Botany Research International 5 (2): 40-43, 2012
ISSN 2221-3635

DOI: 10.5829/idosi.bri.2012.5.2.237

Venomous Effects of $CuSO_4$ on Maize (*Zea mays* L.)

Romana Javed, Sumaria Saeed, Samra, Sheherbano Mughal,
Kiran Ashraf, Noshia Arshad, Khalid Hussain and Khalid Nawaz

Department of Botany, University of Gujrat, Gujrat, Pakistan

Abstract: Metals are a natural part of terrestrial systems occurring in soil, rock, air, water and organisms. Copper, however is essential to plant metabolism in trace amounts. Copper (Cu) is an essential micronutrient for growth and development of plants and plays a significant role in many physiological process. Copper enrichment in agricultural soils is due to an intensive use of copper sulphate for more than 100 years in order to fight fungi development. It can also be due to the input of sewage sludge, fertilizers, pesticides and herbicides. In high concentrations it can become toxic for plants especially it decreases crop yield. This review summarizes the heavy metals ($CuSo_4$) on maize (*Zea mays* L.) for morphological, biochemical and chemical attributes. Copper stress gradually depressed shoots length, roots length and number of roots with increasing Cu levels in MS media. Fresh and dry weight of maize fodder increased with C\u application but decreased at their higher combinations. The main action of Cu is at the whole plant level in reduced growth and at the organ level in leaf symptoms.

Key words: Maize · Growth · Heavy Metal · Effect · $CuSO_4$

INTRODUCTION

Unrestricted mining, municipal waste disposal practices and extensive use of agrochemicals have resulted in the addition of large amounts of heavy metals at many places of the world [1, 2]. Increased amounts of heavy metals (HM) in soil and, consequently, in forage and foodstuffs when penetrate into living organisms produce mutagenic, teratogenic, carcinogenic or toxic effects. Though a higher concentration of HM may cause adverse effects, the biota still may require some of these elements but they are required in trace quantities, not in large quantities [3, 4]. Some heavy metals are essential micronutrients for plants but in most of plant species their excess may result in metabolic disorders and growth inhibition [5]. These metals persist indefinitely in soil so they are causing an ever-increasing threat to human health and agriculture [6]. Metal toxicity actually depends on plant species as these species exhibit considerable genetic variation in their ability in tolerating amounts and the concentration of specific heavy metals [7]. Excessive amount of heavy metals in growth medium causes an apparent damage of plant tissues and this damage can be used as an indicative of toxic effects of metals [8]. Corn ranks third in the global cereal production and is utilized as food, feed and fodder. Large quantities of corn are used in extracting oil, manufacturing cellulose products and mild abrasives. Different studies are reporting different mechanisms that are responsible for tolerance or sensitivity of different plant species to heavy metals [1, 8-10]. Metal tolerance in plant can be defined as avoidance of metal uptake or its accumulation in plant tissues without developing any toxicity symptoms. On the other hand sensitive species may lack this mechanism and show toxicity symptoms and poor development. The present study was aimed at determining heavy metal tolerance in corn and to draw parallels between tolerance and metal accumulations. Heavy metal tolerance was tested at germination and seedling growth of corn as these are the key events for the establishment of plants under any prevailing environment [11].

Growth inhibition is a general phenomenon associated with most of heavy metals [12, 13]. The tolerance limits for HM toxicity are specific for different species even for every variety of cultural plants [14, 15]. Metal toxicity in plants has been reported by various authors [13-16]. However, results of these investigations are rather contradictory, as the nature of HM effect

Corresponding Author: Romana Javed, Department of Botany, University of Gujrat, Gujrat, Pakistan.

depends on the species, variety and age of plants and the concentrations, duration of effect, physical and chemical properties of contaminants [16]. The aim of the work was to investigate the effect of different Cu doses on the growth of maize seedlings.

Copper (Cu) is an essential micronutrient for growth and development of plants and plays an important role in many physiological process. Like most micronutrients, Cu is also needed in small amounts by the plant. At cellular level, Cu plays an essential role in signaling of transcription and protein trafficking machinery, oxidative phosphorylation and iron mobilization [17]. Moreover, Cu is required in biological systems as a structural component. It can inhibit plant growth at higher concentrations in soil so it can act as a stress factor causing physiological responses [18]. Excess of Cu concentrations alters protein function and enzyme activity and so it may induce a significant toxic effect [19]. Toxicity may result from the binding of metals to sulfhydryl groups in the protein. It leads to the inhibition of activity or disruption of the structure [20]. It was proposed that, Cu interferes with the biosynthesis of the photosynthetic machinery modifying the pigment and protein composition of photosynthetic membranes [21, 22]. Copper can also substitute for Mg in chlorophyll present in both antenna complexes and reaction centers, so it damages the structure and function of chlorophyll [23]. In addition, excess Cu concentrations are said to generate oxidative stress due to an increase in the levels of reactive oxygen species (ROS) within subcellular compartments [24].

Effect of $CuSO_4$ on Seedling, Root and Shoot of *Zea mays*: The seeds of maize were applied with varying concentration of copper sulphate. It indicated that Germination of *Z. mays* seed was not affected by $CuSO_4$. Similarly, the rate of germination was constant both in the absence and presence of $CuSO_4$ [25]. Germination frequencies of maize seeds and length of the maize axial organs were treated with different copper solutions was presented [29]. A statistically significant increase of germination rate, as compared with control seeds, was observed for seeds treated with solutions of copper. Under physiologically advantageous amounts of copper, no significant increase of root growth was observed. Moreover, high quantities of copper had a tendency to decrease shoot length [29].

Maize cultivars were grown on MS media supplemented with different concentrations of Cu. Some showed better responses to copper stress. While some showed higher shoots and roots length [36]. Fresh and dry weight of maize fodder increased with the copper application but decreased at their higher combination [37].

In the case of $CuSO_4$ the seeds started germination. The growth of root and shoot was high at control level and it was low at some treatments. There was a marked difference at varying concentration of $CuSO_4$ on *Z. mays* [25]. While in the case of copper after germination, growth distinctions in the root system of maize seedlings were rather obvious. High amounts of copper resulted in root growth inhibition as compared to control plants [29].

Plant growth distinction was even more pronounced. Copper ions stimulated seedling growth at low concentrations but resulted in growth suppression at the higher ones [29]. Plant death was resulted under the exposure of high concentration of copper. Nonetheless, strong yield reductions, proving a toxic effect of copper on maize growth and for the aerial plant for corn [38].

A significant root growth inhibition was resulted on the exposure of maize seedlings to copper solutions, though shoot growth remained less affected. A low copper concentration stimulated an increase of root fresh weight [29]. The effect of copper on shoot-to-root ratio variation was more pronounced. Moreover, exposure to copper increased the content of abscisic acid and induced stomata closure [35].

Excess Cu results in a reduction in plasma membrane integrity in plant roots and it is thought that this is the mechanism by which Cu toxicity retards root [8, 43, 44].

The above discussion showed that copper has no influenced on Z.*mays* seeds. This insignificant effect of copper indicated that seeds use reserved food material during germination but not metal ion [26]. Therefore, the presence of small concentration of heavy metals in the culture medium cannot account for inhibition of germination in *Z. mays* [26]. These results are consistent with other herbaceous species like *Triticum vulgare* and *Avena sativa* [27] and in arboreal gymnosperms *Piceae rubens* and *Abies balsamica* [28]. However the effect of copper was more significant on root and shoot growth of *Z. mays* [28].

In general, a copper physiological concentration stimulates the growth of the young plants. However, the suppression of growth processes and biomass accumulation (especially in roots), leaf area reduction and water misbalance was caused by higher concentrations of copper. A decrease of transpiration and water content plants under the influence of Cu was observed [30-33]. The effect of Cu on water exchange was evidenced by the reduction of leaf size [34] and stomata [29] and by a decrease of turgor [34], the inhibition level depends on the chemical nature and concentration of a heavy metal. Copper toxic effect actualizes via denaturalization of the metabolically relevant proteins [30].

Copper toxicity has a significant effect on root growth and form, often before any effect on above-ground growth [40]. Copper toxicity can be associated with a purpling of foliage [39] but this is not apparent in all species [41]. Common symptoms of Cu toxicity to plants are plant growth reduction and inhibition of plant development [42].

CONCLUSION

Metal toxicity issues in plants and soils are a significant problem throughout the world. The effect of CuSo4 on seedling of maize is insignificant while it is more prominent on root and shoot of maize plant. Seeds use reserved food material during germination but not metal ions. In general, the growth of young plant is more when the copper concentration is high but minimum at low concentration (especially in roots). At this level leaf area reduce and water misbalance also occurs. This all depend upon the chemical nature and concentration of copper.

REFERENCES

1. Ernst, W.H.O., 1996. Phytotoxicity of heavy metals. In: C. Rodrigues-Barrueco, (ed.), Fertilizers and environment. Kluwer Academic Publishers. Dordrechett. Netherlands, pp: 423-430.
2. Mullar, D.H., F. Van Oort and M. Balbane, 2000. Strategies of heavy metal uptake by three plant species growing near a metal smelter. Environ. Poll., 109: 231-238.
3. Imtiaz, M., B.J. Alloway, K.H. Shah, S.H. Siddiqui, M.Y. Memon, M. Aslam and P. Khan, 2003. Zinc nutrition of wheat: I: Growth and zinc uptake. Asian Journal of Plant Sci., 2(2): 152-155.
4. Rout, G.R. and P. Das, 2003. Effect of metal toxicity on plant growth and metabolism: Zinc. Agronomie., 23: 3-11.
5. Claire, L.C., D.C. Adriano, K.S. Sajwan, S.L. Abel, D.P. Thomas and J.T. Driver, 2000. Effects of selected trace metals on germinating seeds of six plant species. Water, Air and Soil Poll., 59: 231-240.
6. Leyval, C., V.B.R. Singh and E.J. Joner, 1995. Occurrence and infectivity of arbuscular mycorrhizal fungi in some Norwegian soils influenced by heavy metals and soil properties. Water, Air Soil Pollut., 84: 201-216.
7. Vojtechova, M. and S. Leblova, 1991. Uptake of lead and cadmium by maize seedlings and the effects of heavy metals on the activity of phosphoenol pyruvate carboxilase isolated from maize. Biol. Plant., 33: 386-394.
8. Luna, C.M., C.A. Gonzalez and V.S. Trippi, 1994. Oxidative damage caused by an excess of copper in oat leaves. Plant and Cell Physiology, 35: 11-15.
9. Chatterjee, J. and C. Chatterjee, 2000. Phytotoxicity of cobalt, chromium and copper in cauliflower. Environ. Pollut., 109: 69-74.
10. Lindon F.C. and F.S. Henriques, 1992. Copper toxicity in rice: Diagnostic criteria and effect on tissue Mn and Fe. Soil Sci., 154: 130-135.
11. Welbaum, G.E., K.J. Bradford, Y. Kyu-Ock, D.T. Booth and M.O. Oluoch, 1998. Biophysical, physiological and biochemical processes regulating seed germination. Soil Sci., 8: 161-172.
12. Peralta, J.R., J.L. Gardea-Torresdey, K.J. Tiemann, E. Gomez, S. Arteaga, E. Rascon and J.G. Parsons, 2000. Study of the effects of heavy metals on seed germination and plant growth on alfalfa plant (Medicago sativa) grown in solid media. Proceedings of the 2000 conference on Hazardous Waste Research, Denver, Colorado, pp: 135-140.
13. Reichman, S.M., 2002. The responses of plants to metal toxicity: a review focusing on copper, manganese and zinc. The Australian Minerals and Energy Environment Foundation. Australia, pp: 54.
14. Liu, D., W. Jiang, F.M. Zhao and C. Lu, 1994. Effects of lead on root growth, cell division and nucleolus of Allium cepa. Environ. Pollut., 86: 1-4.
15. Jiang, W. and D. Liu, 2000. Effects of Pb+2 on root growth, cell division and nucleolus of *Zea mays* L. Bull. Environ. Contam. Toxicol., 65: 786-793.
16. Vassilev, A. and I. Yordanov, 1997. Reductive analysis of factors limiting growth of cadmium-treated plants: a review. Bulg. Journal of Plant Physiol., 23(3-4): 114-133.
17. Yruela I., 2005. Copper in plants. Braz Journal of Plant Physiol., 17: 145-156.
18. Monni, S., M. Salemaa and N. Millar, 2000. The tolerance of Empetrum nigrum to copper and nickel. Environ. Pollu., 109: 221-229.
19. Hansch, R. and R.R. Mendel, 2009. Physiological functions of mineral micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B, Cl). Curr Opin Plant Biol., 12: 259-266.
20. Morelli, E. and G. Scarano, 2004. Copper-induced changes of non-protein thiols and antioxidant enzymes in the marine microalga Phaeodactylum tricornutum. Plant Sci., 167: 289-296.

21. Lidon, F.C. and F.S. Henriques, 1991. Limiting step in photosynthesis of rice plants treated with varying copper levels. Journal of Plant Physiol., 138: 115-118.
22. Maksymiec, W., R. Russa, T. Urbanic-Sypniewska and T. Baszyñski, 1994. Effect of excess Cu on the photosynthetic apparatus of runner bean leaves treated at two different growth stages. Plant Physiol., 91: 715-721.
23. Tanyolaç, D, Y. Ekmekçi and A. Ûnalan, 2007. Changes in photochemical and antioxidant emzyme activities in maize (*Zea mays* L.) leaves exposed to excess copper. Chemosphere, 67: 89-98.
24. Brahim, L. and M. Mohamed, 2011. Effects of copper stress on antioxidative enzymes, chlorophyll and protein content in Atriplex halimus. African Journal of Biotech., 10: 10143-10148.
25. Mahmood, S., A. Hussain, Z. Saeed and M. Athar, 2005. Germination and seedling growth of corn under varying levels of copper. Environ. Sci. Technol., 2(3): 269-274.
26. Stefani, A., I. Arduini and A. Onnis, 1991. Juncus Acutus: Germination.
27. Fiussello, N., 1973. Lead pollution: Effects on chlorophyll. Infor. Bot., 5: 107-108.
28. Scherbatskoy, T., R.M. Klein and G.J. Badger, 1987. Germination responses of forest tree seeds to acidity and metal ions. Environ. Exp. Bot., 27: 157-164.
29. Kumar, P.B.A.N., V. Dushenkov, H. Motto and I. Raskin, 1995. Phytoextraction: The use of plants to remove heavy metals from soils. Environ. Sci. Technol., 29: 1232-1238.
30. Briar, J.F. and M. Lebrun, 1999. Plant responses to metal toxicity. Plant Biology and Pathol., 322: 43-54.
31. Vassilev, A. and I. Yordanov, 1997. Reductive analysis of factors limiting growth of heavy metal-treated plants: a review. Bulg. Journal of Plant Physiol., 23(3-4): 114-133.
32. Bashmakov, D.I., S.L. Aleksandr, V.R. Viktor, D. Povilas, B. Auora and B. Kaestutis, 2005. Growth of maize seedlings affected by different concentrations of heavy metals. Ekologija, 3: 22-27.
33. Wozny, A., J. Schneider and E.A. Gwozdz, 1995. The effects of lead and kinetin on greening barley leaves. Biol. Plant., 37: 541-552.
34. Barcelo, J. and C. Poschenrieder, 1990. Plant water relations as affected by heavy metal stress: A Review. Journal of Plant Nutrition., 13: 1-37.
35. Hernandez, L.E., A. Garate and R. Carpenaruiz, 1997. Effects of cadmium on the uptake, distribution and assimilation of nitrate in *Pisum sativum*. Plant Soil., 189: 97-106.
36. Amina, A. and A.M. Amal, 2012. The effect of copper ions on growth in two maize cultivars (*Zea mays* L.). Australian Journal of Crop Sci., 6(3): 541-549.
37. Awan, I.Z. and K.M. Abbasi, 2000. Interactive effect of phosphorus and copper on maize growth. Pakistan Journal of Agriculture, 16(2): 370-373.
38. Gunkel, P., R. Estelle and F. Bernard, 2003. Copper distribution in chemical soil fractions and relationships with maize crop yield. Environ. Chem. Lett., 1: 92-97.
39. Choi, J., C. Pak and C.W. Lee, 1996. Micronutrient toxicity in French marigold. Journal of Plant Nutrition., 19: 901-916.
40. Minnich, M.M., M.B. McBride and R.L. Chaney, 1987. Copper activity in soil solution. II. Relation to copper accumulation in young snapbeans. Soil Science Society of America Journal, 51: 573-578.
41. O'Sullivan, J.N., C.J. Asher and F.P.C. Blamey, 1997. 'Nutrient Disorders of Sweet Potato. ACIAR Monograph No. 48.' Australian Centre for International Agricultural Research, Canberra., 17: 933-943.
42. Fernandez, J.C. and F.S. Henriques, 1991. Biochemical, physiological and structural effects of excess of copper in plants. Bot. Review, 57: 246-273.
43. Arduini, I., D.L. Godbold and A. Onnis 1995. Influence of copper on root growth and morphology of *Pinus pinea* L. and *Pinus pinaster* Ait. Seedlings. Tree Physiol., 15: 411-415.
44. De Vos, C.H.R., H. Schat, M.A.M. De Waal, R. Vooijs and W.H.O. Ernst, 1991. Increased resistance to copper-induced damage of the root cell plasmalemma in copper tolerant Silene cucubalus. Physiologia Plantarum., 82: 523-528.