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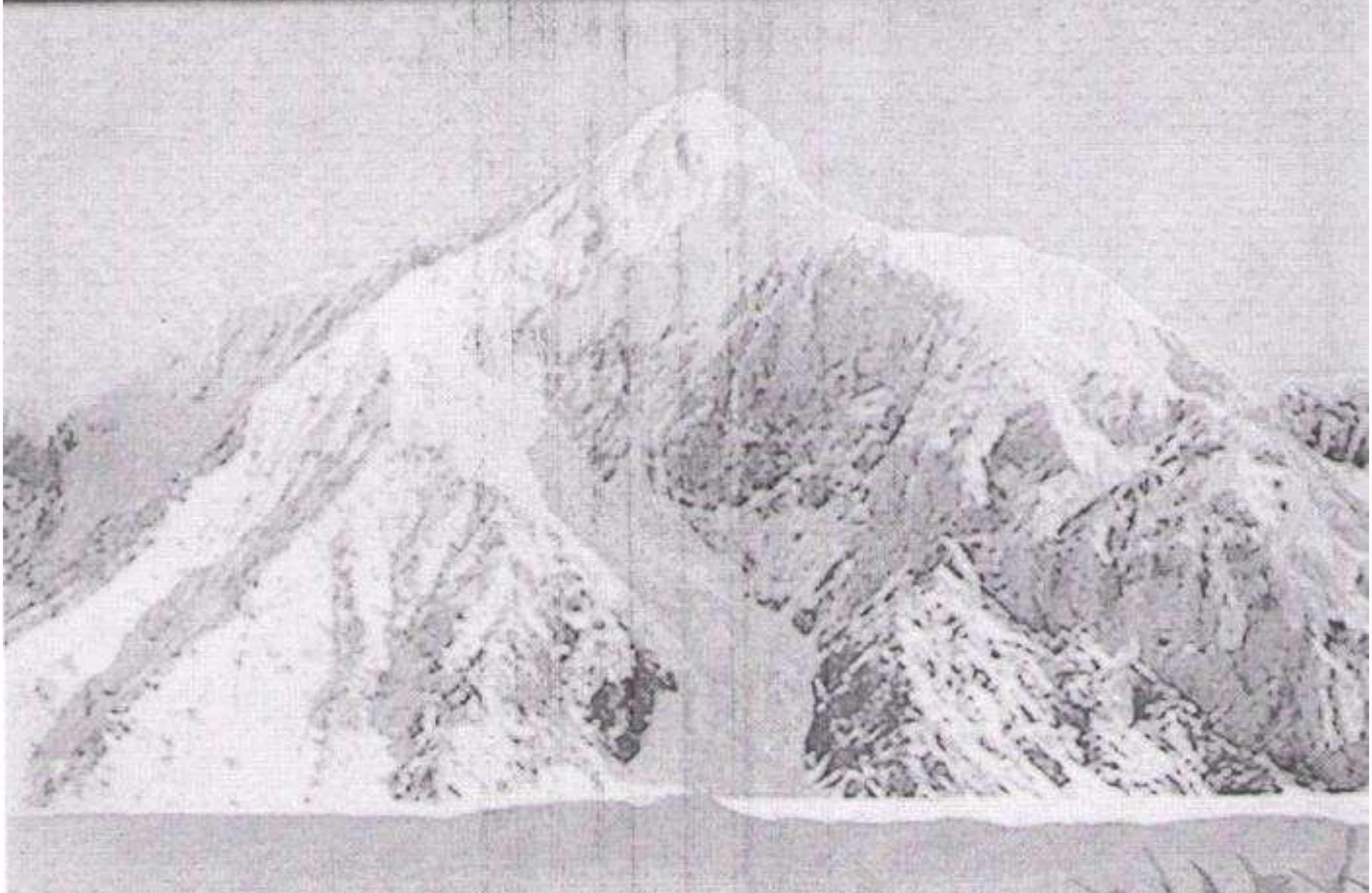

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Impact of Crop Management Practices on Soil Microbial Populations in a Semi Arid Soil of Uzbekistan

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Abstract: The aim of this study was to determine the effect of the plant type, soil depth and seasonal change on the ammonifying bacteria populations in semi arid, salinated soil of Uzbekistan. Soil samples were collected from the soil under groundnut, alfalfa, maize, melon, tomato and fallow in spring, summer, autumn, and winter. The results revealed that the number of ammonifying bacteria depended upon plant type, depth and date of sampling. The total number of ammonifying bacteria populations was tended to be highest under alfalfa and groundnut in spring at the 0-10 and 10-20 cm soil depth regardless of plant type. This study indicated that leguminous plants were able to support the highest number of ammonifying bacteria in all seasons, while fallow soil had the lowest. Thus to increase the soil fertility of salinated arid soil, it is necessary to use legumes, which can increase microbial population that play an important role N cycle making mineral N bio-available in the soil.

Keywords: saline soil, ammonifying bacteria, soil depth, crops, seasonal change

1. Introduction

Nitrogen (N) is an extremely important element to all forms of life, the main component of most organic compounds in plants including amino and nucleic acids, enzymes, chlorophyll, and proteins (Atlas and Bartha, 1987; Stark and Richards, 2008). The organic nitrogenous compounds are decomposed by microbial enzymes to form ammonia (NH_3) and thus the amount of plant available N in soils is increased through those processes (Zak et al., 2000; Schimel and Bennett, 2004). They are also responsible for the digestion of polymers such as cellulose and lignin, which multicellular organisms are unable to utilize (Grayston et al., 1998). According Schimmel and Bennett (2004) N mineralization by soil microbes is the key event in the N cycle making mineral N bio-available, whereas plants only uptake mineral N. Microbial communities, particularly bacteria and fungi constitute an essential component of biological characteristics in soil ecosystems. Ammonifying bacterial population were predominant groups in the rhizosphere of plants (Bossio et al., 1998). Environmental change will have direct and indirect effects on plant nutrient uptake, soil nutrient turnover processes, including N and C cycling (Dijkstra and Cheng, 2008). Some authors identified patterns of microbial population that are consistent across sites that vary in plant composition and agricultural treatment (Felske and Akkermans, 1988; Broughton and Gross, 2000). Changes in N dynamics in soils are closely connected with altering in microbial activities involved in N cycle by biotic and abiotic factors. It has been reported that tillage practices, cover crops and application of manure have a substantial effect on the soil organic matter, but also on microbial activities under stressed condition (Rietz and Haynes, 2003; Wang et al., 2008). Therefore it is very important to determine the factors affecting the microbial processes of N cycling in the soil. Garcia and Hernandez (1996) reported that salinity negatively affects microbiological activity of soil by high osmotic strength and toxic effects by salts on microbial growth can occur. The objective of the present study was to enumerate populations of ammonifying bacterial population in saline arid soils, with respect to season, crop cultivation, and soil depth.

2. Materials and Methods

Sites used in this study represent continuously cultivated fields located in Syrdarya province of Uzbekistan. According to the WRB-FAO (2006) classification, the soils of selected fields were identified as Calcisol (silt loam seirozem). The surface soil horizon was calcareous saline whereas the deeper soil horizons were only mildly alkaline (Egamberdiyeva et al., 2007). In these soils, cotton has been grown for the last 50 to 60 years under a continuous monoculture production system and under flood irrigation without proper drainage facilities but using a natural flow system. In general, high concentration of Ca^{2+}, K^{+}, and Na^{+} are associated with CO_3^{2-} and Cl^{-} ions, reflecting the dominance of carbonates and chlorides in saline soil. On average, the two kinds of soils was taken contained 42 ± 9 g of sand kg^{-1}, 708 ± 12 g of silt kg^{-1}, and 250 ± 13 g clay kg^{-1} (Egamberdieva and Kucharova, 2009). The organic matter content of the soil is 0.694 %; total C, 2.506%; total N, 0.091 %; Ca, 63.5 g/kg; Mg, 20.7 g/kg; K, 6.2 g/kg; P, 1.2 g/kg; Cl, 0.1 g/kg; Na, 0.7 g/kg, and the pH is 8.0.The climate of the sampling site is continental, with a annual average rainfall of 200 ± 36 mm, more than 90% of the total rain falling between October and May. The average monthly minimum air temperature is 0°C in January, and the maximum one is 37°C in July. During the year, the soil temperature ranges between -2 and +35°C. The average maximum relative humidity is slightly more than 80% in January and the minimum one is less than 45% in June. Under a dry continental climate, the combination of high temperature and low rainfall during the growth season makes irrigation essential for crop production.

For determination of bacterial population associated with groundnut, alfalfa, maize, tomato and melon root, the soil cores (divided into 0-10, 10-20, and 20-30 cm depths) were randomly collected under the root system of plants grown in saline soil. The soil samples were collected in spring (April), summer (July), autumn (September) and winter (January). Soil cores were pooled and mixed to obtain a composite sample for each depth. Field-moist soils were then gently sieved through a 2-mm mesh, and a portion of the soil was incubated or analyzed to measure soil microbial populations within 72-h of sampling and processing. Plate dilution method was used for determination of ammonifying microorganisms using nutrient agar (Difco). Ten gram of soil was shaken with 90 ml of sterile distilled water. From this suspension the serial dilution (1:10) was prepared and plated onto agar medium. After 3 days incubation, CFU of bacteria were counted and analyzed. Analysis of variance was performed using Excel version 11 for Windows 2007 (Microsoft Corp.), and standard error, LSD were calculated.

3. Results and Discussion

Tillage practices, crop rotation and ecological factors such as seasonal change, or soil type and properties are known to impact soil microbial populations and microbial activities (Schutter and Dick, 2002; Nannipieri et al., 2003; Crecchio et al., 2007). In semi arid saline soils the distribution of ammonifying bacteria depends mostly on crop cultivation and tillage practices. Quantitative estimation of populations of ammonifying bacteria, in surface soils under plants was estimated and is shown in Fig. 1. Alfalfa was able to support the highest number of ammonifying bacteria (37 Mln CFU/g $soil^{-1}$) in all seasons, while fallow soil had the lowest. It is most probably related to greater release of exudates and availability of C substrates, due to alfalfa's extensive rooting system. Alfalfa had a versatile capacity to produce greater root exudates and enrich the soil with nitrogen through nitrogen-fixing activities (Buckley and Schmidt, 2001). It is reported that C exudation by roots into the surrounding soil and the availability of mineral nutrients in soil are of considerable importance to increasing microbial populations (Bais et al., 2006).

It has been previously reported that each plant provides different amounts and composition of organic compounds into soil (Falchini et al., 2003; Micallef et al. 2009). According to Darrah (1991), the root exudates sugar accumulation was higher in wheat. Those findings may support higher population densities of bacteria associated with wheat (Lupwayi et al., 1998). Similarly, Govaerts et al. (2007) reported about a positive effect of wheat cropping on soil microbial populations (Fig. 1). Niewiadomska et al., (2010) observed highest numbers of ammonifying microorganisms under maize during the phase of emergence in a crop rotation with wheat. The distribution of ammonifying bacteria varied according to soil depth. The total number of bacteria was higher at soil depths of 10-20 cm regardless of plant type.

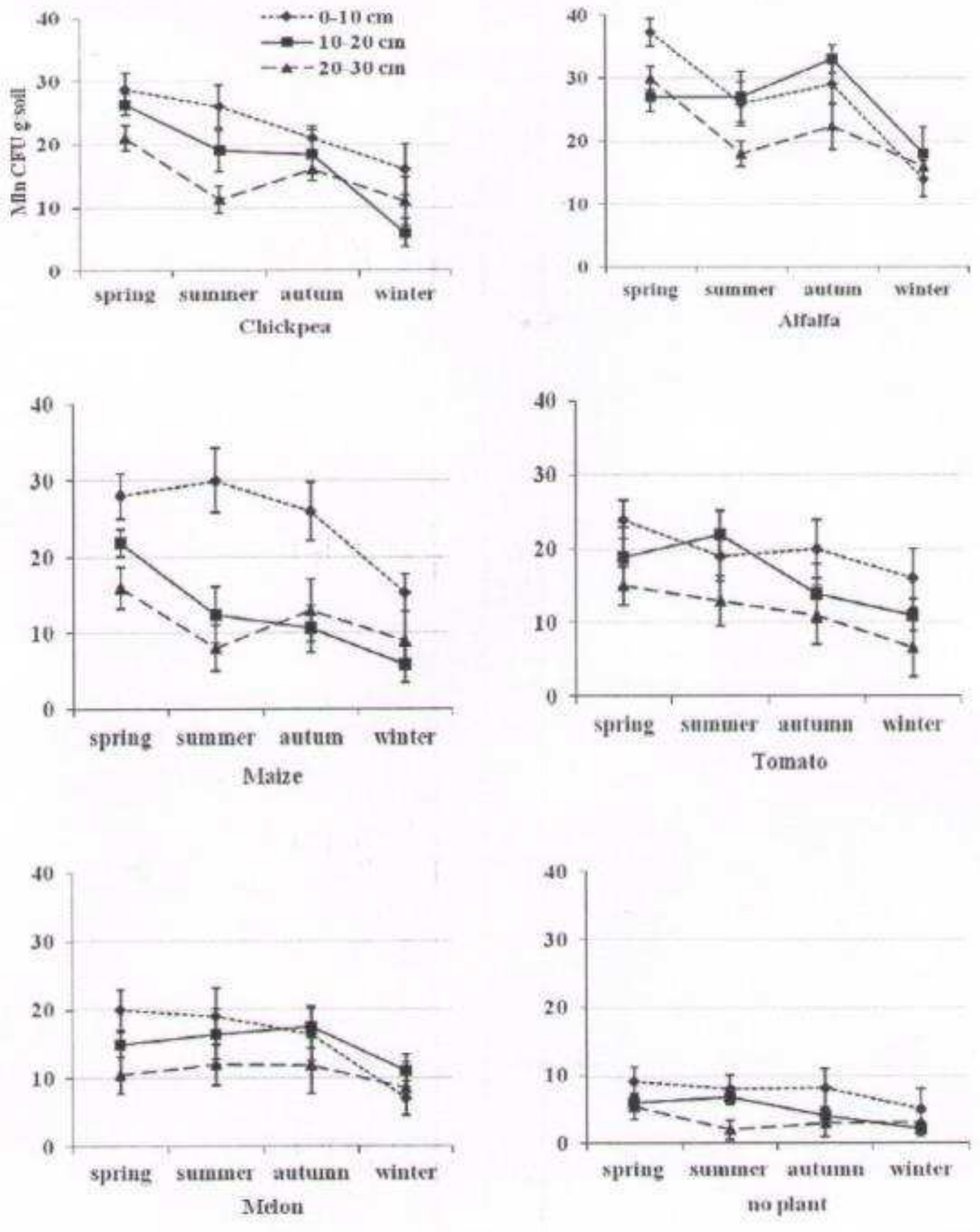

Fig. 1. The number (CFU) of ammonifying bacteria in 0-10, 10-20 and 20-30 cm soil depth under groundnut, alfalfa, maize, tomato, melon and fallow. The samples were taken in spring, summer, autumn and winter.

Several authors reported that conservation tillage allows crop residues to remain on the soil surface thus minimizing soil disturbance (Bucher and Lanyon, 2005; Al-Kaisi et al., 2005). Averaged across crops and soil depth, a greater density of ammonifying bacteria was observed in spring than in the other seasons. According to Zou et al. (2000), the increased moisture content and optimal temperature in soil during the spring period enhance the development of the microflora.

In conclusion, this experiment indicated that various agricultural crops influence ammonifying bacterial population under salinated, semi arid soil. Higher population of ammonifying bacteria was found in soil under alfalfa and groundnut. To increase the soil biological fertility of salinated soil, it is necessary to use legumes, which can increase microbial population in the soil.

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