Research article

Soil Biota Activities Relation with Soil Characteristics in the Improved Salt-affected Area by Tree Plantation

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Abstract Salt affected soil is a serious problem in Thailand, particularly in the Northeast Plateau where salt bearing rocks are abundant. Excessive amounts of salts have a range of adverse effects on the physical and chemical properties of soil microbiological processes and plant growth. However, soil biological aspect of saline environment has been less studied. Tree Plantation has been introduced to improve salt-affected area. Monitoring of the changes by study the soil biota activities relation with physical and chemical soil characteristics are important. The aim of this study was to monitor the change of soil biota activity relation with the soil properties in the improved salt-affected area by Tree Plantation at Amphur Borabue, Mahasarakam Province, Northeast of Thailand. The physical, chemical and biological soil characteristics in soil sample were analyzed before and after tree plantation. The results showed that soil biota activity after tree plantation was higher than before. Soil respiration before and after tree plantation were 12.13 and 71.50 mg CO2/day, respectively. The EC, Na, K, and CEC values were decreased and pH, OM, and N were increased after tree plantation. The result from this study indicated that physical, chemical and biological properties were improved after tree plantation. This study's result would be useful for sustainable land resources improvement and rehabilitation.

Keywords salinity, soil biota, salt affected area, soil characteristics

INTRODUCTION

Salt affected soil is a serious problem in Thailand, in the Northeast Plateau where salt bearing rocks are common (Department of Land Development, 1991). Salt affected soils are extensively developed in many areas in Northeast Thailand such as Nakhon Ratchasima, Khon Kean, Roi Et and Mahasarakham Provinces (Department of Mineral Resources, 1982). Soil salinity generally occurs in discharge areas where the water table is high including edges of closed depressions and low lying areas where evaporation is high and high salt concentrations develop (Wongpokhom et al., 2007). Salinity has a range of adverse effects on the physical and chemical properties of soil, microbiological processes and plant growth. While the effects of salinity on soil chemical and physical properties and plant growth are well documented, the studies on their effects on soil biota activities are limited (Yuan et al., 2006). Salinity show harmful influence on the size and activity of the soil microbial biomass and on biochemical processes essential for maintenance of soil quality. This will result in a reduction in the rate of soil organic matter decomposition and in plant available nutrients, which further limits plant growth and crop production in salt affected soils. Therefore, ecological monitoring of the change of soil physical, chemical and biological changes in the salt-affected area after tree plantation in Northeast Thailand is needed.

The objectives of this study were to monitor the change of soil biota activities in relation with the physical and chemical properties of soil in the salt-affected area before and after tree plantation.

MATERIALS AND METHODS

Study site

The study was conducted in at Ak-Kasatsuntorn water reservoir, Tumbon Borabue, Mahasarakam Province, Thailand. The site is located between latitude of $16^0 0' 47.4''$N and longitude of $103^0 5' 23.8''$E.

Soil sampling and analysis

The study area was divided into 3 zones followed by the plant community found in each area which correlated with the flooding situation and soil salinity. Soil samples from each zone were collected in year 2008. Soil physical and chemical properties were measured. The impact of salinity on soil biota was studied by Basal respiration for microbial activity followed by Anderson method (Anderson, 1982). After carefully removing the surface organic materials and fine roots, each composited moist field soil sample was mixed, homogenized and sieved through a 2 mm mesh screen. Microbial and biochemical analyses were carried out on field moist subsamples, and physicochemical analyses were performed on air dried subsamples. Soil pH and EC were measured in a 1:5 soil to water solution using a glass electrode. Particle size analysis was done by pipette method. Organic C was analyzed by dichromate oxidation method. Total N was estimated by Kjeldahl method. Extractable NO_3 and NH_4 were measured in 2 MKCl extracts of the soil using a Lachat autoanalyzer. Total K in the extract from the 35% HF and 60% $HClO_4$ digestion of the soil and available K with 1 M NH_4OAc were determined by flame photometry. Available P in the extract with 0.5 M $NaHCO_3$ by the Olsen method and total P with 60% $HClO_4$ digestion of the soil were measured colorimetrically. Microbial biomass C and biomass N were estimated by the chloroform fumigation extraction method. Six portions equivalent to 25 g oven dry soil were taken from each soil sample. Three portions were fumigated for 24 h at 25 ^oC with ethanol free $CHCl_3$. Following fumigant removal, the soil was extracted with 100 ml 0.5 M K_2SO_4 by horizontal shaking for 1 h at 200 rpm and then filtered. The other three non-fumigated portions were extracted simultaneously at the time fumigation commenced. Organic C in the extracts was measured using the dichromate oxidation method. Microbial biomass C was calculated as follows: microbial biomass C = EC/kEC, where EC = (organic C extracted from fumigated soils) - (organic C extracted from non-fumigated soils) and kEC = 0.38. Total N in the extracts was measured using the Kjeldahl method. Microbial biomass N was calculated as follows: microbial biomass N = EN/kEN, where EN = (total N extracted from fumigated soils) - (total N extracted from non-fumigated soils) and kEN = 0.54 (Yuan et al., 2006). Basal respiration was determined by placing 30 g of field moist soil in a 50 ml beaker and incubating the sample for 1 day in the dark at 25 ^oC in a air tight sealed jar along with 10 ml of 1 M NaOH. The CO_2-C evolved was determined after 1 day by titration (Anderson, 1982). Basal respiration rate was calculated based on CO_2 evolution over the 1 day period. The microbial metabolic quotient was calculated as basal respiration (mg CO_2) per mg of microbial biomass C (Anderson and Domsch, 1990).

Statistical analysis

An analysis of a variance (ANOVA) was used to compare each zone and the impact on soil biota activites by Statistix 8.

RESULTS AND DISCUSSION

The soil physical and chemical properties before and after tree plantation were shown in Table 1 and 2. The result found that the physical, chemical and biological soil properties were improved after tree plantation. The EC, Na, K, CEC values were reduced and pH, OM, and N were increase significantly differences after tree plantation ($p<0.05$). Soil biota activity after tree plantation was higher than before plantation significantly ($p<0.05$). Soil respiration before and after tree plantations were 12.13

and 71.50 mg CO_2/day, respectively (Table 3). There was a significant increasing in the microbial biomass C after tree plantation ($p<0.05$) (Table 3).

Table 1 The physical properties of soil in different zone at salt-affected area before and after tree plantation

Sampling site	Before	After	Percent Change (%)
Moisture	9.66 a	15.01 b	55.38

Values indicated by different letters in the same row are significantly different ($P \leq 0.05$).

Table 2 The chemical properties of soil in different zone at salt-affected area before and after tree plantation

Sampling site	Before	After	Percent Change (%)
pH (1:5)	5.59 a	5.67 a	1.52
EC (1:5) (dS/m)	0.573 a	0.019 b	-96.68
OM (%)	0.44 a	0.49 b	10.48
Total N (%)	0.018 b	0.087 a	384.72
Available P (ppm)	10 a	6 a	-36.93
Extractable K (ppm)	144 a	27 b	-81.04
Extractable K (c mol(+)/kg)	0.625 a	0.118 b	-81.2
Extractable Na (ppm)	276 a	161 a	-41.56
Extractable Na (c mol(+)/kg)	0.706 a	0.412 a	-41.6
CEC (c mol(+)/kg)	3.67 a	3.18 a	-13.3

Values indicated by different letters in the same row are significantly different ($P \leq 0.05$).

Table 3 The basal soil respiration of soil and soil microbial biomass C, N of soil in different zone at salt-affected area

Sampling site	Before	After	Percent change (%)
CO_2	12.13 a	71.50 b	494.75
MBC	67.46 a	172.32 b	155.44
MBN	81.98 a	25.59 b	-68.79

Values indicated by different letters in the same row are significantly different ($P \leq 0.05$).

The relationships with EC demonstrate the highly detrimental effect that soil salinity had on the microbial activity. The study of Yuan et al. (2006) about the effects of salinity on the size, activity and community structure of soil microorganisms in salt affected arid soils were investigated in Shuangta region of west central Anxi County, Gansu Province, China. Eleven soils were selected which had an electrical conductivity (EC) gradient of 0.32-23.05 mS cm^{-1}. There was a significant negative exponential relationship between EC and microbial biomass C, the percentage of soil organic C present as microbial biomass C, microbial biomass N, microbial biomass N to total N ratio, basal soil respiration, fluorescein diacetate (FDA) hydrolysis rate, arginine ammonification rate and potentially mineralizable N. The exponential relationships with EC demonstrate the highly detrimental effect that soil salinity had on the microbial community. In contrast, the metabolic quotient (qCO_2) was positively correlated with EC, and a quadratic relationship between qCO_2 and EC was observed. Soil microbial biomass has been used to compare natural and disturbed ecosystems. Microbial biomass C was lowest in those soils where CO_2-C emission was also low.

This suggests that in salt affected soils biomass C can serve as a sensitive indicator of changes in soil organic matter and it is one of the general indices to soil microbial activities (Wick et al., 1998). Since basal respiration represents the living component of microbial biomass C (Sparling, 1992), our study shows that the biological activity in soil in salt affected area were increasing after tree plantation.

CONCLUSION

It is obvious that salinity not only had adverse effects on soil physical and chemical properties and crop growth but also on the soil biota activity which is essential for maintenance of soil fertility. Tree plantation in the salt-affected area can improved physical, chemical and biological soil characteristics. Monitoring of the ecosystem changes in salt affected area by studying the soil biota activities is important. The result of this study would be useful for land resources improvement and rehabilitation.

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