# Effects of Lead Stress on Growth and Some Physiological Characteristics of Bean

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**Abstract:** This study was conducted to determine the effects of different lead (0, 1000, 1500 and 2000 mg/kg) levels on physiological and morphological responses of bean plants in 2019 in Atatürk University, Faculty of Agriculture, Department of Horticulture under laboratory and greenhouse conditions. Bean (*Phaseolus vulgaris* L.) Gina cultivar was used as plant material in the experiment. According to study findings, it was determined that differences between treatments were statistically important. The bean plants grown under heavy metal stress conditions were affected regarding to plant growth parameters (fresh and dry weight ect.), some plant physiological parameters such as tissue electrical conductivity (TEC), tissue rational water content (TRWC). Lead stress conditions negatively affected plant growth. Plants grown under heavy metal stress had more TEC and less TRWC values compared to the control plants. Heavy metal stress caused the decreased chlorophyll a, chlorophyll b and caretenoid content in bean plants. In conclusion, bean plants responded to lead stress by reducing growth, TRWC and pigment concentration, increasing TEC.

**Keywords:** *Phaseolus vulgaris*, Heavy metal, Physiology.

## INTRODUCTION

With the development of industry; our ecosystem is exposed to heavy metal accumulation. Soil, water and heavy metals accumulated in the air directly affect all living things in the world. Exhausts of motor vehicles, industrial activities, mining operations, fertilizers and chemicals used in agricultural activities, volcanic activities and urban wastes caused heavy metals to spread to the environment [1]. Heavy metals, which may be present in different proportions in the ecosystem, have direct negative effects on plant growth and physiology. In areas where heavy metal content is high, there are serious yield losses in plants [2]. Heavy metal (Cd, Ni, Pb, Cu, Zn) concentrations are higher in the plant production areas causing stress in the plant. Heavy metal stress in the plant, by encouraging the formation of free radicals can damage plant tissues and can lead to oxidative damage [3].

Heavy metals cause damage to plants primarily in the roots. Heavy metals cause shortening of roots and prevention of fringe root formation. Heavy metals have also been reported to cause deterioration of the epidermis and hypodermis by lignification of the roots. In later periods, the effect starts to be seen in other parts of the plant. Fresh and dry weights of both root and stem are reduced and plant growth slows down. In addition, depending on the type of metal and concentration of leaf areas shrinkage, shape changes, yellowing and various necrotic spots appear [4].

Bean (*Phaseolus vulgaris* L.) is a legume plant that can be grown for dry grain or fresh purposes in almost every part of Turkey and World. High protein (22.6%), carbohydrate (56%), minerals and vitamins in the grains increase the importance of dried beans. Beans also contain phasol and phaseolin, which is also lowering effect on blood sugar [5].

Plants' response to heavy metal stress may vary. As a result of our literature review, it is seen that studies investigating the reactions of bean to heavy metal stress are limited. This study was carried out under greenhouse conditions to determine the effect of heavy metal stress on plant growth and some physiological properties in bean which is an important problem for agricultural land and waters of our country.

## MATERIALS AND METHODS

### Experiment Set Up

This research was conducted in the greenhouse and laboratory of Department of Horticulture, Faculty of Agriculture, Atatürk University in 2019. The aim of this study was to determine the effects of heavy metal stress on plant growth and some physiological and biochemical properties of beans. In-greenhouse temperature measurements were made daily and the average minimum temperature was 17.5 °C and the average maximum temperature was 31.6 °C. In this research, bean (*Phaseolus vulgaris* L.) Gina cultivar

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which is widely cultivated in our country was used as plant material.

2 L pots were filled with 2: 1: 1 (v: v: v) ratio of soil: sand: peat to medium volume of 3.170 g/cm$^3$. Some physical and chemical properties of the environment are fallow; sand:30.7%, silt: 35.9%, clay:33.4%, pH:7.8, EC: 155 mikromhos/cm, OM: 1.05%, total N: 0.008%, P: 8.5 mg/kg, K: 375 mg/kg, Ca: 2590 mg/kg and Mg: 196 mg/kg. The pots were randomly distributed on the benches in the greenhouse. Five seeds were sown into each pot. After the seedlings emergence, homogeneous two plants were left in each pot. Moisture status of the pots was continuously checked and water was given to the pots up to the field capacity when needed.

### Heavy Metal Treatments

For heavy metal stress treatments, different concentrations of lead [0-control, 1000 mg/kg (Pb1), 1500 mg/kg (Pb2) and 2000 mg/kg (Pb3)] were mixed into the medium and diluted to the field capacity and then incubated for 3 weeks. At the end of the incubation period, bean seeds were sown.

### Harvest and Measurements

The experiment was terminated 50 days after sowing and at the end of the experiment, the plants were taken from the pots. Plant height, leaf fresh weight, stem fresh weight, root fresh weight, leaf dry weight, stem dry weight and root dry weight were determined.

Leaf areas of plants were determined using leaf area meter (CID-202 Portable Laser Leaf Area Meter by CID Bio-Science, Inc. 1554 NE 3rd Avenue, Camas, WA, USA).

Chlorophyll measurement was performed with a portable chlorophyll meter (SPAD-502, Konica Minolta Sensing, Inc., Japan), which measures the amount of chlorophyll present in the leaf.

A sign of damage to leaf tissues and especially cell membranes due to stress in plants is the electrical conductivity measurements of wet leaf tissues. For this purpose, tissue electrical conductivity (TEC) was determined according to Kaya *et al.* [6].

Tissue rational water content was determined according to Kaya *et al.* [6].

Chlorophyll a and b concentration were determined according to Ni *et al.* [7].

Total carotenoid content was determined according to Rodriguez-Amaya and Kimura [8].

The experiment was established by randomized plot design with three replications. The study was carried out with 48 pots (96 plants), four heavy metal levels, three replicates and four pots per each replication. The data obtained as a result of the experiment was subjected to variance analysis with the help of SPSS 18 package program and the differences of the means were determined by Duncan multiple comparison test [9].

## RESULTS

In Figure **1**, it is seen that heavy metal applications adversely affect plant growth properties in bean and this negative effect increases as lead concentrations increase. The lowest values were determined in the Pb3. Pb3 treatment reduced leaf area, leaf fresh weight, stem fresh weight, root fresh weight and plant height by 16, 13, 20, 42 and 21%, respectively, compared to the control application. Leaf dry weight, stem dry weight and root dry weight decreased by 44, 51 and 53%, respectively in Pb3 compared to the control.

The effect of different doses of heavy metal applications on TEC and TRWC values in bean is presented in Figure **2**. Pb applications caused an increase in TEC conductivity in bean, and this increase was higher as the dose increased. In contrast, heavy metal applications led to a decrease in TRWC value in bean, the lowest value occurred in Pb3 application.

Lead stressed bean plants had less chlorophyll a, chlorophyll b and total carotenoid content than the control plants. The greatest values were obtained from the control treatment. The least Chlorophyll a content was obtained from Pb2 and Pb3 while Pb3 treated plants gave the least Chlorophyll b value. total carotenoid content decreased in Pb2 and increased in the Pb3 treatment again (Figure **2**).

## DISCUSSION

Lead is one of the most toxic elements that have lethal effects on plants [10]. In this study, it was determined that Pb treatments negatively affected plant growth (Figure **1**). It has been determined by many researchers that heavy metals adversely affect plant growth and cause oxidative damage by disrupting metabolism [11-14]. Similarly, the reduction in growth due to heavy metal application has been explained by the interaction of heavy metals with important metabolic factors such as photosynthesis, transport of photosynthetic products and nutrients [15]. Marshner [16] has demonstrated that Cd can affect cell wall expansion and cell division, thereby reducing growth. Opeolu *et al.* showed that the number of leaves in tomatoes and plant height were negatively affected by Pb applications [17].

We observed that Pb stress conditions caused an increase in TEC while TRWC values decreased (Figure **2**). Metal toxicity can affect plasma membrane permeability, resulting in a reduction in water content; in particular, Cd has been reported to interfere with water balance [18-20]. The decreasing TRWC observed in our study may be due to heavy metal-

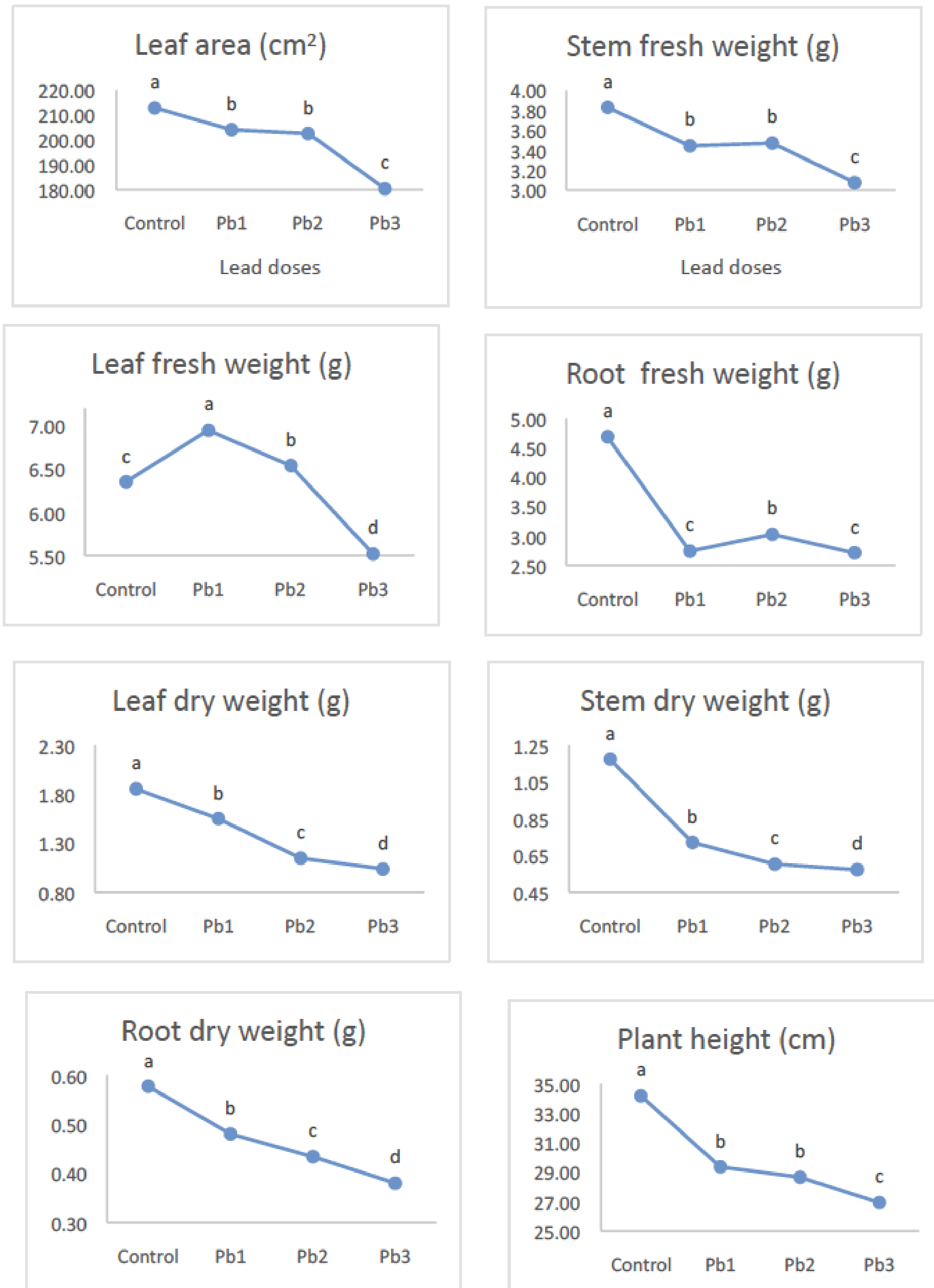


**Figure 1:** Effects of lead stress on plant growth characteristics of bean.
There is no statistical difference between the means indicated by the same letter.

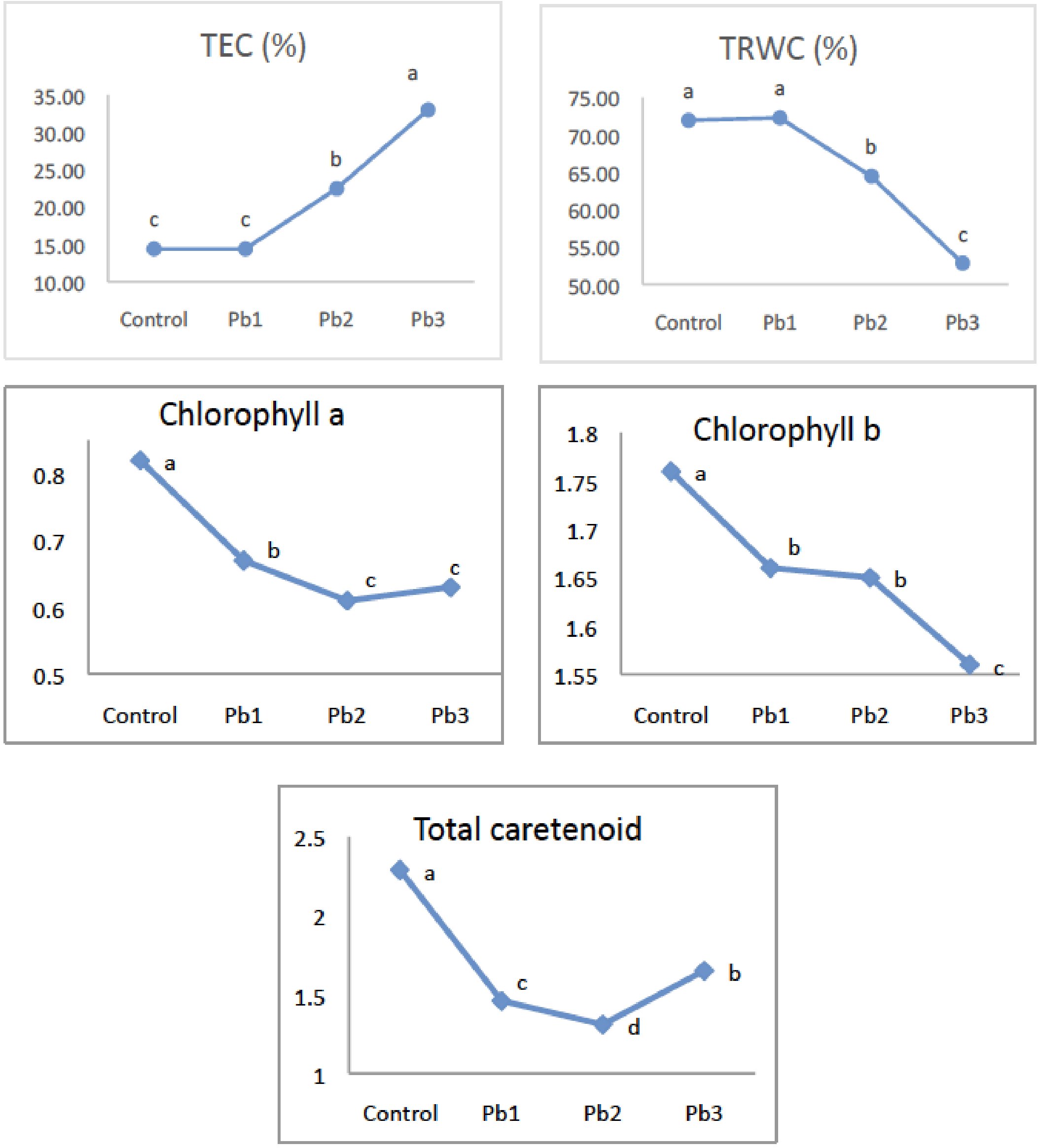


**Figure 2:** Effects of lead stress on TEC, TRWC, chlorophyll a, chlorophyll b and carotenoid content of bean. There is no statistical difference between the means indicated by the same letter.

induced reductions in hydraulic conductivity [21]. Similarly, previous researchers have shown that heavy metal stress causes a decrease in TRWC value in some plant species [22, 23]. Our findings are similar to those of Alyemeni *et al.* [24] shows that Cd leads to an increase in electrical conductivity in beans. Heavy metals produce free radicals and lead to oxidative degradation of the lipids of the tilacoid membranes [25].

Heavy metal stress caused the decrease in Chlorophyll a, chlorophyll b and total chlorophyll content in the study (Figure **2**). The reduction in Chlorophyll a, chlorophyll b and total chlorophyll content due to heavy metal stress has also been reported by Zengin and Munzuroğlu [26], Deshna and Bafna [27] and Kasim *et al.* [28]. Decreased chlorophyll content associated with heavy metal stress may be the result of inhibition of the enzymes responsible for chlorophyll biosynthesis [27]. Indeed, heavy metal stress has been reported to cause the reduction of chlorophyll concentration associated with inhibition of chlorophyll biosynthesis [29].

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