showed a decrease in morphological, physiological and biochemical parameters (soluble protein content) (Capelo et al., 2012). In the present study is study, some morphological and physiological characteristics were measured to evaluate the impacts of Pb in beans.

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Materials and Methods

This study was conducted under greenhouse with day/night temperature of 25/18 °C. Pb ($Pb(NO_3)_2$) was contaminated to the medium (2:1:1 (v:v:v); soil:sand:peat) at four doses (0, 1000, 1500 and 2000 $mgkg^{-1}$ Pb). The pots, from each Pb level, were irrigated to field capacity, left to equilibrate for three weeks, then three bean seeds were planted into pots, and one seedling was left after germination.

For vegetative growth attributes, stem diameter, plant height, leaf area, fresh weight of the leaf, shoot and root were determined. The plant material was kept at 70 °C for 48 h for measure of leaf, shoot and root dry weight.

Leaf area was determined with CI-202 (CID, Inc USA). SPAD value was determined with SPAD-502 Plus).

LRWC was determined according to Sahin et al. (2018). The LRWC is calculated by the formula given below.

$$\text{LRWC \%}: \ [(FW - DW)/(TW - DW)] \times 100.$$

EL was measured according to Sahin et al. (2018). EL is calculated by the formula given below.

$$EL = (EC1/EC2) \times 100$$

Chlorophyll a, b and total chlorophyll were determined at 645 and 663 according to Sahin et al. (2018).

SPSS (software version 19.0) was used to analyze the data. Duncan test was employed to compared the means.

Results and Discussion

Heavy metal stress conditions can negatively influence soil, hindering crop performance (Zhou et al., 2020). Morphological differences were observed between treatments. Pb, which is not essential for plant growth, caused inhibition of root and shoot development on seedling growth. Depending on the increasing concentration, Pb application caused a decrease in plant growth compared to control. The highest decrease occurred at 2000 mg kg^{-1} Pb concentration compared to the control, and decreased by 20.47%, 18.32% and 20.22% in plant height, stem diameter and leaf area, respectively (Figure 1A).

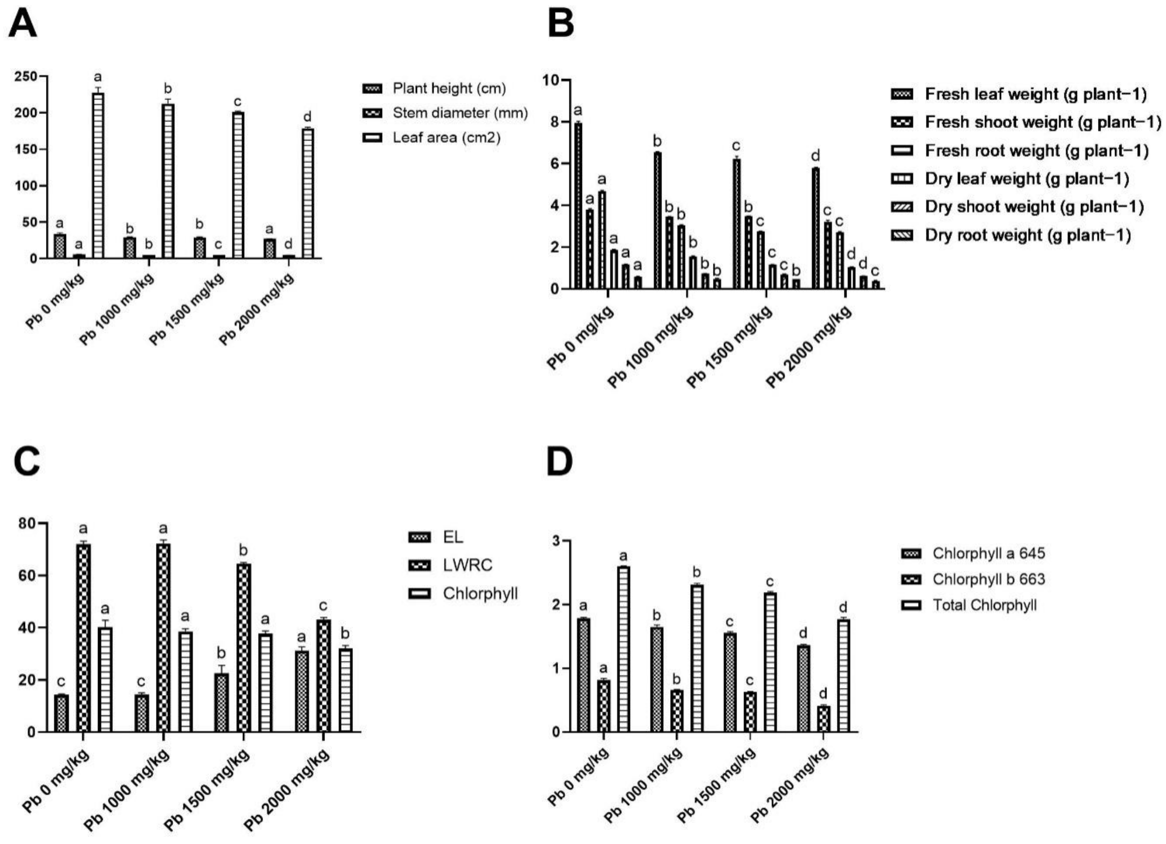

Figure 1: A:Pb heavy metal toxicity induced changes on growth (plant height, stem diameter, and leaf area) B:Effects of Pb heavy metal on plant fresh and dry weight C:Effects of Pb heavy metal on EL, LRWC and chlorophyll (SPAD) D:Impact of Pb on chlorophyll a, b and total in bean seedlings.

In this study, biomass production of bean seedlings decreased in beans as Pb application increased (Figure 1B). Compared to the control, 2000 mg kg^{-1} Pb application decreased the fresh leaf, stem and root weights by 27.16%, 15.56%, and 42.09%, respectively. In addition, 2000 mg kg^{-1} Pb application decreased the dry leaf, stem and root weights by 43.78%, 48.71% and 32.75%, respectively, compared to the control. Similarly, lead stress conditions have been previously indicated in several crops (Brunet et al., 2008; Malar et al., 2016). Restricted plant growth could be due to the inhibition of mitotic index caused by Pb stress (Vecchia et al., 2005).

Pb concentration of 1500 mg kg^{-1} increased EL by 56.36% compared to control (Figure 1C). Increasing EL amount decreased membrane integrity. LRWC content decreased at all Pb concentrations and the greatest decrease was observed at 2000 mg kg^{-1} Pb treatment (40.29%) compared to control. Heavy metal stress conditions have been reported to reduce LRWC value as an indicator of phytotoxicity (Su et al., 2005). Similarly, the amount of chlorophyll (SPAD) decreased at all Pb concentrations and the highest decrease was observed in 2000 mg kg^{-1} Pb treatment (20.22%) compared to control.

The impact of Pb applications (1000 to 2000 mg kg^{-1}) on chlorophyll pigment is shown in Figure 1D. Chlorophyll content was reduced with increasing the Pb doses. The chlorophyll a, b and total chlorophyll was reduced by 23.59%, 49.38% and 31.92%, respectively, in 2000 mg kg^{-1} Pb treated plants compared to the control. Heavy metals cause chlorophyll degradation and decrease in leaf chlorophyll index by inhibiting chlorophyll synthesis (Ayhan et al., 2005; Comlekcioglu and Simsek, 2017).

Conclusion

In conclusion, Pb stress inhibited plant growth by affecting physiological and metabolically properties of bean seedlings.

Declaration of Interest Statement

The authors declare that they have no conflict of interests.

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