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Influence of Plant Growth Regulators and Humic Substance on the Phytoremediation of Nickel in a Ni-Polluted Soil

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Introduction: Plants can uptake, bioaccumulate and immobilize different metals in their tissues. Phytoremediation technique has been used to remove hazardous substances including heavy metals from the environment. Assisted phytoremediation is usually the process of applying a chemical additive to heavy metal contaminated soils to enhance the metal uptake by plants. The main objective of present study was to investigate the effectiveness of plant growth regulators (PGRs) and a humic substance (HS) on Ni phytoremediation by maize in a Ni-pollutrd calcareous soil.

Materials and Methods: The experiment designed as a 5×3 factorial trial arranged in a completely randomized design with three replicates. Three kilograms of soil was placed in plastic pots and pots were watered with distilled water to field capacity and maintained at this moisture level throughout the experiment by watering the pots to a constant weight. The soils were polluted with 250 mg Ni Kg^{-1} as Ni-nitrate Ni $(NO_3)_2$. Six maize (Zea mays L.) seeds were planted 2 cm deep in soil and thinned to three uniform stands 1 week after emergence. Treatments consisted of three levels of soil application of commercially humic substance, HS, (0, 3, and 6 mg kg as Humax 95-WSG containing about 80% humic acid, and about 15% fulvic acid) and five levels of PGRs (0 or 10 µM GA_3, IAA, BAP and SA). The HS was applied as split doses in three times at 15 day intervals along with irrigation water. The seedlings were exposed to aqueous solutions of HS 16 days after sowing for the first time. Prepared solutions of PGRs were sprayed three times at 15 day intervals from emergence. Seven weeks after planting, shoots were harvested and roots were separated from soil carefully, both parts were rinsed with distilled water and dried at 65°C for 72 h, weighed, ground, and dry meshed at 550°C. Root and shoot dry matter and Ni concentration and uptake and phytoremediation criteria were considered as plant responses. Data were statistically analyzed using SAS and SPSS software packages. Application of different PGRs had no considerable effect on phytoextraction or translocation efficiencies. Among the four PGRs studied application of SA and BA significantly increased mean uptake efficiency.

Results and Discussion: Among four PGRs evaluated, application of GA_3 increased mean shoot dry matter yield and application of SA increased mean root dry matter yield. Application of the highest HS level (6 mg kg^{-1}) decreased both mean root and shoot dry weight. Application of SA increased Ni concentration in both maize root and shoot. Application of BA only increased Ni concentration in maize root. Although application of the highest HS level (6 mg kg^{-1}) caused an increase in Ni concentration in maize shoot, this effect was attributed to the influence of HS on the decrease in decreasing dry weight of maize shoot. Application of all PGRs except GA_3 increased leaf greenness criterion. Addition of HS had no significant effect on leaf greenness. Application of PGRs enhanced root concentration factor (RCF) and decreased translocation factor (TF). Among PGRs evaluated, BA was the most effective on TF, and SA or BA was the most effective on RCF. However HS were not significantly influenced these phytoremediation criteria, as compared with control. The efficiency of PGRs in root Ni uptake was in the order of SA > BA > GA_3 > IAA. Application of BA had a significant effect on Ni distribution among root and shoot, in comparison with other PGRs, and caused an increase and a decrease in root and shoot uptake of Ni, respectively. However HS had a negative effect on tolerance index and its application decreased root and shoot dry weights. Results showed that the values of Ni in maize root was considerably higher than that of maize shoot demonstrated that phytostabilization was the main mechanism involved in the phytoremediation of Ni by maize and application of PGRs was effective on this mechanism.

Conclusion: Results reported here indicated that although the addition of HS did not cause a significant effect on Ni phytoremediation, application of most studied PGRs had a positive effect on Ni phytoremediation by maize. Application of SA and BA increased uptake efficiency and RCF and application of GA_3 increased

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shoot dry matter and tolerance index. The fact that Ni uptake by roots was significantly higher than that of shoots demonstrated that phytostabilization was the main mechanism involved in the phytoremediation of Ni by maize. According to results reported herein the addition of PGRs especially SA is likely to be promising in phytostabilization of Ni in calcareous soils polluted with this metal.

Keywords: Benzyle adenine, Gibberlic acid, Indole-3-acetic acid, Salicylic acid, Phytostabilization

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