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Role of Biological Soil Crusts Enrichment through Bacteria Inoculation and Stimulation of Nitrogen Increasing in an Erosion-Prone Soil

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Introduction: Land degradation and soil losses are common and universal problems which is a pose threat to food security, ecosystem health and consequently sustainable development and human well-being. Meanwhile, improving the chemical and physical properties of biological soil crusts is an effective factor in soil loss controlling. Also, the chemical properties specially soil nitrogen are the important factors for soil quality determination. To this end, various strategies on techniques of amendments have been implemented to improve soil properties and quality. Although the application of most strategieshave been verified to soil quality,but their application in real conditions is restricted due to detrimental environmental effects, instability, cost and time-consuming and less accessibility. Recently, biological soil crusts enrichment based on soil microorganism inoculation and stimulation has been raised as a biological and useful strategy in soil conservation sciences. Accordingly, the present study aimed to investigate the role of individual and combined inoculation of bacteria and stimulant nutrient material into small-scale plots on soil nitrogen variation as one of the important soil chemical component.

Material and Methods: The study soil was collected from the erosion-prone and poor biological crust of a sub-watershed from Chalusrood watershed located in Mazandaran Province. The soil sampling was carried out from the upper of the soil surface using a 5cm-diameter coring polyvinyl chloride. The sampled soils were air-dried and sieved by a 2 mm-sized mesh. The Nutrient Agar and Tryptic Soy Agar general were used to bacteria isolation. The identification of isolated bacteria was carried out based on available protocols. Effective nitrogen-fixing bacteria were selected and then purified by selective *Azotobacter* Agar, Modified II and DSMZ1media. The purified bacteria proliferated by LB Broth medium and then inoculated into soil small sized-plots simultaneously with stimulant nutrient material throught spraying technique. The study was conducted at plot scale with 0.5×0.05×0.5 m dimensions and the plots filled by study soil based on standard protocols. The soil samples were taken at once the 7-8 days from surface of soil plots and the amounts of soil nitrogen were measured by using Kjeldahl method. As well as, experiment period was planned about 60 days. The one-way ANOVA and Tukey HSD test were subjected to statistically analyses.

Results and discussion: The results indicated that the *Azotobacter* sp. and *Bacillussubtilis* strain were selected as the most appropriate bacteria to be applied for nitrogen fixing in soil. Also, the results showed that the average total organic nitrogen in control plots ranged from 0.082 to 0.136%, which implies the soil limitation of total nitrogen. However, the measured total organic nitrogen in the bacteria, stimulant nutrient, and combined inoculation plots varied from 0.11 to 0.241%, 0.117 to 0.204%, and 0.124 to 0.374%, respectively. These results demonstrated the positive role of inoculated treatments on fixing nitrogen in the soil. Therefore, the population of *Azotobacter sp*., the *Bacillussubtilis* strain, was considerably increased after the inoculation process, and this led to converted and fixed atmospheric nitrogen (N_2) into utilizable nitrogen (NH_4 or NO_3) in soil by using the enzyme nitrogenase as a catalyst. The statistical analyses and evaluation results were indicative of a significant ($p<0.05$) increase of soil total organic nitrogen in inoculated treatments. After one month, the fixed nitrogen was significantly ($p<0.01$) increased in the bacteria, stimulant nutrient material, and combined inoculated plots to respective of 148, 110, and 284%, compared to control plots. Additionally, decreasing of nitrogen from plots were begun after one month of inoculation time. It can be related to the quickly reducing bacteria nutrient resources due to fast proliferation and activity of bacteria. However, amount of nitrogen in the treated-plots remained fixed after two month of inoculation. Accordingly, after 60 days, the amount of fixed nitrogen in the bacteria and combined inoculated plots were about 16 and 17% more than to control ($p<0.01$).

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Conclusion: The land degradation rate critically depends on soil quality. Soil crust enriched by inoculation of bacteria can improve soil chemical and especially properties nitrogen and, ultimately, soil quality. Eventually, biological soil crusts enrichment by inoculation of bacteria was proved as a completely biologic, safe and economically techniques in soil chemical properties improving. Though, more insight studies on applicability of soil microorganisms on soil quality and quantity conservation are essentially needed under different conditions with further emphases on field application to allow drawing more certain conclusion.

Keywords: Microorganisms Inoculating, Soil Bio-technology, Soil Erosion, Soil Amendments, Soil Stability