Iranian Journal of Field Crops Research
Vol. 15, No. 2, Summer. 2017, p. 368-379

نشریه پژوهشهای زراعی ایران
جلد ۱۵، شماره ۲، تابستان ۱۳۹۶، ص. ۳۷۹-۳۶۸

Evaluation of Foliar Spraying of Zinc and Calcium Fertilizers on Yield and Physiological Traits of Safflower under Lead Stress

P. Jamshidi[1*]- M. Baradaran Firoozabadi[2]- H. Oloumi[3]- H. Naghavi[4]

Received: 09-11-2015
Accepted: 05-07-2016

Introduction: In order to evaluate the effect of foliar spraying of zinc and calcium on yield and physiological traits of safflower under lead stress, a factorial experiment based on randomized complete block design was performed in Kerman agricultural and natural resource research and education center in 2014-2015 with three replications. The first factorial included three levels (control, and 0.5 and 1 µM lead spraying), whereas the second and third factorials were spraying zinc sulfate at three concentrations (zero, and 10 and 20 µM) and spraying calcium chloride at two levels (zero and 20 µM), respectively. According to the results, grain yield, the 1000-grain weight, leaf dry weight, number of seeds per head, head weight and chlorophyll content decreased. On the other hand, a significant increase was observed in the activities of catalase and ascorbate peroxidase enzymes and amount of malondialdehyde in plants. Moreover, spraying zinc fertilizer in lead treatment resulted in a significant increase in activity of catalase enzyme, reduction of membrane lipid peroxidation, prevention of chlorophyll destruction and maintenance of grain yield. However, the effect of spraying calcium fertilize in lead treatment was only significant on chlorophyll content. According to the results of the research, it seems that spraying zinc fertilizer had more effects on improved growth of safflower under lead stress, compared to spraying calcium fertilizer. Therefore, in air pollution with heavy metals (lead), application of zinc sulfate fertilizer can be an effective approach to maintain the growth and production of plants.

Among the various heavy metals, lead (Pb) is a major anthropogenic pollutant that has been released to the environment since the industrial revolution and accumulated in different terrestrial and aquatic ecosystems These elements will transfer to leaves in polluted areas and will rapidly uptake and cause irreparable damages to the most important part of the plant, i.e. photosynthetic system and changes immune system activity (Enzyme activity) and finally reduces the plant yield. Ca^{2+} improves plant resistance is related to maintaining a higher photosynthetic rate under stresses**.** Zn has a role in modulation of free radicals and their related processes through antioxidant properties and Zn applied by foliar spraying can increase the yield of crops. Therefore, this study aims to investigate how zinc and calcium fertilizers as foliar application increase safflower plant resistance to lead stress and their role on the damages caused by the stress on the activity of antioxidant defense system and photosynthetic pigments and its role in improving the plant yield in lead leaf absorption.

Materials and Methods: The field experiment was carried out in a factorial based on randomized complete block design with three replications in the farm of Agricultural and Natural Resources Research and Education center of Kerman. The first factor consisted of three levels of lead (Control, 0.5 and 1 mM lead foliar) and the second factor, the foliar application of zinc sulfate in three concentrations (zero, 10 and 20 mM) and the third factor was the foliar application of calcium chloride in two concentrations (zero and 10 mM). Cultivars used in this experiment were Goldasht cultivars (safflower). In this study, the activity of ascorbate peroxidase, catalases enzymes and malondialdehyde contents were measured. At harvest time, stem and leaf dry weight, seed number per head, Head weight, 1000 seed weight and seed yield was calculated. All data were analyzed with SAS software. Analysis of variance and statistical analysis was performed using SAS and Excel softwares, Mean comparison was done by least significant difference (LSD) test at 5 percent.

Results and Discussion: The results indicated that lead stress had a significant effect on most of the studied traits. Due to lead stress seed yield, 1000 seeds weight, leaf dry weight, seed number per head, head weight and

1- PhD Student of Agronomy, Department of Agronomy and Plant Breeding, Faculty of Agriculture, Shahrood University of Technology, Shahrood, Iran
2- Associate Professor, Department of Agronomy and Plant Breeding, Faculty of Agriculture, Shahrood University of Technology, Shahrood, Iran
3- Assistant Professor, Department of Ecology, Institute of Science and High Technology and Environmental Sciences, Graduate University of Advanced Technology, Kerman, Iran
4 - Assistant Professor Scientific, Soil and Water Research Department, Kerman Agricultural and Natural Resources Research and Education Center, Areeo, Kerman, Iran
(*- Corresponding Author Email: pari.asteria@gmail.com)

chlorophyll contents decreased and the activity of catalases, ascorbate peroxidase and malondialdehyde contents showed significant increase in the plant. Based on the results we concluded that, decrease in seed yield and plant growth by lead exposure can be in relation to this toxicity and oxidative stress. Also the present results revealed that the increase in the activity of catalases, ascorbate peroxidase and malondialdehyde content prevent the occurrence of oxidative damage under Pb stress. The results showed that lead and zinc interaction effects were significant on grain yield, chlorophyll b and malondialdehyde. The foliar application of zinc improved catalases enzymatic activity, decreased membrane lipid peroxidation and prevented destruction of chlorophyll and maintained yield in stress lead. The optimization of zinc under Pb stress could alleviate Pb-induced toxic effects by enhancing biochemical reactions and physiological processes in safflower plant. The variance analysis showed that only lead and calcium interaction effects on chlorophyll a were significant. Content of chlorophyll a increased at non-stress conditions along with the foliar treatment of calcium (10 mM) compared to the control.

Conclusions: The lead toxicity led to decline in growth and dry matter accumulation and the reduction of chlorophyll synthesis in plants and finally the reduction of the safflower yield. In the lead stress condition, the foliar application of zinc sulfate can be affected in the activation of plant defense systems and prevented the destruction of chlorophyll. Calcium successfully prevented occurrence of chlorosis and increased chlorophyll content. Based on the results, it seems that the application of zinc can have a greater impact on improving safflower growth than calcium fertilizer in lead stress. So in areas contaminated by heavy metals lead, zinc sulfate fertilizer can be as a solution to keep growing and production plants.

Keywords: Chlorophyll, Enzyme activity, Heavy metal, Malondialdehyde