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Comparisons of Soil Properties between Earthworm Casts and Top Soil of Red Pine Forests in a Limestone Area

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石灰岩地域 소나무림에서 지렁이 Casts와 上層土 性質의 比較

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ABSTRACT

Comparisons of the physico-chemical properties of earthworm(*Lumbricus terrestris*) soil casts and top soil of red pine forests in a limestone area were carried out. The casts production durign August and September in 1990 amounted to 6~7t/ha. The particle of top soil and casts ranged 40~50% and 10~20% for sand, 25~30% and 30~35% for silt, and 20~25% and 55~65% clay, respectively. Significant difference in pH value was not observed between casts and top soil. The casts had 1.4times of organic matter, 1.5times of N, 1.8times of available P, 2times of exchangeable K, 1.3times of exchangeable Ca, and 1.6times of exchangeable Mg than the top 10cm of soil did. Earthworms have altered the soil texture and increased nutrient availability through production of the soil casts in this limestone area.

INTRODUCTION

Some species of soil macroaunae are agents of soil disturbance in ecosystems as results of digging burrows, soil ingestion and excretion(Donahue *et al.*, 1983). Earthworms have been considered to have a marked effect on the structure and properties of the soil. They have an improtant role in litter decomposition(Edwards and Heath, 1963 ; Syers *et al.*, 1979), and maintenance of soil fertility in the top soil layer(Barley and Jennings, 1959 ; Wallwork, 1970 ; Wallwork, 1970 ; Syers and Springett, 1984 ; Bhadauria and Ramakrishnan, 1989). Earthworm ingest decaying organic matter and mineral soil, and then excrete soil casts with the unassimilated organic particles passing out of the gut as

feces. The properties of such soil casts quite differ from the normal top soil(Syers *et al.*, 1979 ; Bhadauria and Ramakrishnan, 1989).

In Korea, calcareous soils are developed in limestone areas in Kang-Won and Chungbuk Provinces. We observed many earthworm(*Lumbricus terrestris*) soil casts in the red pine forest in these limestone areas. This study is to compare the soil properties of the casts with the top soil, and to evaluate the contribution of earthworm activity to nutrient dynamics in this red pine forest.

METHODS

The site description, basic climatic data and community structure of the study area, which is located at Maep'o near Tanyang(37° 03′N, 128° 18′E), Ch'ungbuk Province in Korea, have been described in detail by Mun *et al.* (1990). Soil samples were collected at 0~10cm depth as top soil and 10~20cm as subsoil in October and December, 1989, and February, March, April, May, July, August and September, 1990. To estimate earthworm cast production, five 25×25cm quadrats were set in the study area in July, 1990. Existing earthworm soil casts in each quadrat were removed, and collected newly formed ones in August and September. All the soil samples were tightly sealed in vinyl bags and moved to laboratory. Analyses of physico-chemical properties of soil were carried out after Mun *et al.* (1990).

RESULTS AND DISCUSSION

Cast production

The amount of soil cast production in red pine forest during two months from August to September was estimated as 6~7ton dry weight/ha(600~700g/m^2). Annual cast production was 33t/ha in a pasture ecosystem(Syers *et al.*, 1979), and 15.7t/ha in 5-year-old fallows and 40t/ha in 15year-old fallows of shifting agricultural systems(Bhadauria and Ramakrishnan, 1989). Moisture content of fresh casts ranged 70~80%. The casts gradually became dry and finally dispersed over the forest floor after heavy rain. Their granular structure improves physical properties of surface soil through acceleration of water permeability and aeration of the soils(Foth, 1984). Moreover, the earthworm soil casts were usually formed on the sourface litter layer which may speed up litter decomposition(Syers and Springett, 1984).

Comparison of soil texture

Sand and clay content of the top soil ranged 40~50% and 20~25%, and those of subsoil ranged 70~80% and 5~10%, respectively(Table 1). The top soil and subsoil, therefore, belong to sandy clay loam soil and loamy sand soil, respectively(Foth, 1984). Percen-

Table 1. Particle analysis of top soil, subsoil and earthworm casts of red pine forest in the study area

	Coarse sand(%)	Fine sand(%)	Silt (%)	Clay (%)	Soil type
Top soil	20~25	20~25	25~30	20~25	Sandy clay loam
Subsoil	60~65	10~15	5~10	5~10	Loamy sand
Casts	4~8	8~10	25~35	55~65	Clay

tages of sand and clay of the earthworm casts were 10~20% and 55~65%, respectively, which belong to clay soil. The greater amount of clay in the top soil than in the subsoil may be due to the addition of clay through cast forming activity of earthworm. The ability of the soil to hold moisture and nutrients positively related to the clay content of the soil (Foth, 1984). Therefore, it would be postulated that earthworms should affect soil chemical properties through modification of soil texture.

Comparisons of soil properties

Earthworms have influence on the supply of plant nutrients in the soil several ways. Syers and Springett(1984) reported that the amount of nitrogen released annually by earthworms into the soil, mainly as dead tissue as well as excretion of mucus, urea, uric acid and ammonia, was estimated as 18 to 92kg/ha, depending on their population size. Another route of the nutrient supply into the soil is through the casts production. The nutrient enrichment of casts relative to the surface soil occurs because the organic materials ingested by earthworms contain higher concentration of nutrients than soil(Graff, 1970 ; Sharpley and Syers, 1977 ; Sharpley *et al.*, 1979). Bhadauria and Ramakrishnan (1989) reported that the pH of casts was significantly higher than that of normal soil. In this study area, however, significant difference in the pH value was not observed between the casts and the top soil(Table 2).

However, the amounts of organic matter, total nitrogen, available phosphorus, and exchangeable potassium, exchangeable calcium and exchangeable magnesium in the casts were significantly greater than those in the top soil. The casts from the study area had about 1.5 times of total nitrogen, 1.8 times of available phosphorus, 2 times of exchange-

Table 2. Comparisons of soil properties bnetween earthworm casts and top soil of red pine forest in the study area(mean±SE)

Properties	Soil casts	Top soil	Properties	Soil casts	Top soil
Organic matter(%)	17.3±1.2*	12.7+4.2	K(mg/g)	0.23±0.04***	0.11±0.03
pH	7.9±0.1 NS	8.0±0.1	Ca(mg/g)	2.61±0.13***	1.98±0.15
Total-N(mg/g)	0.21±0.03**	0.14±0.02	Mg(mg/g)	0.39±0.05***	0.24±0.04
P(mg/100g)	1.45±0.02***	0.80±0.07			

*p<0.05, **p<0.01, ***p<0.001, NS; not significant

able potassium, 1.3 times of exchangeable calcium, and 1.6 times of exchangeable magnesium than the top soil did. The extent of increase in nutrients in the casts were smaller than that in the casts from a ploughed soil, which had approximately 7 times of available phosphorus, 11times of exchangeable potassium, and 3 times of exchangeable magnesium than the top 15 cm of soil did(Lunt and Jacobson, 1944). From these results it is concluded that earthworms bring about both the alteration of soil texture and improvement of nutrient availability through soil casts production in this limestone area. Further researches on the cast production, earthworm population dynamics, and surface litter removal by earthworms are necessary to understand the nutrient cycling in this limestone ecosystem.

摘 要

충북 단양군 매포읍의 석회암 지역에 형성된 소나무림에서 지렁이의 soil casts와 표층토의 물리, 화학적 성질을 비교하였다. 표층토의 토성은 사질식양토인데 비해 지렁이 casts의 그것은 식토이었다. 상층토의 점토함량이 하층토보다 많은 이유는 지렁이가 casts를 형성함으로써 점토가 첨가되었기 때문이다. 지렁이 casts는 상층토보다 1.4배의 유기물, 1.5배의 질소, 1.8배의 유효인산, 2배의 치환성 칼륨, 1.3배의 치환성 칼슘, 그리고 1.6배의 치환성 마그네슘을 더 많이 함유하고 있었다. 본 조사지역에서 지렁이의 활동은 상층토의 토성을 변화시키고 토양의 영양염류 이용도를 증가시켰다.

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