Research article

The Influence of Eucalyptus Plantation on the Soil Ecosystem under Different Soil Series in Northeast Thailand

PRAEWPAYAP NAMPAKDEE
Faculty of Agriculture, Khon Kaen University, Thailand
Email: payup141@gmail.com

THEPPARIT TULAPHITAK, SURASAK SERIPONG AND CHULEEMAS BOONTHAI IWAI
Faculty of Agriculture, Khon Kaen University, Thailand

Received 26 December 2009 Accepted 25 July 2010

Abstract Eucalyptus has been introduced to the farmer and extensively grown in Thailand for paper pulp production and giving high income to the farmer. However, the long term impact of eucalyptus plantation on soil ecosystem has been less studied. Therefore, the aim of this study was to investigate the influence of eucalyptus plantation on the soil ecosystem under different soil series in Northeast Thailand. The study site was located at Amphur Nam Pong, Khon Kaen, Northeast of Thailand. The biological, physical and chemical soil properties in Eucalyptus plantation (more than 3 years) were analyzed compared with the dry dipterocarp forest nearby. Moreover, impacts of eucalyptus on soil biota (Earthworm) under different soil series (Pimai and Nampong soil series) were evaluated in the laboratory. The results indicated that microbial activity such as soil respiration, microbial biomass nitrogen and microbial biomass carbon in Eucalyptus plantation were less than in the dry dipterocarp forest significantly from 3.950 to 5.916 mg C/day for microbial activity and 15.811 and 108.620 µg N/g soil for microbial biomass nitrogen and 102.24 to 244.25 µg C/g for soil microbial biomass carbon ($p<0.01$), respectively. For the 50% avoidance of the earthworm to eucalyptus leave in Pimai (Pm) and Nampong (Ng) soil series were 17.35 and 19.44 g/kg soil, respectively. The result showed that eucalyptus plantation has adverse effect on soil microbial activity in soil ecosystem and differ in each soil series. The result of this study is useful as decision making in appropriate land use management. The impact of eucalyptus plantation should be considering of site specific location and find out the suitable place to grow eucalyptus.

Keywords eucalyptus, soil characteristics, soil ecosystem

INTRODUCTION

Eucalyptus has been introduced to the farmer and extensively grown in Thailand for paper pulp production and giving high income to the farmer. Eucalyptus plantation area has been increasing. In 2007, eucalyptus plantation was 20 million rai (1 ha = 6.25 rai) (Department of Agriculture, 2009) and showed the trend of increasing in next year. Now eucalyptus plantation has been extended into northeast area in Thailand due to the suitable condition making eucalyptus tree grow faster than other parts of Thailand (The Thailand Research Fund, 2006). However, the long term impact on soil ecosystem has been less studied. One study of the impact of eucalyptus on soil biota was done in the earthworm *Pontoscolex corethrurus.* The result found that the earthworm population in eucalyptus plantation less than in albizia plantation. Mean earthworm densities ranged from 92 earthworms per m^2 in eucalyptus plantation area and 469 earthworms per m^2 for albizia plantation area (Zou, 1993). The study of the impact of eucalyptus on ecosystem mostly has been done on the water use and plant germination. Therefore, the influence of eucalyptus plantation on the soil ecosystem under different soil series in Northeast Thailand was investigated. The result of this study will be useful for involved

organizations for decision making and land use management. The impact of eucalyptus plantation should be considering of site specific location and find out the suitable place to grow eucalyptus.

MATERIAL AND METHODS

The study of the influence of eucalyptus plantation on the soil ecosystem under different soil series in Northeast Thailand was done in laboratory experiment and field study. The study site was located at Amphur Nam Pong, Khon Kaen, Northeast of Thailand (Global Position System location is E 16^0, $47^{'}$, $5.77^{''}$, N 102^0, $46^{'}$, $11.28^{''}$).

Laboratory experiment

The impacts of eucalyptus on soil biota (Earthworm) under different soil series (Pimai and Nampong soil series) were evaluated in the laboratory to study on the avoidance of earthworm. A laboratory experiment was set up to find percent (%) avoidance of earthworm on eucalyptus leave *(Eucalyptus camaldulensis)* in the two different soil series. For each treatment, 200 g of soil was add in two side of plastic box (7cm x 11cm x 5cm). One side containing soil without the eucalyptus leave and other side containing soil with eucalyptus leave (60 mesh size) (Chander, 1995) in different concentrations in each treatment (Treatment 1: Soil plus eucalyptus leaves at 10 g/kg soil, Treatment 2: Soil plus eucalyptus leaves at 20 g/kg soil, and Treatment 3: Soil plus eucalyptus leaves at 40 g/kg soil). After that the earthworm *Eudrillus eugeniae* were added in center plastic box and left it for 24 hours to monitor the proportion of earthworm in each side and then calculation for the percent of avoidance (%) as followed.

$$PA = \frac{NECS - NETS}{TN} x100 \quad (1)$$

Where: PA : The percent of avoidance (%)
NECS : Number of earthworm in control side
NETS : Number of earthworm in treatment side
TN : Total number of earthworm in each treatment

Field studies

The biological, physical and chemical soil properties in Eucalyptus plantation were analyzed comparing with the dry dipterocarp forest nearby. Soil samples were collected at the various distances from the eucalyptus plantation and dry dipterocarp forest and analyzed for microbial biomass C, microbial biomass N and soil microbial activity.

Soil microbial biomass measurement

Microbial biomass C was measured by the chloroform fumigation extraction method (Sparling, 1991; Tate et al. 1988). Two replications of 10 g of each soil were fumigated with ethanol-free chloroform for 24 hour. After that soil were extracted with 0.5 M K_2SO_4 (using a soil: solution ratio of 1:5) for 30 minute. Two replication of each unfumigated soil were extracts similarly at time fumigation commenced and filtered soil extracts stored at -15 ^oC until analysis.

Microbial biomass N was measured by the chloroform fumigation extraction method (Sparling, 1991; Tate et al. 1988). Two replications of 10 g portions of each soil were fumigation with ethanol-free chloroform for 24 hour. After extracted with 1M KCl (using a soil: solution ration of 1:5) for 30 minute, the soils were measured by spectrophotometer at 570 nm. Microbial biomass C and Microbial biomass N were calculated from:

MBC, MBN= (Microbial biomass C, Microbial biomass N chloroform fumigation) – (Microbial biomass C, Microbial biomass N unfumigared).

Soil microbial activity

Soil microbial activity was measured for soil respiration by the method of Anderson (1992) and Rowell (1997). As many as 15 ml of NaOH was added in small vial (5 cm high and 2.5 cm diameter) and hang in the jar containing soil and leave for 24 hour. Excess NaOH was titrated with 0.05 N HCl by adding 2.5 M $BaCl_2$. Soil respiration was calculated from:

$$SR = (B - V)N \; x \; 6 \qquad (2)$$

Where SR : Soil respiration (mg Carbon unit)
B : HCl for titration blank (ml)
V : HCl for titration sample (ml)
N : Concentrated HCl

RUSULTS

The results indicated that microbial activity such as soil respiration, microbial biomass nitrogen and microbial biomass carbon in Eucalyptus plantation were significantly less than in the dry dipterocarp forest from 3.950 to 5.916 mg C/day for microbial activity and 15.811 and 108.620 µg N/g soil for microbial biomass nitrogen and 102.24 to 244.25 µg C/g for soil microbial biomass carbon ($p<0.01$), respectively (Table 1). For the 50% avoidance of the earthworm to eucalyptus leave in Pimai (Pm) and Nampong (Ng) soil series were 17.35 and 19.44 g/kg soil, respectively (Fig.1). The soil chemical and physical properties in Eucalyptus plantation compared with the dry dipterocarp forest showed in Table 2 and 3. The soil chemical and physical properties in Eucalyptus plantation compared with the dry dipterocarp forest. The result found that organic matter (OM), total N, Available P (ppm) and Extractable K (ppm) in eucalyptus plantation less than in the forest. The better soil physical property was found in the forest than eucalyptus plantation.

Table 1 Microbial biomass N (µg N/g soil) and microbial biomass C (µg C/g soil) and soil microbial activity (mg) in Eucalyptus plantation and dry dipterocarp forest

Area	Microbial biomass N (µg N/g soil)	Microbial biomass C (µg C/g soil)	Soil microbial activity (mg)
Eucalyptus	15.81 b	102.24 b	3.950 b
Dry dipterocarp forest	108.62 a	244.25 a	5.917 a

a,b Significant at $P \leq 0.05$ Values followed by the same letter in the same column

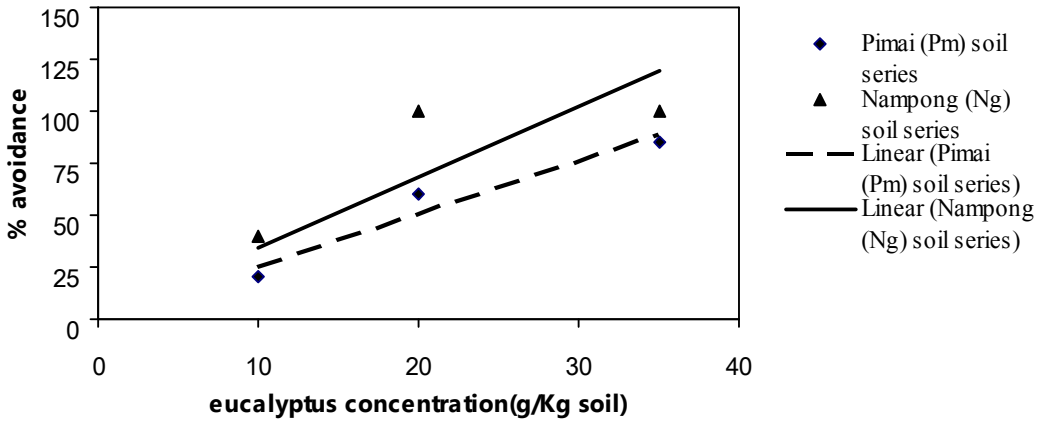

Fig. 1 Percent (%) in avoidance of earthworm exposure to the different eucalyptus concentration in Pimai (Pm) and Nampong (Ng) soil series

Table 2 Chemical soil properties in Eucalyptus plantation and dry dipterocarp forest

Area	Dry dipterocarp forest	Eucalyptus
pH (1:1)	5.05±0.04	4.87±0.44
% OM	1.71±1.07	0.67±0.04
%T-N	0.02±0.10	0.03±0.00
Available P (ppm)	3.66±1.76	2.05±0.24
Extractable K (ppm)	61.67±41.93	50.67±2.52

Values are mean ± standard deviation. Mean with the same letter in the row are not significantly different control (P>0.05).

Table 3 Physical soil properties in Eucalyptus plantation and dry dipterocarp forest

Area	Dry dipterocarp forest	Eucalyptus
Bulk density (g/cm^3)	1.40±0.19	1.58±0.05
Saturated hydraulic conductivity (cm/h)	0.33±0.29	1.16±0.54
Soil moisture (%)	20.61±4.75	12.81±6.30

Values are mean ± standard deviation. Mean with the same letter in the row are not significantly different from control (P>0.05).

CONCLUSION

According to the results, it indicated that eucalyptus plantation has some adverse effect on soil microbial activity in soil ecosystem and differ in each soil series. However, organic matter decomposition is a complex process, which involves leaching, physical abrasion, microbial conditioning and processing by soil biota. The relative importance of these factors can be changed, resulting in highly variable species-and site-specific dynamics (Pozo et al., 1998). The result of this study will be useful for involved organizations for decision making and land use management. The impact of eucalyptus plantation should be considering of site specific location and find out the suitable place for eucalyptus plantation.

ACKNOWLEDGEMENTS

The authors would like to thank the Graduate school, Khon Kean University for research funding, in addition to the farmers in Ban Nomdongmun, Nampong, Khon Kean province for the study sites. And special thanks to Association of Environmental and Rural Development (AERD) and Prof. Dr. Machito MIHARA for special support.

REFERENCES

Anderson, T.R. (1992) Modelling the influence of food C:N ratio, and respiration on growth and nitrogen excretion in marine zooplankton and bacteria. Journal of Plankton Research, 14, 1645-1671.

Chander, K., Goyal, S. and Kapoor, K.K. (1995) Microbial biomass dynamics during the decomposition of leaf litter of poplar and eucalyptus in a sandy loam. Bio Fertil Soils, 19, 357-362.

Department of Agriculture (2009) retrieved August 5, 2009 from http://it.doa.go.th/pibai/pibai/n11/v_11mar/ceaksong.htm.

Pozo, J., Basaguren, A., El´osegui, A., Molinero, J., Fabre, E. and Chauvet, E. (1998) Afforestation with Eucalyptus globulus and leaf litter decomposition in streams of northern Spain. Hydrobiologia 373/374, 101-109.

Rowell, D.L. (1997) Soil Science: methods and application. John Wiley and Sons, Inc. New York, USA, 117-121.

Sparling, G.P. (1991) Organic matter C and microbial biomass C as indicators of sustainable land use. Proceeding of the International workshop on evaluation for sustainable land management in developing world, IBCRAM proceeding, No. 12.

Tate, K.R., Ross, D.J., and Feltham, C.W. (1988) A direct extraction method to estimate soil microbial C, Effect of experiment variables and some different calibration procedures. Soil Biol. Biochem, 20, 329-335.

The Thailand Research Fund (2006) http://www.trf.or.th/News/Content.asp?Art_ID=574.

Zou Xiaoming (1993) Species effects on earthworm density in tropical tree plantation in Hawaii. Bio Fertil Soils, 15, 35-38.