MICROBIAL AND BIOCHEMICAL CHANGES INDUCED BY ROTATION AND TILLAGE IN A CALCAREOUS SOIL UNDER MELON, TOMATO, WHEAT AND COTTON PRODUCTION

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ABSTRACT

The aim of this study was to was to evaluate changes in soil microbial community in response to tillage, rotation and seasons throughout the melon, tomato, wheat and cotton growing season in a calcareous soil Uzbekistan semi arid region. The number of ammonifying bacteria, oligonitrophilic bacteria, oligotrophic bacteria and nitrogenase activity in Calcisol soil under different agricultural crops in Surhandarya region Uzbekistan were compared. Soil samples were collected from the soil under cotton, melon, tomato, wheat in spring, summer, autumn, and winter. We measured the microbial population after tillage at depth intervals of 0-10 cm, 10-20 cm, and 20-30 cm. The results revealed that the number and enzymatic activity of microorganisms depended upon plant type, depth and date of sampling. The total number of ammonifying bacteria, and oligotrophic bacteria tended to be highest under tomato and wheat. The number of ammonifying and oligotrophic bacteria were higher at the 20-30 cm soil depth of soil than at the 0-10 cm depth regardless of plant type. Seasonal changes in the numbers of soil microorganisms were marked in all agricultural crops, with the lower numbers in winter and higher numbers in spring and summer. This experiment indicated that different agricultural crops ad tillage practice affected the microbial characteristics of soil.

INTRODUCTION

Soil microorganisms play important roles in maintaining soil quality and plant production. The study of diversity, distribution, and behavior of microorganisms in soil habitats is essential for a broad understanding of soil health. Agricultural management practices, particularly inputs of manure and cover crops, can have large impact on the size and activity of soil microbial communities (Atlas et al., 1991; Klug and Tiedije, 1993; Overas and Torsvik, 1998; Buckley, 2001). Some authors identified patterns of microbial population that are consistent across sites that vary in plant composition and agricultural treatment (Broughton and Gross, 2000; Felske and Akkermans, 1988). Also in comparative studies have been observed differences between microbial communities in field with different histories of soil amendment, irrigation, tillage and plant community structure (Baath, et al., 1995; Bloem et al., 1992; Bossio et al., 1998). Tillage practices have a considerable effect on the quantity and quality of soil organic matter especially in the near-surface layers (Angers et al., 1993). Tillage leads to the development of soil microbial communities dominated by aerobic microorganisms with high metabolic rates, typically bacteria, whereas under conservation practices, plant residues left at or near the soil surface encourage fungal growth and the temporary immobilization of nutrients (Panhust et al., 2002)..

Soil enzyme activities are believed to be able to discriminate between soil management treatments (Dick, 1993) probably because they are related to microbial biomass, which is sensitive to such treatments. It is well-documented that N_2- fixation is an important process in the soil biological activity. Nitrogenase activity in soil depends on ecological conditions in association with the specific N-fixation capabilities of certain microorganisms, plant genotypes, and climatic conditions.

Soil with high organic substance will have higher nitrogenase activity. Biotic factors can influence the bacterial activity in soil. The degree of nitrogenase activity is plant-specific (Rennie, 1983). Several studies have been carried out to characterize the nitrogenase activity in many types of soils. However the studies of microbial communities in calcareous soil with conventional tillage practices of southeastern part Syrhandarya province Uzbekistan semi arid region not yet performed. The objectives of this study were to determine the influence of the plant type, conventional tollage, soil depth and seasonal change on the microbial population and activities in calcareous soil Uzbekistan semi arid region.

MATERIAL AND METHODS

Study Site and Soil Sampling

Sites used in this study represent continuously cultivated (more than 50 years) fields located in Surhandarya province, southeastern part of Uzbekistan. Soil is calcareous serozem soil (1 % organic matter, 0.6 mg N 100 g-1 soil; 3.0 mg P 100 g $^{-1}$; 12 mg K 100 g^{-1}; 6 mg Mg 100 g^{-1} soil; pH 7.4) having a calcic horizon within 50 cm of the surface. The orchic horizon is low in organic matter. The climate is semi arid with mean annual air temperatures of 16^{o}C and 18^{o}C, and mean annual rainfalls of 200 mm. The conventional tillage consisted of moldboard plowing to 20 cm depth after harvest and offset disking, to a depth of 10 cm, prior to planting in the spring. Soil samples of 0-10 cm, 10-20 cm, 20-30 cm depth were taken with a soil corer (3,5 cm dia) between the rows of melon, tomato, wheat and cotton at assistance of 20 cm from the center of the plants. Samples were collected at 3-month intervals in October (autumn), January (winter), April (spring), and July (summer). Conventional mineral fertilizers N, P, K input rates range from 150 to 200 kg ha^{-1}yr^{-1} for cotton and wheat. For tomato and melon range from 60 to 140 kg ha^{-1}yr^{-1}. The cores were pooled; field-moist soils were sieved (<2mm) directly after collection. The soil samples were kept in black polyethylene bags and stored at 4°C. These "fresh" field-moist, sieved samples were used for the incubation study.

Soil chemical and physical analysis

Air-dried samples were analyzed for the total C, N, P, K and Mg contents. Soil particle distribution was determined using natrium phosphate. The soil chemical and physical properties are presented in Table 1. The total carbon content, C_{tot}, was identified by elementary analysis while total nitrogen, N_{tot}, content was determined by the Kjeldahl method. The molybdenum blue method determined the total phosphorus content, P_{tot}, in soil. Potassium, K, was determined using the Flame Photometric Method (Riehm, 1985). The Atomic Absorption Spectrophotometer (AAS) was employed to measure calcium chlorite ($CaCl_2$) and extractable magnesium (Schachtschnabel and Heinemann, 1974). Soil pH-value was measured by means of electrometer.

Soil microbiological analyses

Plate dilution method was used for determination of numerous microorganisms using agar medium. In order to count the number of microorganisms, 10 g of soil was shaken with 90 ml of ster.-distilled water. From this suspension the serial dilution (1:10) was prepared and plate counts were performed in triplet and incubating until growth occurred (usually 3-7 days). CFU of ammonifying bacteria were enumerated on glycerin peptone agar. Oligotrophic bacteria on soil agar containing 900 ml water, 100g soil, 18g agar L^{-1}, oligonitrophilic bacteria was determined on Eshbi agar containing 0,2 g K_2HPO_4, 0,2 g $MgSO_4$, 0,2 g of NaCl, 0,1 g K_2SO_4, 5 g $CaCl_2$, 20 g sacharosa, agar 15 gl^{-1}. Microbial density was expressed as colony forming units (CFU). Nitrogenase activity was measured using acetylene reduction assay. The data were analyzed using the statistical analysis of variance by (ANOVA).

RESULTS AND DISCUSSION

Microbial Population

Marked effects were found to have taken place on the bacterial populations under melon, tomato, wheat and cotton. This is clearly demonstrated by the total number of bacteria colony-forming units (cfu) recorded from the plates. Our results showed that microbial population was different in soils under different agricultural crops with different soil depths. The highest density of ammonifying bacteria was observed under tomato and wheat during summer and the lowest in winter (Fig.1). After tillage we found higher ammonifying bacterial population at 20-30 cm depth.

Microbial diversity was significantly higher under wheat preceded by red clover green manure or field peas than under wheat following wheat (Lupwayi, 1998). According to Merckx et al., (1987), obviously the input of nutrient by the roots into surrounding soil as well as the mineral nutrients levels in the soil are of considerable importance. Rovira (1965) was convinced that root exudates play a key role in the selective stimulation of microorganisms and the view has shared by others (Atkinson et al., 1975).

The total number of oligonitrophil bacteria decreased on soil planted to melon and wheat and increased in soil under cotton (Fig.2). These bacteria populations are distributing well, when soil has low N content. Uzbekistan soil is nitrogen deficient soil, and oligonitrophil bacterial strains are higher than other microbail populations. Bacterial density was the lowest in winter and increased gradually through spring and autumn. According to Entry et al., (1996) soil microbial biomass N was lower in the cotton grown soil.

The number of oligotrophic bacteria tended to be lowest under melon and cotton and highest under wheat and tomato (Fig.3). Also (Govedarica et al., 1995; Egamberdiyeva, 1997).found that total number of oligotrophic and oligonitrophilic bacteria decreased in soil under maize and cotton Seasonal changes in the number of oligotrophic bacteria showed that with increase in the atmospheric temperature, their numbers increasing. The highest number was found in summer, and lowest in winter. Also Zou Li et al., (2000) found similar changes in microbial population during different seasonal time that in winter the total number of microorganisms decreased.

The differences of microbial populations varied between depth distributions after conventional tillage practices. The total number of microorganisms was higher at the 20-30 cm soil depth of soil than at the 0-10 cm and 10-20 cm depth regardless of plant type. Also some authors suggest that the number of ammonifying bacteria, oligonitrophilic, oligotrophic bacteria decreased in soil sampled from 10-20 cm. layers (Govedarica et al., 1995; Zou Li, et al., 2000).

Nitrogenase Activity

The results revealed that tomato and cotton cultivated in the Surhandarya region contributed to the high nitrogenase activity (Fig.4). Soil without plant cover had a lower nitrogenase activity in comparison to soil with plant cover. According to Govedarica (1995), soil with high organic substance will have higher nitrogenase activity. Plants, which produce exudate, exhibit higher N_2-Fixation. N_2- fixation bacteria are active in the root area (Egamberdiyeva, 1997). This source of energy is an important basis for the heterotrophic soil microflora, which can for N_2 – Fixation. It has also been found that nitrogenase activity was higher during the spring. Nitrogenase activity was higher in the 10-20-cm. horizons. In this soil depth, microbial activity was higher as a result of the root system.

CONCLUSION

In conclusion, this experiment indicated that conventional tillage practices and different agricultural crops affected the microbial characteristics of soil. Soil microbial population and activities were stimulated in soil under wheat and tomato at 20-30 cm soil depthh in this study. Seasonal changes in the numbers of microbial population were marked in soil under all plant types, soil layers, with the numbers increasing with increase in the atmospheric temperature.. To increase the soil fertility, particularly the soil biological fertility of Calcisol Uzbekistanian soil, it is necessary to plant crops, which can increase microbial biomass and nitrogenase activity in the soil and reduce tillage practices. This is especially important for the low organic-content soils of the region.

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