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Enhancement of Kettara mine tailings phytoremediation under drought stress using *Peganum harmala inoculated by* plant growth promoting rhizobacteria

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Abstract

Abandoned sulfide-mining wastes can cause extensive and irreversible damage to the local environment. Use of a vegetation cover can be an eco-friendly and cost-effective alternative method for rehabilitation of these abandoned wastelands. However, many characteristics of the tailings are inimical to successful vegetation establishment, such as very acidic pH, phytotoxic levels of heavy metals, low nutrient content and poor physical structure of the substrate. Furthermore, in Kettara pyrrothite mine case, the semi-arid climate makes the revegetation process more difficult due to the very low annual precipitation. The present study aims to assess whether amendment mixtures and locally-sourced bacterial inoculums can help the establishment of *Peganum harmala* in mining waste under drought stress (DS) condition.

Plants were grown in mine tailings mixed with 40% of topsoil (i.e., pre-mined superficial soil), supplied with marble sludge (4%) and Sheep manure (8%), then inoculated with a consortium of four drought-tolerant strains: *Mesorhizobium tamadayense* BKM 04, *Enterobacter xiangfangensis* BKM 30, *Pseudomonas azotifigens* BKM 07 and *Streptomyces Caelestis* BKM 05 previously isolated by Benidire et al., (2016).The plants were subjected to three irrigation regimes: daily watering at 80% (control– C), 40% (medium stress– MS) and 25% (severe stress– SS) of field capacity.

Severe water stress affected negatively plants growth, by reducing plants' shoot growth by 57% in comparison to control test. Bioinoculants mitigated the negative effects of induced drought stress on shoot biomass by increasing it up to 75% in plants exposed to SS. The results of plant length and biomass measurement showed no significant differences between control and medium stress. However, bacterial inoculation increased significantly shoot fresh and dry weight and chlorophyll content under control condition and in the presence of DS. Water stress increased amino acids, soluble sugars and proline content, which were significantly higher by about 30%in inoculated plants. In contrast, the concentrations of soluble proteins decreased significantly in stressed and uninoculated plants, while an increase of about 45.45% was observed in the inoculated treatments. Drought stress also resulted in increased antioxidant enzymes activities (catalase, peroxidase, polyphenoloxidase, and ascorbate peroxydase), which was much more pronounced in inoculated plants.

These findings indicate that the interaction between organo-mineral amendments, PGPR consortium and *P. harmala* could be used for the improvement of phytoremediation of metal polluted soils under semi-arid conditions.

Keywords: Heavy metals, Mine tailings, Plant growth promoting rhizobacteria, Rehabilitation

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